8th BINATIONAL MEETING
of the
LAKE ERIE MILLENNIUM NETWORK

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Status of Lake Erie: Understanding the Nearshore and its Connections

February 21 - 23, 2017

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Status of Lake Erie: Understanding the Nearshore & Its Connections

The 8th Binational Meeting of the Lake Erie Millennium Network

February 21 - 23, 2017
University of Windsor
Windsor, Ontario, Canada

Convened by:

University of Windsor
Environment and Climate Change Canada
Ohio Sea Grant - F.T. Stone Laboratory, Ohio State University
Great Lakes Research Station, U.S. Environmental Protection Agency at Grosse Ile

CONTENT

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Natural Sciences and Engineering Research Council of Canada (Connector Event)

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PROGRAM

Status of Lake Erie: Understanding the Nearshore & Its Connections

The 8th Binational Meeting of the Lake Erie Millennium Network

Ambassador Auditorium, CAW Student Centre
University of Windsor
February 21 - 23, 2017

Tuesday, February 21st

12:45 p.m. Welcoming Remarks and Introductions
Dr. K. W. Michael Siu, Vice-President Research
Dr. Chris Houser, Dean of Science
Dr. Daniel Heath, Executive Director, Great Lakes Institute for Environmental Research

Theme 1: Nutrients & Responses - Assessment of Nutrient/Eutrophication Dynamics in Lake Erie

Moderator: Jeff Reutter, Ohio State University

1:10 p.m. **ALICE DOVE, Sean Backus, Matt Maccoux, Debbie Burniston and Vi Richardson,** Environment and Climate Change Canada
Water quality and nutrient load monitoring in the Great Lakes – with a focus on Lake Erie

1:30 p.m. **ERIC OSANTOWSKI, G.Warren**, U.S. Environmental Protection Agency
Long-term monitoring and assessment of water quality for Lake Erie 1983-2015

1:45 p.m. **CRAIG STOW**, Great Lakes Environmental Research Laboratry, NOAA
Target loads, strategies to meet them, lessons from the past

2:00 p.m. **LAURA JOHNSON, David Baker, Rem Confesor, Jack Kramer, Ellen Ewing, Barb Merryfield, Aaron Roerdink, and Jake Boehler**, National Center for Water Quality Research, Heidelberg University
Sources, transformation, and measurement of dissolved reactive phosphorus in Lake Erie tributaries

2:15 p.m. **MICHAEL BROOKER, M. Evert**, Ohio State University, **K. Longnecker, E. Kujawinski**, Woods Hole Oceanographic Institute, **and P. Mouser**, Ohio State University
Discerning organic phosphorus signatures in pollutant sources from Lake Erie tributaries

2:30 p.m. **MARK R. WILLIAMS and Kevin. W. King**, U.S. Department of Agriculture
Decreasing phosphorus losses with drainage water management practices

2:45 p.m. **REMEGIO B. CONFESOR JR.**, National Center for Water Quality Research, Heidelberg University
Modeling the influence of agricultural practices on watershed export of phosphorus

3:00 p.m. **SHALIN KHOSLA**, Ontario Ministry of Agriculture, Food and Rural Affairs
Ontario greenhouse strategies to address phosphorus in the Great Lakes

3:15-3:45 p.m. BREAK

3:45 p.m. **THOMAS BRIDGEMAN**, University of Toledo, **Gerald Matisoff,** Case Western Reserve University, **Richard Becker, Kenneth Gibbons,** University of Toledo, **John Bratton, Edward Verhamme,** Limnotech, **Sandra Kosek-Sills,** Ohio Lake Erie Commission
Assessment of nutrient/eutrophication dynamics in western Lake Erie

4:00 p.m. **JOHN F. BRATTON, Edward M. Verhamme, Todd M. Redder, Derek A. Schlea, Jeremy Grush, and Joseph DePinto**, LimnoTech
Connecting phosphorus loads to cyanobacteria biomass using the Western Lake Erie Ecosystem Model

4:15 p.m. **JUSTIN D. CHAFFIN,** Ohio State University, **Douglas D. Kane**, Defiance College
Accuracy of data buoys for tracking cyanobacterial blooms in Lake Erie

4:30 p.m. **GREGORY L. BOYER,** State University of New York, **Wayne W. Carmichael**, Wright State University, **Steven W. Wilhelm,** University of Tennessee, **and Susan B. Watson,** University of Waterloo
Microcystins and toxicity of HABS

4:45 p.m. **PARIS D. COLLINGSWORTH,** Purdue University, **R.T. Kraus,** U.S. Geological Survey, **J.C. May and G.J. Warren**, U.S. Environmental Protection Agency
What is the spatial extent of hypoxia in Lake Erie?

5:00 p.m. **CHRISTOPHER VANDERGOOT, C. Holbrook,** Great Lakes Science Center, US Geological Survey, **N. Nate, and C. Krueger**, Michigan State University
Using the GLATOS Network to understand fish behavior and

movement at unprecedented spatial scales

5:15 p.m. **Discussion**

6:00 -8:00 p.m. **Reception and poster viewing**

Wednesday, February 22nd

Theme 2: Delineating and understanding the nearshore of Lake Erie & the Connecting Channels

Moderator: Chris Winslow, Ohio State University

8:45 a.m. **Welcome, recap & announcements**

9:00 a.m. **PETER J. ZUZEK,** Zuzek, Inc., **J. Anderson, J. McKenna, J. Hatcher**, Environment and Climate Change Canada

GLWQA pilot application of the Nearshore Framework and Baseline Habitat Survey, Long Point to Fort Erie study area

9:15 a.m. **TIMOTHY W. DAVIS,** NOAA OAR Great Lakes Environmental Research Laboratory, **T. Johengen, K. Meyer,** Cooperative Institute for Limnology and Ecosystem Research, **D. Smith, G. Dick,** University of Michigan, **S. Ruberg, D. Gossiaux,** NOAA OAR Great Lakes Environmental Research Laboratory, **A. Burtner, D. Palladino,** Cooperative Institute for Limnology and Ecosystem Research, **V. Denef, M. Berry,** University of Michigan, **S. Watson,** Environment and Climate Change Canada, **J. Ciborowski,** University of Windsor, **G. Bullerjahn, R.M. McKay,** Bowling Green State University, **G. Doucette, T. Mikulski,** NOAA NOS National Centers for Coastal Oceans Science, **J. Birch, C. Scholin,** Monterey Bay Aquarium Research Institute, **J. Mickett**, University of Washington Applied Physics Laboratory

Combining monitoring, advanced molecular techniques and near real-time instrumentation to investigate the response of cyanoHABs in Lake Erie and Lake St. Clair to different environmental conditions

9:30 a.m. **DAVID DEPEW, Sean Backus, Alice Dove, Luis Leon, Reza Valipour, Ram Yerubandi, Veronique Hiriart-Baer**, Environment and Climate Change Canada

Cladophora in eastern Lake Erie: A synthesis of findings from the Great Lakes Nutrient Initiative

9:45 a.m. **SCUDDER MACKEY, D. Beck, L. Garrity, and J. Park**, Office of Coastal Management, Ohio Department of Natural Resources

Nature-based shoreline management – a new coastal management paradigm

10:00 a.m. **CHRIS HOUSER**, University of Windsor
Natural and socio-economic pressures affecting longshore redistribution of sediment and shoreline maintenance in Lake Erie

10:15 - 10:45 a.m. BREAK

10:45 a.m. **MARY ANNE EVANS, N. King, and J. Scheffer**, Great Lakes Science Center, US Geological Survey
Benthic algae and submerged aquatic vegetation (SAV) in Western Lake Erie

Theme 3: Connecting Channels - St. Clair Detroit River System & Niagara River
Moderator: Michelle Selzer, Michigan Department of Environmental Quality, Office of the Great Lakes

11:00 a.m. **DEBBIE BURNISTON, S. Backus and A. Dove**, Environment and Climate Change Canada
Water quality monitoring in the St. Clair River-Detroit River corridor

11:15 a.m. **SANDRA EBERTS, Alex Totten, Joe Duris and Chris Hoard**, U.S. Geological Survey
Trenton Channel of the Detroit River monitoring

11:30 a.m. **MOLLY WICK, Matt Pawlowski, David Bolgrien, Ted Angradi, Jill Scharold, Mark Pearson, Mari Nord, Beth Hinchey-Malloy, Rose Ellison, Todd Nettesheim**, US Environmental Protection Agency
EPA's National Coastal Condition Assessment: pilot research in Great Lakes connecting channels

11:45 a.m. **BRAD HILL**, Environment and Climate Change Canada
Upstream/downstream monitoring in the Niagara River (Tentative)

12:00 - 1:00 p.m. LUNCH

1:00 p.m. **SUSAN DOKA, E. Gertzen, A. Lewin, J. Midwood, K. Leisti, D. Reddick, S. Larocque and R. Tang**, Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS), Fisheries and Oceans Canada
Assessing fish habitat quality and supply in the nearshore of Lakes and connecting channels

1:15 p.m. **NGAN DIEP,** Ontario Ministry of Environment and Climate Change, **Alice Dove, T. Howell and S. Backus,** Environment and Climate Change Canada
Lake St. Clair – Thames River water quality and harmful algal bloom (HABs) assessmen

1:30 p.m. **LISA RICHMAN,** Ontario Ministry of Environment and Climate Change, **Danielle Milani, Debbie Burniston and Chris Marvin**, Environment and Climate Change Canada

Trends in suspended sediment quality in the St. Clair – Detroit River corridor: assessment of management of contaminated sediments in dynamic riverine environments using sediment traps

1:45 p.m. **EDWARD ROSEMAN, Robin DeBruyne,** Great Lakes Scienc Center, US Geological Survey, **Justin Chiotti, James Boase,** US Fish and Wildlife Service, **Richard Drouin, Ontario,** Ministry of Natural Resources and Forestry, **Roger Knight,** Great Lakes Fishery Commission, **and Michelle Selzer,** Michigan Department of Environmental Quality

The St. Clair – Detroit River System initiative science and monitoring strategy

2:00 p.m. **APRIL WHITE**, Environment and Climate Change Canada **and Melanie Foose**, Michigan Department of Environmental Quality, Office of the Great Lakes

Connecting Channels – St. Clair Detroit Rivers systems and Niagara River

2:15 p.m. **MELANIE FOOSE,** Environment and Climate Change Canada **and Claire Sanders**, Detroit River Canadian Cleanup

Research and monitoring efforts in the Detroit River Area of Concern

2:30 - 3:15 p.m. BREAK

Theme 4: Status of the Lake Erie Food Web

Moderator: Elizabeth Hinchey-Malloy, U.S. Environmental Protection Agency

3:15 p.m. **ROBERT MICHAEL MCKAY**, Bowling Green State University

Life (and death) under ice: Lake Erie's "other" algal bloom

3:30 p.m. **JAMES WATKINS,** Cornell Biological Field Station, **R.P. Barbiero,** CSC, **G.J. Warren, E.K. Hinchey Malloy,** U.S. Environmental Protection Agency, **J.K. Connolly, L.G. Rudstam**, Cornell Biological Field Station

Crustacean zooplankton in Lake Erie, 1997-2014

3:45 p.m. **ALEXANDER KARATAYEV, L. Burlakova, K. Mehler,** Great Lakes Center, Buffalo State College, **S. Bocaniov, P. Collingsworth, G. Warren, R. Kraus, and E. Hinchey**, U.S. Environmental Protection Agency

Biomonitoring using invasive species in a large lake: Dreissena distribution maps hypoxia zones

4:00 p.m. **RICH DROUIN, Andy Cook, Megan Belore, Stephen Marklevitz, Tom MacDougall, Paulette Penton, Karen Soper**, Ontario Ministry of Natural Resources and Forestry
Status of major stocks – Lake Erie and Lake St Clair

Theme 5: Threats
Moderator: Luca Cargnelli, Environment and Climate Change Canada

4:15 p.m. **SHAHRAM TABE,** Ministry of the Environment and Climate Change, **Joanne Parrott,** Environment Canada, **Vince Pileggi, Monica Nowierski, Sonya Kleywegt, and Paul Yang,** Ministry of the Environment and Climate Change
Emerging contaminants in the Detroit River: occurrence, removal, and environmental Impacts

4:30 p.m. **KEN G. DROUILLARD, J. Lafontaine, A. Grgicak-Mannion, J. Demers, K. McPhedran, G.D. Haffner:** University of Windsor
Spatial and temporal patterns of priority contaminants in sediments of the Huron-Erie Corridor

4:45 p.m. **BERNARD CRIMMINS, Hao Zhou, Sadjad Baygi,** Clarkson University, **James Pagano,** State University of New York at Oswego, **Michael Milligan,** State University of New York at Fredonia, **Philip Hopke,** Clarkson University, **Thomas Holsen, Elizabeth Murphy** US EPA, Great Lakes National Program Office
Contemporary bioaccumulation in the Lake Erie: results from the Great Lakes Fish Monitoring and Surveillance Program

5:00 p.m. **Discussion**

5:30 p.m. **Public Keynote Address**
Dr. JEFF M. REUTTER, Ohio Sea Grant & F.T. Stone Laboratory, Ohio State University:
Lake Erie in a Nutshell: What we need to know and why we should care

6:00 p.m. **Evening Social & Poster Viewing**

Thursday, February 23rd

Theme 6: Identifying & Proposing Solutions
Moderator: Russell Kreis, Large Lakes Research Laboratory, US EPA, Grosse Ile

8:30 a.m. **KEVIN CZAJKOWSKI, J. Gottgens**, University of Toledo
Study of the near-shore environment on the south shore of Lake Erie

8:45 a.m. **MARY THORBURN,** Ontario Ministry of the Environment and Climate Change, **Natalie Feisthauer and Pamela Joosse**, Agriculture and Agri-Food Canada
Characterization of Canadian watersheds in the Lake Erie basin

9:00 a.m. **STEVE RUBERG,** NOAA / Great Lakes Environmental Research Laboratory, **Tom Johengen,** Cooperative Institute for Limnology and Ecosystem Research, **Andrea Vander Woude,** Global Science and Technologies, Inc., **Tim Moore,** University of New Hampshire, **Tim Davis,** NOAA / Great Lakes Environmental Research Laboratory, **Danna Palladino, Russ Miller,** Cooperative Institute for Limnology and Ecosystem Research, **Ron Muzzi, Steve Constant, Kyle Beadle,** NOAA / Great Lakes Environmental Research Laboratory
Emerging solutions supporting ecosystem research, monitoring, and forecasting

9:15 a.m. **REBECCA LOGSDON MUENICH, Donald Scavia, Jen Read, Branko Kerkez, Awoke Teshager, Serghei Bocaniov, Yao Hu,** University of Michigan, **Margaret Kalcic,** Ohio State University, **Yu-Chen Wang, Colleen Long, Lynn Vacarro,** University of Michigan
Assessing the sources and management options for Detroit River nutrient loads to Lake Erie

Theme 7: Hypotheses, Research needs and Planning

9:30 a.m. **Jan Ciborowski**, University of Windsor
Charge to the conference: Coordinating Research

9:45 a.m. **Research needs and Planning in Breakout groups (Tentative Topics)**
SCDRS research questions & needs
Nearshore-offshore Intreractions and exchanges - research questions & needs
Understanding toxicity of Harmful Algal Blooms
Delivery of materials to the land-lake interface - assessment & implications
Aquatic invasive species research needs

12:00 p.m. **Chris Marvin**, Environment and Climate Change Canada
Reporting out (Lunch Provided)

12:45 p.m. **Jan Ciborowski**, University of Windsor
Final comments & next steps

1:00 p.m. **Adjourn**

Special workshops:

1:15 - 3:00 p.m.	**New Investigators Workshop** (Please Preregister online)
3:00 - 6:00 p.m.	**Brainstorming Workshop** (Please preregister online)

SESSION ABSTRACTS

Theme 1:
Nutrients & Responses - Assessment of Nutrient/Eutrophication Dynamics in Lake Erie

Water quality and nutrient load monitoring in the Great Lakes – with a focus on Lake Erie

Alice Dove[1], Sean Backus[1], Matt Maccoux[2], Debbie Burniston[1] and Vi Richardson[1]

[1] Water Quality Monitoring and Surveillance Division, Environment Canada
[2] Milwaukee, WI 53222, USA

Phosphorus is the key nutrient limiting the amount of phytoplankton and attached algae in Lake Erie. The primary sources of phosphorus loadings to Lake Erie in the decades leading up to the 1972 Great Lakes Water Quality Agreement included municipal sewage plants and other point sources. Today, external phosphorus loads occur largely as runoff from diffuse land uses such as fertilized farm fields, lawns and impervious surfaces. The recent, possibly accelerating, decline of this lake, manifested as impaired water quality, algal blooms, hypoxia and fish kills, has focused binational attention on the need for actions to reduce external inputs of phosphorus. Accurate, timely and up-to-date in-lake nutrient concentration data and external loading data are needed to inform policy development and management actions to protect the lake. This presentation will give an overview of water quality in Lake Erie relative to the other Great Lakes, the temporal trends of total phosphorus and soluble reactive phosphorus, and spatial distributions of nutrients both within Lake Erie and basin-wide. An overview of Lake Erie nutrient loads is provided, accounting for trends by basin, country, and source type.

NOTES:

Long-term monitoring and assessment of water quality for Lake Erie 1983-2015

Eric Osantowski[1], G.Warren[1]

[1]USEPA/Great Lakes National Program Office, Chicago, IL

In accordance with the Great Lakes Water Quality Agreement, the U.S. EPA Great Lakes National Program Office (GLNPO) has monitored a wide range of water quality parameters within the open waters of the Great Lakes annually since the mid-1980s. GLNPO used nonparametric statistical methods to identify significant trends in water quality across Lake Erie by basins in Spring data from 1983-2015. The observed trends and data across multiple parameters (turbidity, specific conductance, dissolved reactive silica, total phosphorus, total dissolved phosphorus, nitrate and dissolved reactive phosphorus) identified increases in silica, phosphorous and conductance with declining trends in nitrate.

NOTES:

Target loads, strategies to meet them, lessons from the past

Craig Stow

Great Lakes Environmental Research Laboratory, NOAA

The recurrence of nuisance and harmful algal conditions in Lake Erie has prompted the development of new phosphorus targets, superseding the 1978 11,000 metric ton/year load target. When the 1978 target was established it was unclear how the lake would respond; there was little precedent for this kind of management manipulation at such a large scale. However, by the mid-1980s phosphorus inputs had decreased and water quality improvements were apparent. The general outlook was that the eutrophication problem had been solved, and concerns shifted toward other issues such as toxic pollutants. Consequently, there was a lapse in monitoring, annual phosphorus load estimation was only sporadically updated, and the community was caught off-guard when eutrophication symptoms began to reappear in the early 2000s. Moving forward it will be important to formalize an active Adaptive Management process to meet the updated targets and ensure that resultant water quality improvements are maintained. This process is unlikely to be entirely organic in nature, and it must be supported by an administrative framework that provides resources, structure, and continuity. Otherwise, we run the risk of repeating the mistakes of the past.

NOTES:

Sources, transformation, and measurement of dissolved reactive phosphorus in Lake Erie tributaries

Laura Johnson, David Baker, Rem Confesor, Jack Kramer, Ellen Ewing, Barb Merryfield, Aaron Roerdink, and Jake Boehler

National Center for Water Quality Research, Heidelberg University, Tiffin, Ohio.

Over the past decade, Lake Erie has been experiencing a recurrence of harmful algal blooms (HABs) in the western basin and an increase in hypoxia in the central basin. Data from the Maumee, Sandusky, and Raisin rivers collected by the National Center for Water Quality Research at Heidelberg University indicate that the return of western basin HABs corresponds to a 2-fold increase in dissolved reactive phosphorus (DRP) loading from the mid-1990s to today. Hence current recommendations developed as part of Annex 4 of the Great Lakes Water Quality Agreement suggest a 40% reduction in March-July total P and DRP loads will reduce the frequency HABs in western Lake Erie. This is the first time DRP has been explicitly identified in load reduction recommendations for Lake Erie. Traditionally, TP has been the primary form of P analyzed in water in part because of its stability, but also because historically the primary source of P entering the lake was from wastewater effluent where TP is primarily dissolved and bioavailable. Agricultural sources of TP, however, tend to be composed primarily of particulate P (PP), which has a low bioavailability. Thus, measuring only TP in watersheds dominated by nonpoint sources of P can mask changes in the highly bioavailable dissolved portion of TP. Furthermore, there is substantial evidence that a large portion of PP settles out in river mouths and estuaries during runoff events prior to delivery into the western basin, whereas DRP concentrations change little throughout the storm plume. In this presentation, we will discuss reasons to include DRP in monitoring efforts as well as details in how to conduct a monitoring program that has DRP as one of the analytes.

NOTES:

Discerning organic phosphorus signatures in pollutant aources from Lake Erie tributaries

Michael Brooker[1], M. Evert[1], K. Longnecker[2], E. Kujawinski[2], and P. Mouser[1]

[1] Ohio State University, Department of Civil, Environmental, and Geodetic Engineering, Columbus, OH
[2] Woods Hole Oceanographic Institute, Microbial Biogeochemistry, Woods Hole, MA

The severity of harmful algal blooms (HABs) in Lake Erie is dependent upon loading of bioavailable phosphorus from its tributaries. There are many point sources (e.g. wastewater effluent or industrial discharge) and nonpoint sources (e.g. crop or animal agricultural runoff) that may contribute to the phosphorus loads driving HABs. Phosphorus loading has traditionally been monitored through analysis of phosphate, an inorganic form of phosphorus. However, other forms of phosphorus, specifically organophosphorus compounds, may also contribute to loading from pollutant sources. The objective of this research is to investigate signatures of organic phosphorus from point and non-point sources, and examine their use for identifying and tracking pollutant sources in the drainage basin. We first optimized methods for extracting dissolved organic phosphorus from aqueous samples using solid phase extraction and pH manipulation. Next, we applied these extraction and concentration techniques to samples from the Sandusky River and five pollutant sources in the watershed: chicken manure, dairy manure, hog manure, municipal wastewater effluent, and edge-of-field drainage. High-resolution mass spectrometry (FT-ICR MS ESI) was used to identify formula within a 200 to 800 Dalton molecular weight range. Our analysis detected hundreds of organic phosphorus formula across these six sample types. Manure samples contained formula with a lower average molecular weight compared to the other samples. The Sandusky River, edge-of-field drainage, and wastewater effluent samples had the greatest number of shared molecular formula while manures differed considerably from each other and the Sandusky River in their molecular signatures. Continued research will apply statistical techniques to compare source signatures and apply these methods in order to discern sources signatures in additional watershed samples.

NOTES:

Decreasing phosphorus losses with drainage water management practices

Mark R. Williams[1] and Kevin. W. King[2]

[1] USDA-ARS National Soil Erosion Research Lab, West Lafayette, IN
[2] USDA-ARS Soil Drainage Research Unit, Columbus, OH

Managing phosphorus losses from agricultural fields in the western Lake Erie basin (WLEB) is critical for reducing the magnitude and extent of harmful and nuisance algal blooms. Many fields within the WLEB are artificially drained (e.g., subsurface tile drains or surface tile inlets), which increases the hydrologic connectivity between fields and downstream water bodies. As a result, water management practices will be vital to achieving Lake Erie phosphorus loading targets. In the presentation, an overview of phosphorus concentrations and loads in surface runoff and subsurface tile drains from an extensive edge-of-field monitoring network (>40 fields) in Ohio and Indiana, USA, will be discussed within the nutrient reduction framework proposed by Annex 4 of the Great Lakes Water Quality Agreement of 2012. The presentation will also include results from edge-of-field studies examining the effect of water management practices such as drainage water management and blind inlets on phosphorus losses. Findings from this research indicate that drainage water management practices can significantly decrease phosphorus concentrations and loads from agricultural fields in the WLEB.

NOTES:

Modeling the influence of agricultural practices on watershed export of phosphorus

Remegio B. Confesor Jr.[1]

[1] Senior Research Scientist, NCWQR, Heidelberg University, Tiffin, OH.

The United States and Canada, through the 2012 Great Lakes Water Quality Agreement (GLWQA) agreed to reduce Lake Erie phosphorus loading by 40% from the 2008 levels. Field- and watershed-scale models are potential tools to evaluate load reduction strategies to achieve this goal. Models are used to identify critical source areas of nutrients and sediments and can be also employed to evaluate management practices in reducing phosphorus load exports. This presentation will discuss the findings of modeling studies that used the Soil and Water Assessment Tool (SWAT) and the Nutrient Tracking Tool (NTT), a web-based frontend of the Agricultural Policy/Environment eXtender (APEX). Simulation results showed that some agricultural practices can reduce dissolved reactive phosphorus (DRP) but not total phosphorus (TP), while other practices can reduce TP but not DRP. Some suite of practices can reduce both DRP and TP. However, the uncertainties of the SWAT input variables (e.g., fertilizer rate, timing, application method, soil characteristics, and tillage method, etc.) render individual fields unique to each other in the watershed. A management practice may be effective in reducing phosphorus loads in one field but may exacerbate the problem in another, thus, "there is no magic bullet." The use of field-scale modeling (i.e., NTT) is a promising approach to guide the implementation of these best practices.

NOTES:

Ontario greenhouse strategies to address phosphorus in the Great Lakes

Shalin Khosla

Ontario Ministry of Agriculture, Food and Rural Affairs

The Ontario greenhouse sector is a dynamic, fast growing highly technology driven sector of Ontario agriculture. This sector is expanding to meet the consumer demand for fresh, high quality, local produce all 12 months of the year. To achieve this goal most modern greenhouse vegetable operations use a hydroponic/soilless production system where plants are grown in bags of soilless media (rockwool, coco fibre, etc.). A complete nutrient solution, containing all the essential elements, is applied using a computer controlled automated drip system. The excess nutrient solution is collected, disinfected, amended and reapplied to the crop. Overtime, there is a buildup of limiters that need to be addressed. Critical limiters are the buildup of non- essential elements such as Na, Cl, and SO_4.

Over the past 10 years The Ontario Greenhouse Association (TOGA) (representing members of the Ontario Greenhouse Vegetable Growers (OGVG) and Flowers Canada Ontario (FCO)) with the Ministry of Environment and Climate Change (MOECC) and the Ministry of Agriculture Food and Rural Affairs (OMAFRA) have coordinated a multi-facetted approach to work with the greenhouse growers to minimize and eliminate their offsite discharge of Greenhouse Nutrient Feed Water (GNF). This was conducted through education sessions, pilot projects, and regulatory devices and is ongoing.

Some of the key strategies are: 1) install an irrigation and collection system that is efficient in its delivery of the nutrient solution; 2) a collection system that does not leak; 3) limit the buildup of the limiters; 4) implement technologies designed to remove specific elements from the nutrient solution; 5) apply greenhouse nutrient feed (GHF) water to land under the a) Nutrient Management Act or b) Ontario Water Resources Act; 6) release the GNF into the municipal sanitary sewage system or septic system designed to do so.

Research and pilot projects were conducted at various grower operations, research facilities (Agriculture and Agri-Food Canada (AAFC), and various University campuses, such as University of Guelph, University of Western Ontario, University of Waterloo, and University of Windsor). Funding agencies included AAFC, OMAFRA, MOECC, OGVG, FCO, Canadian Greenhouse Conference, and Growing Forward 2.

NOTES:

Assessment of nutrient/eutrophication dynamics in western Lake Erie

Thomas B. Bridgeman[1], Gerald Matisoff[2], Richard Becker[1], Kenneth Gibbons[1], John Bratton[3], Edward Verhamme[3], Sandra Kosek-Sills[4]

[1]University of Toledo Lake Erie Center, Toledo, Ohio
[2]Case Western Reserve University, Cleveland, Ohio
[3]Limnotech, Ann Arbor, Michigan
[4]Ohio Lake Erie Commission, Sandusky, Ohio

In recent years, nutrient loading to the western basin of Lake Erie has been recognized as a pivotal component in the re-occurrence of harmful and nuisance algal blooms (HABs) throughout the lake and hypoxia in the Central Basin. Through a combination of *in situ* experiments, laboratory studies, and modeling, we examined the roles of external and internal nutrient loading, especially as influenced by weather forcing events. Results of bottom chamber deployments and sediment core incubations indicate that under normal summer conditions, western Lake Erie sediments contribute on average 1.4 mg P/m2/day, translating to a mean annual loading that is only 3 - 7% of target (40% reduction) tributary load. Therefore, lake sediments are normally not a large factor in P loading or the resulting harmful algal blooms. However, if western Lake Erie were to experience a basin-wide anoxic event combined with elevated water temperatures, the sediments could release a pulse of DRP that would rival the DRP loads of the Maumee River. SWAT models of the Maumee watershed examining future climate scenarios indicated that mild to moderate climate change will not increase phosphorus loading from the Maumee River watershed. Severe climate warming, however, would increase river discharge and P loads during the late winter and spring - the critical loading period for the development of summer HABs.

NOTES:

Connecting phosphorus loads to cyanobacteria biomass using the Western Lake Erie Ecosystem Model

John F. Bratton[1], Edward M. Verhamme[1], Todd M. Redder[1], Derek A. Schlea[1], Jeremy Grush[1], and Joseph DePinto[1]

[1] LimnoTech, 501 Avis Drive, Ann Arbor, Michigan.

Western Lake Erie has experienced progressively worse eutrophication symptoms, including harmful algal blooms, over the last 20 years. Numerical modeling has been performed to help set target phosphorus objectives for reducing algal blooms in the lake, as required by the U.S.-Canada Great Lakes Water Quality Agreement. The Western Lake Erie Ecosystem Model (WLEEM) was developed and enhanced to assist in this effort. WLEEM is a three-dimensional, fine-scale, process-based model that links hydrodynamic, sediment transport, and in-lake biogeochemical and ecological processes. The model was used to assess system sensitivity to multiple variables, and ultimately to develop a robust relationship between spring phosphorus loading and cyanobacteria biomass response in summer blooms. This was done in order to determine a maximum load of total phosphorus from the Maumee River and other tributaries during the period of March to July that would produce a mild cyanobacteria bloom in Western Lake Erie. The model was subsequently used as part of a Cooperative Science and Monitoring Initiative project to explore other in-lake processes such as phosphorus fluxes from sediment due to diffusion and advection, impacts of dreissenid mussel grazing, and lag time in bloom response to load reductions. Given the natural variability of systems like this, use of tools like WLEEM in an iterative operational modeling mode, and supported by tributary and lake monitoring, will be essential going forward. Science-based adaptive management of mitigation measures using models and monitoring, along with ongoing research to improve process understanding, is likely to accelerate improvements in Lake Erie conditions and those of other nutrient-impacted water bodies where restoration is desired or underway.

NOTES:

Accuracy of data buoys for tracking cyanobacterial blooms in Lake Erie

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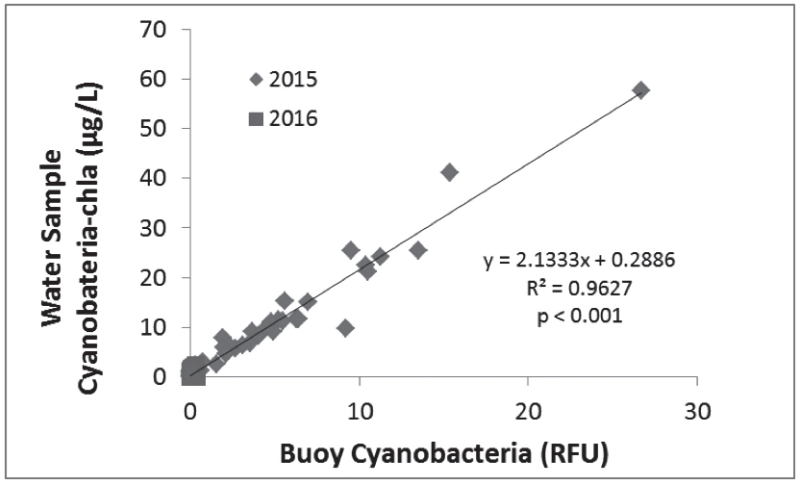
Real-time data buoys have become a valuable tool for lake managers, water treatment plant operators, and the public to monitor cyanobacteria abundance in Lake Erie. However, the buoys utilize sensors that measure total algae and cyanobacteria by fluorescence, which is an indirect proxy for chlorophyll concentration. Furthermore, the sensors on the buoys are located about 0.6 m from the surface, whereas cyanobacteria can regulate buoyancy and may be over or underestimated by the buoy sensors. The objective of this project was to determine how accurate data buoys are at monitoring for cyanobacteria abundance. Surface water samples (0-2 meter, n=147) were collected next to a data buoy located near Gibraltar Island throughout summers 2015 and 2016 and analyzed for total chlorophyll using traditional methods and for cyanobacteria-specific chlorophyll using a FluoroProbe. Additionally, on a subset of dates (n=34) water was collected at every meter throughout the water column to determine vertical position of cyanobacteria. Cyanobacteria-specific chlorophyll concentration measured in surface water samples peaked in late July 2015 at 116 ppb and had a very strong positive linear relationship ($R^2 = 0.96$) with the buoy cyanobacteria-RFU (relative fluorescence units). However, there was a weaker relationship between total chlorophyll from the water sample and the buoy chlorophyll-RFU ($R^2 < 0.50$) and trends were different between the 2 years. The every-meter sampling indicated that cyanobacteria were spread evenly throughout the water column or increased in concentrations towards the surface. Surface cyanobacteria accumulations led to a few inconsistencies between the buoy data and every-meter data that could potentially lead to inaccurate warnings and water treatment procedures.



Cyanobacteria abundance detected by the buoy sensor was proportional to cyanobacteria-chlorophyll *a* concentration collected and measured from a water sample.

NOTES:

Microcystins and the toxicity of hazardous algal blooms

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Harmful cyanobacterial blooms (HABs) have significant socioeconomic and ecological costs, which impact drinking water, fisheries, agriculture, tourism, real estate, water quality, food web resilience and habitats, and contribute to anoxia and fish kills. Many of these costs are well described for the Lake Erie ecosystem, but in fact are largely unmeasured. HABs produce toxins, which cause acute or chronic health effects in mammals (including humans) and other organisms. This paper synthesizes information on HABs occurrence, toxicology and health effects, and relates this to past and current conditions in the Great Lakes. In particular we focus on Lake Erie, where increased reporting of HABs has worsened from the early 1990's. We evaluate available information and case reports of HAB-related illness and death and show that HABs occur throughout the basin, with reports of animal (including human) illness and death. The dominant toxigenic cyanobacterium in Lake Erie is the genus *Microcystis*, which is known to produce microcystins. However cyanobacteria produce a wide range of toxic metabolites (anatoxin-a, paralytic shellfish toxins, cylindrospermopsin, Beta-methyl amino alanine) known or suspected to occur in Lake Erie. The presence of these other cyanotoxins may implicate an important role for other toxigenic cyanobacteria such as *Anabaena* (*Dolichospermum*) and *Lyngbya,* which may in term impact our management, monitoring and control strategies for HABs in the future.

NOTES:

What is the spatial extent of hypoxia in Lake Erie?

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Seasonal hypoxia is a regularly-occurring, natural phenomenon in the bottom waters of the central basin of Lake Erie. However, there is increasing evidence that hypoxic conditions are influenced, at least in part, by tributary loading of nutrients. In order to fully account for such anthropogenic contributions, baseline estimates of the spatial extent and severity of hypoxia are required. Here, we present results from a monitoring program designed to provide a high-resolution estimate of the spatial extent of hypoxia in central Lake Erie. During the summer of 2014, in conjuncture with the Cooperative Science and Monitoring Initiative field year in Lake Erie, we deployed an array of 25 dissolved oxygen loggers over a 7000 km^2 area of the central basin of Lake Erie, with an emphasis on near shore areas. Our results indicate that the hypoxic zone is dynamic, particularly along nearshore areas where rapid intrusions of hypoxic water into near shore areas are common. To estimate the spatial extent of hypoxia, we used a Bayesian kriging algorithm to calculate the total area of the hypoxic zone within the logger network and to determine the level of uncertainty associated with the estimate. We conclude with a discussion about the implications of dynamic hypoxia for Lake Erie's fisheries.

NOTES:

Using the GLATOS network to understand fish behavior and movement at unprecedented spatial scales

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Despite a plethora of fish tagging studies in the Great Lakes basin over the past decades, little is known about fine-scale movements of fish over broad geographic scales. To address this knowledge gap, the Great Lakes Fishery Commission embarked on a multi-year research initiative focusing on understanding fish behavior and movement patterns at resolutions and spatial scales previously unattainable with traditional tagging approaches. Associated with advances in acoustic telemetry technology, the Great Lakes Fishery Commission made a capital investment in the infrastructure (i.e., autonomous data recording receivers, data storage and warehousing) necessary to achieve this research objective using Great Lakes Research Initiative funds administered through the Environmental Protection Agency. Currently, fish behavior and movement studies using acoustic telemetry technology are underway in each of the Laurentian Great Lakes and connecting waterways (e.g., St. Mary's River and St. Clair/ Detroit River System). To date, the majority of studies have focused on understanding fine-scale movements of fish over relatively small spatial-scales (e.g., on a spawning reef) or coarse-scale movements over large spatial-scales (i.e., inter and intra lake). In conjunction with instruments designed to measure environmental conditions (e.g., dissolved oxygen, temperature, and microcystin sensors) within the lake and the vast acoustic receiver network currently maintained by the Great Lakes Acoustic Observation System (GLATOS), researchers can gain a better understanding of how fish respond to changing lake conditions such as harmful algal blooms and hypoxic events. Ultimately, this type of information could be used by fishery resource managers to forecast how native and non-native species fish populations may respond to future habitat conditions.

NOTES:

SESSION ABSTRACTS

Theme 2:
Delineating and understanding the nearshore of Lake Erie & the Connecting Channels

GLWQA pilot application of the Nearshore Framework and Baseline Habitat Survey, Long Point to Fort Erie study area

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Environment and Climate Change Canada are leading a pilot application of the Nearshore Framework and Baseline Survey of Habitat in Lake Erie from Long Point to Fort Erie. The assessment includes three comprehensive steps: 1) delineation and classification of habitat, 2) assessment of condition and functionality, and 3) biological confirmation of the survey. A draft application has been completed for the study area to identify areas of high quality, areas under stress, and the causes of impairment and threats. The Nearshore Framework is also focused on developing tools and approaches to share the findings, assist local entities with interpreting the survey findings, and encouraging collaborative projects to protect and restore the Lake Erie coastal zone. The pilot application is supported by a Bi-national Core Team, Advisory Panel, and focused Sub-groups, which are providing technical guidance and peer review. The presentation will demonstrate the delineation of the regional and nested habitat units in Lake Erie, summarize the condition assessment, and review the use of existing biological data to confirm the survey findings. Tools will also be presented, including dashboard maps of the condition assessment, a searchable online geo-spatial database to archive and disseminate the information used for the assessment, and an online web-mapping application to visualize the data and findings.

NOTES:

Combining monitoring, advanced molecular techniques and near real-time instrumentation to investigate the response of cyanoHABs in Lake Erie and Lake St. Clair to different environmental conditions

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Lake Erie is once again experiencing intense cyanobacterial harmful algal blooms (CHABs) in the western basin. While it is well known that cultural eutrophication is a primary driver of these phenomena, there is fierce debate over the roles of nitrogen (N) and phosphorus (P) in stimulating the growth and toxicity of CHABs. While it has been shown that estimates of bloom size can be made using spring P-loading values from the Maumee River to Lake Erie, to date no such model exists for estimating bloom toxicity. Furthermore, the role of N in stimulating CHAB growth and toxicity in Lake Erie has only recently been gaining attention. Several investigators have addressed this issue but to date no clear consensus exists. This lack of understanding is partially due to the fact that the limnological conditions in western basin Lake Erie are highly variable and blooms may be experiencing both P limitation and N limitation simultaneously, therefore sampling bias may skew conclusions. Furthermore, different organisms are responsible for the CHABs in the open lake versus Lake Erie tributaries. For example, *Microcystis* spp. comprises much of the bloom biomass in the lake proper where as *Planktothrix* spp. comprises a majority of the biomass in Sandusky Bay and the Maumee River. Both genera have strains that are able to produce toxic microcystins, however, N and P can stimulate bloom growth differently throughout the season. I will present the results from long-term remote and discrete monitoring, microcosm experiments and advanced genetic techniques. All of these data indicate that while P is critical for initiating western Lake Erie CHABs, N may be more important for stimulating growth and toxin production in total, hence both N and P must be considered when developing nutrient mitigation strategies.

NOTES:

Cladophora in eastern Lake Erie: a synthesis of findings from the Great Lakes Nutrient Initiative

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Recurrent fouling of the nearshore by the filamentous alga *Cladophora*, has plagued much of the east basin of Lake Erie since the mid-1990s. Sporadic research and monitoring of *Cladophora* have generally concluded that suitable habitat has increased as a consequence of ecosystem changes (more hard substrate, improved water clarity) mediated by dreissenid mussels. Less clear, however, is an understanding of the relative importance of various phosphorus (P) sources in terms of driving growth dynamics. These challenges have prevented the establishment of P load reduction targets for the east basin of Lake Erie as prescribed under the amended Great Lakes Water Quality Agreement of 2012. This presentation will integrate research and monitoring findings relevant to *Cladophora* from Environment and Climate Change Canada's Great Lakes Nutrient Initiative program (2012-2015) in eastern Lake Erie with emphasis on nearshore P dynamics and implications for management of *Cladophora*.

NOTES:

Nature-based shoreline management – a new coastal management paradigm

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Important elements of coastal systems include coastal sand resources, nearshore and coastal habitats, nearshore water quality, and functional ecosystems. Coastal systems provide socio-economic benefits that include the protection of public health and safety, infrastructure, water resources, ecosystem services, commercial and recreational navigation, and tourism. Nature-based shoreline management includes management actions that protect, maintain, and restore natural coastal and ecological processes. In Ohio, Landscape Conservation Design (LCD) principles and concepts are being applied to coastal systems at landscape scales with the objective to maximize social-economic, environmental, and functional benefits derived from coastal conservation projects at multiple scales. What we have learned is that it is critical to link LCD concepts and benefits to coastal management goals and state priorities. From a coastal management perspective, each of these goals will have place-based actions that may result in potential impacts or benefits relative to existing local geographic, physical, biological, and socioeconomic conditions along the coastline. Critical to these analyses is a comprehensive set of high-resolution coastal and nearshore physical, chemical, and biological datasets. By integrating these actions, regional implementation and management strategies can be developed by performing a systematic reach-based analysis of place-based actions (and interactions) that maximize benefits and minimize harmful impacts. A GIS database that incorporates the results of these reach-based analyses is being developed to identify Priority Management Areas (PMAs) that will guide coastal regulatory decision-making, provide design guidance, and direct future investments along the Ohio Lake Erie coastline.

NOTES:

Natural and socio-economic pressures affecting longshore redistribution of sediment and shoreline maintenance in Lake Erie

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There is a paucity of studies describing shoreline change and longshore redistribution of sediments from within the Great Lakes Basin, despite recent evidence to suggest that many sections of the coast (including the south shore of Lake Erie) are severely sediment starved. Based on studies conducted within the Great Lakes Basin, and along the Eastern Seaboard and the Gulf Coast of the United States, this presentation describes the current state of the science in understanding shoreline change. Through examples it is shown how regional variations in the rates of shoreline change is a function of the dominant type and distribution of coastal landform and incident forcing, as well as the relative amount of human development. Development along the shoreline has starved the system of sediment through trapping at jetties and groins, harbor dredging and placement offshore, and bluff armoring. The rate and alongshore variation of shoreline change in Lake Erie in the future will depend on a change in storm characteristics, water level variations, sea-ice coverage and timing, and further changes in shoreline development. It is argued that there is an urgent need for studies to examine how the shoreline of Lake Erie will change in the future, and that studies need to examine the impacts of changes in wave and water level forcing in combination with potential socio-economic pressures that will determine future shoreline development patterns.

NOTES:

Benthic algae and submerged aquatic vegetation (SAV) in western Lake Erie

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Benthic algae and submerged aquatic vegetation (SAV) provide important habitat and food resources for many fish species. However, benthic algae and SAV can also contribute to nuisance shoreline fouling under certain conditions. Anecdotal evidence suggests that current SAV distribution in western Lake Erie is reduced relative to the 1800's, possibly due to a combination of increased water turbidity from river runoff and feeding by common carp. Recent research on benthic algae and SAV has focused on *Lyngbya wollei* fouling and SAV as food for invasive carp. Extensive shoreline fouling by *L. wollei*, c. 2006, led to a series of studies assessing its benthic distribution and growth controls. However, *L. wollei* distribution does not seem to have been consistently tracked since 2010. The discovery of evidence of invasive grass carp spawning in the Sandusky River motivated a broad scale survey of SAV distribution and species composition to both assess the potential food supply for grass carp and to establish a baseline against which to assess grass carp effects on SAV. Key information gaps related to benthic algae and SAV include quantitative temporal trend data, impacts of SAV on the native fish community, and assessments of what factors currently limit the extent of SAV in western Lake Erie. Recent SAV mapping efforts show that a combination of aerial image assessment, sonar transects, and point samples for SAV species composition provides an effective method for determining broad scale SAV distribution while tracking species composition and maintaining invasive species surveillance.

NOTES:

SESSION ABSTRACTS

Theme 3:
Connecting Channels - St. Clair Detroit River System & Niagara River

Water quality monitoring in the St. Clair River-Detroit River corridor

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Long-term (2001-2015) water quality monitoring data for the St. Clair River are combined here with data from studies in the Detroit River in 2014 and 2015 to provide an overview of nutrient concentrations and loadings for the Lake Huron – Lake Erie corridor. This information is much sought after to validate nutrient loading estimates in the corridor. For total phosphorus, the data demonstrate that the total load into the corridor is in the range of 900-1200 MTA and that the total load exiting the mouth of the Detroit River is currently in the range of 2500-3250 MTA and is in excellent agreement with the Maccoux et al. (2016) estimate using a sum-of-sources approach. Concentrations of TP in the St. Clair River have tracked changes in Lake Huron, with additional sources of TP indicated to the River. In the Detroit River, loads were monitored using both high-frequency automated samples and spatially-distributed grab samples to account for both the spatial and temporal variability of nutrient concentrations in the river. The data indicate that both concentrations and loadings of TP have declined since our previous work in 2007 in the Trenton Channel, with possible declines observed in the mid-river and possible increases observed in the Amherstburg Channel.

NOTES:

Trenton Channel of the Detroit River monitoring

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In 2014, the U.S. Geological Survey began a study to develop a better understanding of nutrient concentrations entering Lake Erie through the Detroit River. Objectives of the study include (1) compare nutrient and suspended-sediment concentrations obtained by using integrated and point-sampling methods, and (2) evaluate the distribution of constituent concentrations and velocities in the sampled cross-section on the Detroit River (Trenton Channel only) at Trenton, MI. Over the course of one year, we made monthly measurements of water velocity and streamflow. We also collected monthly water samples using the equal-width incremental sampling technique and a point sample taken from a location near the east bank. Four times over that same year, discrete samples were taken at 24 different locations spanning the horizontal and vertical extent across the channel. As of November 2016, sampling has been completed and all samples have been analyzed. Data compilation and review are still in progress, but preliminary results indicate systematic differences in concentrations from the different sampling methods. Seasonal variations in constituent concentrations and spatial patterns in concentrations and velocities were observed in the sampled cross-section.

NOTES:

EPA's National Coastal Condition Assessment: Pilot Research in Great Lakes Connecting Channels

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The EPA Office of Water's National Aquatic Resources Surveys assess wetlands, lakes, rivers, and coastal areas on 5-year cycles to help satisfy the reporting and anti-degradation provisions of the Clean Water Act. Measuring extant conditions precedes measuring change in conditions. Surveys are challenged to adequately sample extreme conditions occurring in small areas. Extremely bad conditions are targets for remediation. Extremely good conditions are targets for protection. In 2010, the National Coastal Condition Assessment (NCCA) found the majority of the coastal Great Lakes (by area) were in "good" condition for water (60%) and sediment quality (51%) but not biology (benthos, 20% and fish tissue contaminants, <1%). As part of the 2014 Lake Erie CSMI field year, EPA's Great Lakes National Program Office, working with the Office of Research and Development, began pilot research to integrate connecting channels into Great Lakes surveys. Stand-alone assessments of the Huron-Erie corridor (HEC; 2014, 2015) and St Marys River (SMR; 2015, 2016), were sampled using a probabilistic sample design and NCCA sampling protocols.

Water, sediment, and benthic quality data from the 2014 HEC survey (n=57) were compared to 2010 NCCA data from the adjacent Great Lakes. Water quality rated "poor" (as % area) in HEC was intermediate compared to Lake Huron and Erie regardless of which set of lake-specific water quality thresholds were used. However, the amount of area classified as "good" depended on which threshold was used, with 18% of the HEC classified as good using the Lake Huron thresholds, and 73% classified as good using Lake Erie thresholds. The sediment quality index (based on sediment chemistry and sediment toxicity data) was estimated to be 49% good, which was intermediate to the adjacent lakes. Rocky substrates, hard-bottom and swiftly flowing river channels, and shallow sites meant that 6% of the HEC area could not be assessed. While this was less than the 22-25% of Great Lakes nearshore area left unassessed in 2010, sampling success represents an ongoing challenge for connecting channels assessments.

The probabilistic survey design allowed separate estimation of conditions in the Detroit River. The sediment quality index was estimated as 12% good, 63% fair, 7% poor, and 18% missing (n=16). Sediment chemistry, alone, resulted in 31% good, 63% fair, 0% poor, and 6% missing. A comparison between survey results and recent targeted sampling found similar spatial patterns of good sediment quality within the channel and upstream of Detroit. Fair conditions were more common downstream of Detroit. While targeted sampling identified areas of contamination, our system-wide survey assessment shows that these areas represented a small portion of the total system. However, the survey underestimated the extent of poor conditions clearly present in the targeted data. This may improve when 2015 data become available. Both the population-based estimates and site-based spatial patterns were consistent with the river's situation within a highly urbanized region. Overall, the probabilistic design allows us to evaluate the entire Detroit River and HEC system, providing previously unavailable and highly valuable context for managers. Our results also highlight the challenges for national-scale assessments nearshore coastal waters to identify sites in extremely good and extremely poor condition as they generally represent relatively small proportions of the total area. Analysis of 2014-2015 HEC data and 2015-2016 St Marys River data is ongoing and results of the connecting channel assessments will be included in the 2015 National Coastal Condition Assessment reports.

Assessing fish habitat quality and supply in the nearshore of lakes and connecting channels

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Our quantitative fish habitat assessments have typically used a cyclical approach to evaluation. Assessments begin with a baseline compilation of habitat variables from various sources (field points and transects; remote sensing with acoustics or satellite imagery) and gap filling with our own surveys. Layers are created from compiled data by interpolation or modelled from multiple layers. Sometimes habitat classification is used in assessments where categories are useful for binning inputs or outputs. Information from the scientific literature and our own studies on fish-habitat associations and tolerances are compiled for individual or suites of variables. Habitat quality is then assessed using individual or combinations of variables either by modelling. Field-based quality indices and fish community measurements can confirm the inferred habitat quality. All these pieces of information are then used in evaluations to assess habitat status and trends and to inform spatial or temporal habitat management objectives. These can include restoration or creation actions to benefit one or many fish species, longer term management strategies given natural variability and climate trends, and site-specific development activity evaluations. The habitat evaluation process outlined above will be highlighted by examples from Long Point Bay and the St Clair – Detroit River system, especially Walpole Island work with First Nations, to put it into the Lake Erie context.

NOTES:

Lake St. Clair – Thames River water quality and harmful algal bloom (HABs) assessment

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Lake St. Clair is a shallow mesotrophic lake feeding into western Lake Erie via the Detroit River. Recent NOAA satellite imagery of Lake St. Clair indicate cyanobacterial blooms that are not well documented at present. The Thames River is the largest tributary on the Canadian shoreline of the lake and has been identified as a priority tributary in recent objective setting under Annex 4 -Nutrients of the GLWQA underscoring the need to better understand conditions in Lake St. Clair and linkage between discharges from the Thames River to lake conditions. Our project intends to assess water quality and harmful algal blooms (HABs) in eastern Lake St. Clair and at the mouth of the Thames River. Surveys were conducted in 2016 along the shoreline from Chenal Ecarte to the Detroit River using real-time water quality sensors to describe patterns in water quality. Modeling of hydrodynamics of the Lake St. Clair demonstrated the potential for the Thames River plume to be expansive and extend into the Detroit River, notably at the beginning of the ice-free season. Deployed water quality sensors spread over the shoreline detected episodic turbidity peaks indicative of tributary plumes. Spatial mapping of the shoreside (1 – 3 m) and nearshore (> 3m) with field sensors was used to describe the Thames River plume in detail on two occasions. Water chemistry and nutrient conditions in eastern Lake St. Clair were highly variable with inshore-offshore gradients. We will expand our spatial coverage to include the upper Detroit River in 2017 using a higher frequency sampling to capture a broader range of anticipated water quality conditions.

NOTES:

Trends in suspended sediment quality in the St. Clair – Detroit River corridor: assessment of management of contaminated sediments in dynamic riverine environments using sediment traps

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Assessments of suspended sediment quality in the Detroit River – St. Clair River corridor using sediment traps have been ongoing since 1997. Sediment downstream of industrial sources in the Upper St. Clair River was historically contaminated with mercury (Hg), hexachlorobutadiene (HCBD), hexachlorobenzene (HCB) and octachlorostyrene (OCS). Concentrations of contaminants of concern (COCs) in suspended sediment collected from traps in the late 1990s suggested bottom sediment was mobile and a source of contamination to downstream areas. Post remediation concentrations of COCs in bottom sediment and suspended sediment throughout downstream areas were high, relative to concentrations measured at the upstream reference sites; however, data from sediment traps indicated that concentrations of COCs were trending downward since remediation efforts that were completed in 2005. Concentrations of COCs in suspended sediments in the Detroit River also indicate general reductions in concentrations of COCs over the past 20 years.

NOTES:

The St. Clair – Detroit River system initiative science and monitoring strategy

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The St. Clair-Detroit River System Initiative (SCDRSI) is an interdisciplinary initiative that has evolved to serve as a governance structure guiding decision-making and communication through a network of collaborating scientists and stakeholders. To measure progress toward a common agenda of restoring ecosystem integrity, a science and monitoring strategy has been developed based on priority objectives identified by the Initiative. In order to measure progress in achieving priority objectives, physical and biological/response indicators were developed through workshops with the SCDRSI membership, guidance from experts, and linkages with established broader scale environmental objectives. Monitoring programs within the SCDRS have been inventoried and provide the foundation for indicator assessment. In some cases, indicators were identified as important; however some lack a clear monitoring program, and most lack long-term assessment. These knowledge and monitoring gaps will influence the science strategy for future research in the SCDRS. Ongoing monitoring and research projects have been cataloged in an online database informing SCDRS membership. Cooperation and collaboration between partners within the SCDRSI serves to reduce effort duplication and increase monitoring and restoration efficiency on this large Great Lakes connecting channel.

NOTES:

Connecting channels – St. Clair Detroit rivers systems and Niagara River

April White[1] and Melanie Foose[2]

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The St. Clair River was identified as an Area of Concern (AOC) due to a lengthy history of urban and industrial development along its shores leading to habitat loss and elevated levels of contaminants in water, fish, wildlife and sediment. It is a binational AOC with remedial activities implemented by the Canadian and American governments (federal, provincial, state and municipal), industry, First Nations and local communities. Progress towards delisting the St. Clair River as an AOC continues with the re-designation of beneficial use impairments (BUIs) on both sides of the river. Presently, there are four BUIs that remain "impaired" on the American side of the St. Clair River, while six remain in Canada. In addition, Canada has three BUIs designated as "requiring further assessment". To support BUI status assessments and BUI re-resignations/removals, scientific evidence is collected through monitoring programs and scientific studies. This presentation will briefly highlight specific fish and wildlife related studies and monitoring programs that have been instrumental in informing the status of impaired and requires further assessment (RFA) beneficial uses on both sides of the river.

NOTES:

Research and monitoring efforts in the Detroit River Area of Concern

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The Detroit River Area of Concern (AOC) includes the entire 31 miles (51 km) of the river from the mouth of the Lake St. Clair to the north end of Lake Erie. Years of extensive industrial, urban, and agricultural development along the Detroit River resulted in the historical release of harmful legacy pollutants from industry, bacteria from wastewater treatment plants, and nutrients from agricultural runoff. This pervasive development contributed to significantly impaired water quality, contamination of sediment and degradation of benthic communities, body burden impacts to fish and wildlife, and loss of critical habitat. For over 25 years, American and Canadian governmental agencies, municipalities, industries, and community groups have been working steadily to clean up, restore, and revitalize the river. Recent successful remediation undertaken on each side of both rivers can provide insight on required scientific data needed to assess remaining beneficial use impairments (BUIs). Current monitoring programs in the Detroit River include actions to assess the following BUIs: fish tumours or other deformities, bird or animal deformities or reproduction problems, degradation of benthos, degradation of fish and wildlife populations, loss of fish and wildlife habitat, degradation of phytoplankton and zooplankton populations, and restrictions on fish consumption.

NOTES:

SESSION ABSTRACTS

Theme 4:
Status of the Lake Erie Food Web

Life (and death) under ice: Lake Erie's "other" algal bloom

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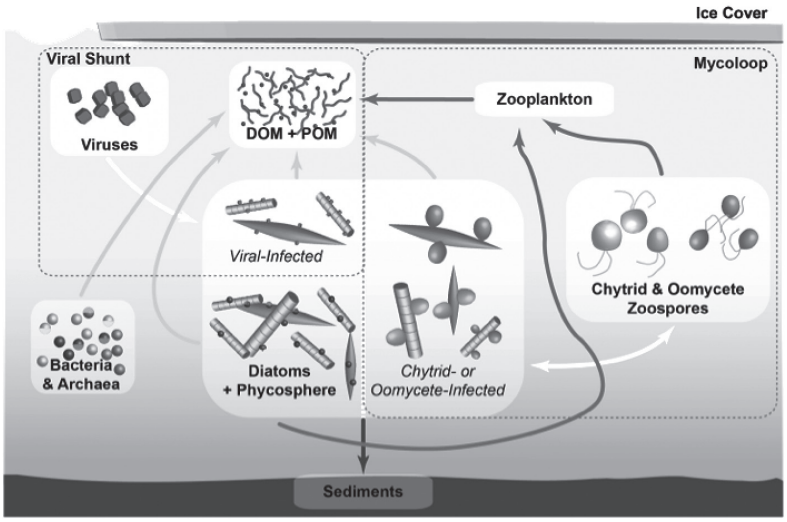
Ice cover presents a logistical obstacle to our understanding of north temperate ecosystems. Reflecting this, ecosystem models frequently underestimate, or even neglect biological parameters associated with ice cover including potentially high rates of primary productivity. Yet current warming trends in global climate are reinforcing the need to focus attention on ice covered environments. Our previous surveys of ice-covered Lake Erie highlight the existence of expansive under-ice blooms of phytoplankton dominated by diatoms. While we are growing more confident in our predictions of factors that will lead to bloom development, identifying factors that lead to bloom decline and the subsequent fate of this biomass remain important questions to address. While nutrient depletion and ice melt are undeniably factors that contribute to the decline of Lake Erie's winter bloom, recent surveys point to novel interactions with microbial pathogens as important to bloom decline. Amongst potential pathogens identified by microscopy and transcriptomic analysis are chytrid fungi and oomycetes, fungal-like protists that are well-known pathogens causing disease in agriculture and aquaculture. Additional insights into novel host-pathogen interactions come from the observation that most virus sequences mined from the metatranscriptome aligned with the dsRNA *Partitiviridae* family whose natural hosts are fungi and plants. Given that chytrids are known pathogens of diatoms, it is tempting to speculate that these viruses may help control chytrid parasites of the ice-associated diatom community. The implications of these preliminary findings are manifold and provide the framework to hypothesize roles for diverse microbial interactions in regulating bloom fate whereby pathogens effectuate a shunt reducing the amount of carbon that is directly exported to the benthos. In doing so, pathogens transform bloom biomass into pools more readily acquired by diverse members of the pelagic food web.



Microbes from all domains of life interact in Lake Erie's winter food web. Recent transcriptome analysis revealed a novel role for eukaryotic parasites (mycoloop) in bloom control and carbon cycling. Viruses may also represent important vectors in carbon cycling either directly by attacking the bloom or indirectly by targeting bloom parasites. (Credit: Dr. Ben Beall).

NOTES:

Crustacean zooplankton in Lake Erie, 1997-2014

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US EPA's Great Lakes National Program Office (GLNPO) samples all five Great Lakes biannually with the R/V Lake Guardian to detect new invasive species and to assess zooplankton abundance and composition. We present GLNPO zooplankton data from spring (April) and summer (August) 153-um metered whole water column tows in the western (6 sites), central (10 sites) and eastern (4 sites) basins of Lake Erie from 1997-2014. In April, zooplankton biomass has been highest in the central basin. The zooplankton community is dominated by cyclopoid copepods in the central and eastern basins and calanoid copepods in the western basin. The calanoids found in the western basin are likely washed down from southern Lake Huron. In August, zooplankton biomass and diversity has been highest in the western basin. *Daphnia* and other cladocerans are an important component of summer biomass. Long-term trends in biomass in all three basins are difficult to discern but community composition has been consistent. In summer 2014 samples, we detected a new nonnative species, the cyclopoid copepod *Thermocyclops crassus*, near the entry of the Detroit River into Lake Erie. This shallow, warm, eutrophic habitat is consistent with *T. crassus* native range and invasion history. Within US/Canada, this Eurasian species had only been previously detected in a eutrophic bay in Lake Champlain, Vermont in 1991. We continued to collect *T. crassus* at low abundances in summer 2015 and 2016 samples in western Lake Erie, with its range expanding eastward throughout the western basin. The species' potential impact on the ecosystem is uncertain as we continue to monitor its population.

NOTES:

Biomonitoring using invasive species in a large lake: *Dreissena* distribution maps hypoxia zones

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In the Laurentian Great Lakes the most severe hypoxia routinely develops in the central basin of Lake Erie causing strong negative ecological impacts. We measured bottom dissolved oxygen using 19 high frequency data loggers distributed throughout the central basin to validate a three-dimensional hydrodynamic-ecological model simulating dissolved oxygen distribution, and compared predicted values with the distribution of *Dreissena*. We found that a deep, offshore hypoxic zone was formed by early August, and expanded into nearshore waters by late September, restricting *Dreissena* population to shallow areas of the central basin. Deeper than 20 m, where bottom hypoxia routinely develops, only young of the year mussels were found in small numbers, indicating restricted recruitment and survival of young *Dreissena*. Monitoring *Dreissena* occurrence and length-frequency distribution can be an effective tool for mapping the extent and frequency of hypoxia in freshwater. In addition, our results suggest that an anticipated decrease in the spatial extent of hypoxia resulting from nutrient management has the potential to increase the spatial extent of profundal habitat in the central basin available for *Dreissena* expansion.

NOTES:

Status of major stocks – Lake Erie and Lake St Clair

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The Lake Erie Management Unit (LEMU) of the Ministry of Natural Resources and Forestry (MNRF) provides leadership and direction on sustainable resource management for Lake Erie, by maintaining and, where possible enhancing the social, economic, cultural and environmental benefits of the lake's rich aquatic resources. The LEMU works to achieve this through its annual fisheries assessment programs, Port Observer program and management activities on the Canadian waters of Lake Erie, Lake St. Clair and connecting waters.

The Province of Ontario and four U.S. States share the responsibility for managing Lake Erie's fishery resource. Since fish populations do not recognize borders, international cooperation is essential to the sustainable management of Lake Erie's fisheries. This cooperation is achieved via the Lake Erie Committee (LEC), which is comprised of representatives from state and provincial fisheries management agencies under the auspices of the Great Lakes Fishery Commission (GLFC). The unit also consults with resource management partners, namely Ontario sport and commercial fish interests on Lake Erie and Lake St. Clair. The principal venue for this consultation process is the Fisheries Management Zone 19 Council and the Lake Erie Percid Management Advisory Group (LEPMAG).

The purpose of the LEMU Status of Stocks report is to summarize and present Ontario's assessment and fishery data for Lake Erie and Lake St. Clair. This data is incorporated with similar information from the U.S. jurisdictions and analyses are performed by various task groups to determine population status, and recommended harvest levels that are consistent with LEC objectives.

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SESSION ABSTRACTS

Theme 5:
Threats

Emerging contaminants in the Detroit River: occurrence, removal, and environmental impacts

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The occurrence, removal efficiency, and environmental impacts of 220 compounds discharging from two wastewater treatment plants (WWTPs) in Windsor, Ontario, into the Detroit River were studied. The target substances covered both emerging and legacy compounds. This presentation is focused on 47 pharmaceutically active compounds (PhACs) and endocrine disrupting compounds (EDCs). The occurrence was studied at the influent, different stages of treatment and the discharge of the WWTPs. The removal efficiencies of the existing treatment processes in removing the target substances were examined. Finally, the environmental impacts of these substances were studied in the laboratory using actual treated wastewater.

It was concluded that three of the target substances, acetaminophen, ibuprofen, and naproxen, together contributed 89-96% of the total concentration of PhACs/EDCs in the influents of the two WWTPs. The existing treatment processes removed the target compounds at 95-98% efficiency. This was due to the high removal rate of the three most occurring PhACs.

The environmental impacts of the target compounds were assessed through a number of tests including in vitro cell-based screening assays, as well as acute, chronic and full-life cycle in vivo exposures. The results were not indicative of any significant toxicity. However, enhanced algal growth was observed in a test. Also, liver-somatic index changes were reported in full-lifecycle test of exposed fathead minnow. Furthermore, production of viable fry decreased. Neither alteration is thought biologically significant. It was concluded that because the discharged effluent from the WWTP dilutes significantly after mixing with the river water, the level of risk to aquatic receptors and the environment is probably negligible.

NOTES:

Spatial and temporal patterns of priority contaminants in sediments of the Huron-Erie Corridor

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Contaminated sediments are linked to several beneficial use impairments in the St. Clair and Detroit River Area's of Concern (AOCs). Surveys of sediment contamination using a stratified random sampling design were completed in 1999-2004 and in 2013-2014 enabling contrasts of changes in sediment quality with time and identification of localized zones of high and low contamination. This presentation will provide an overview of contaminant mass balance, regional assessment of sediment improvement and local zones of contamination for priority metals and organic pollutants. At the corridor scale, PAH contamination is largely associated with the U.S. nearshore waters of Detroit River. PCB contamination is highly restricted within the upper zone of the St. Clair River and U.S. nearshore Detroit River. Mercury exhibits more extensive contamination relative to sediment quality guidelines in the corridor, although localized zones of high contamination exhibit restricted distribution at the corridor scale within the St. Clair River, Lake St. Clair and Detroit River. Additional evidence on stable isotopes of mercury demonstrate that mercury sources to Detroit River sediments differ between U.S. versus Canadian waters. Sediment inventories of priority contaminants have remained stable within the corridor over the past decade.

NOTES:

Contemporary bioaccumulation in the Lake Erie: results from the Great Lakes Fish Monitoring and Surveillance Program

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The Great Lakes Fish Monitoring and Surveillance Program has measured contaminant concentrations in the Great Lakes for decades. Since the early 70s the program has provided polychlorinated biphenyl (PCB) and organochlorine pesticide (OCP) concentrations in top predator fish to help managers understand the impact of anthropogenic chemicals in each of the Great Lakes. Lake trout and walleye (Lake Erie only) are collected yearly, alternating between near shore and offshore sites to capture the effect of habitat on contaminant exposure and bioaccumulation. Historically, the program consisted of ecosystem and human health components using whole fish and fillets, respectively. In 2010, the program's name was changed to the Great Lakes Fish Monitoring and Surveillance Program and the directives shifted away from fillet monitoring creating the opportunity for emerging chemical exploration and bioaccumulation assessment components. In collaboration with the Coordinated Science Monitoring Initiative supported by NOAA, the program directed resources to understand the impact of recent food web perturbations and the effect of these changes on contaminant distributions. Beginning in 2011, Lakes Superior, Huron, Ontario, Erie and Michigan were sampled (1/year) intensively concurrent with the CSMI schedule. With the support of state and federal partners (EPA, DEC, NOAA) biological samples were acquired for contaminant analyses. These included fish (forage and top predator), plankton (pico-, phyto-, and zooplankton), and benthic invertebrates (oligochaete and diporeia). In 2014, Lake Erie was selected and GLFMSP sites from the western and eastern basin (Middle Bass Island and Dunkirk, respectively) were sampled. Stable isotopes of N and C, fatty acids and Hg were determined for walleye, trout, forage fish, benthic invertebrates and plankton to develop a contemporary energy flow assessment of bioaccumulation in Lake Erie. Distinct energy flow differences were observed using stable isotopes between the two basins. Results appear to illustrate the effects of nutrient loadings and the incorporation of round goby in top predator diets. Basin differences will be discussed in terms of temporal and spatial contaminant concentrations and trophic markers.

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SESSION ABSTRACTS

Theme 6:
Identifying & Proposing Solutions

Study of the near-shore environment on the south shore of Lake Erie

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The near shore environment of Lake Erie has undergone many changes in the past such that most has been affected by humans. The near shore environment contributes to habitat, spawning areas, and erosion control. This talk will address research being conducted on the US side of Lake Erie. Significant changes to the Lake Erie shoreline have occurred through commercial, industrial and residential development. Along with physical development, research studies have been conducted addressing the growing harmful algal bloom (HAB) problem. A group of citizen scientist pilots have started a program flying over Lake Erie and the near shore during HAB season. They are mapping the HAB as well as looking at the shoreline and potential contributions to nutrient runoff. A study conducted in a near shore wetland of Lake Erie by the University of Toledo used a flux tower to monitor energy, water, carbon dioxide and methane fluxes. The project found that the wetland was a significant source of methane and carbon to the atmosphere having a larger flux than other wetlands that have been studied. Lastly, work is being conducted on area farms to study the balance of nutrients on agricultural fields. Remote sensing is being used to map management and best management practices on farm fields including tile drains, cover crops, tillage practice and buffer strips. Work by Kevin King of the USDA is looking at how management practices and nutrient runoff are related.

NOTES:

Characterization of Canadian watersheds in the Lake Erie basin

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An important basis for the development of actions under the Canada-Ontario plan for phosphorus reduction in Lake Erie is a good understanding of the type and location of land use and land activities within the basin. This is because the type of land use and/or land activity within an area, in combination with the susceptibility of the landscape to soil erosion or surface water runoff, can suggest different sources and pathways of phosphorus loss within that area. If all areas within the basin are characterized by the same method, then the inferred sources and pathways of phosphorus loss within the Lake Erie basin can be compared.

With this in mind, a multi-agency federal and provincial Science Subcommittee under the COA Nutrients Annex characterized watersheds within the Lake Erie basin according to the basin-wide distribution of distinguishing land use/activities. Watersheds within the Lake Erie basin were characterized by the following land use/ activity categories: urban, agricultural-crop, agricultural-livestock, natural heritage, or uncategorized. The distribution among watersheds of landscape characteristics that could render a watershed more vulnerable to phosphorus loss was also identified and included the risk of soil erosion and the risk of surface runoff. The distribution of water phosphorus concentrations among watersheds was also identified.

We would like to recognize the input of all COA Nutrient Annex science subcommittee members.

NOTES:

Emerging solutions supporting ecosystem research, monitoring, and forecasting

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New observational technologies are providing valuable insight into the optically complex waters of Lake Erie enabling NOAA and partners to develop decision support products benefitting researchers and regional managers in US and Canadian waters. Lake radiance data collection at a fixed location in western Lake Erie under the Aerosol Robotic Network's Ocean Color (AERONET-OC) program will continue during the 2017 field season. This is the first photometer data collection site to be deployed in the Great Lakes under this international effort providing validation of satellite-derived measurements of ocean color. Observations of the distribution of phytoplankton during cyanobacteria blooms using an autonomous vertical profiler in variable wave conditions will be used to improve forecast models. A network of real-time buoys deployed to provide high-resolution time-series observations of phosphorus, nitrate, and optical properties is contributing to an improved understanding of the role of episodic events in harmful algal bloom (HAB) formation. Airborne hyperspectral imagery (HSI) is being used to detect and map HABs under clouds and near shore where satellite observations are ineffective. Research is currently underway to use airborne HSI to identify and map a wide range of phytoplankton functional types.

NOTES:

Assessing the sources and management options for Detroit River nutrient loads to Lake Erie

Rebecca Logsdon Muenich[1], Donald Scavia[1], Jen Read[1], Branko Kerkez[2], Awoke Teshager[1], Serghei Bocaniov[1], Yao Hu[1], Margaret Kalcic[3], Yu-Chen Wang[1], Colleen Long[1], Lynn Vacarro[1]

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In an effort to reduce harmful algal blooms and hypoxia in Lake Erie, the United States and Canada have recently updated total phosphorus load reduction targets set in the Great Lakes Water Quality Agreement. These new targets call for a 40% reduction in loads from all Lake Erie tributaries from their 2008 levels. To best achieve these goals, states and provinces will be developing domestic action plans to address the major sources of phosphorus in the watersheds entering Lake Erie. The Saint Clair-Detroit River System (SCDRS) contributes ~35% of the total phosphorus loads to the Western Basin of Lake Erie and 21% to the Central Basin. Evaluating the major sources of nutrients in SCDRS is complicated given the watershed crosses the U.S. and Canada, has both large urban (20%) and agricultural (50%) areas, and is transected in the middle by a large, shallow water body - Lake St. Clair. The goal of this project is to assess the major sources of phosphorus in the SCDRS watershed by developing watershed, urban, and in-lake models. Once major sources have been identified, the project team will run multiple scenarios informed by our advisory group to help identify pathways to achieve the load reduction targets.

NOTES:

POSTER SESSION ABSTRACTS

Distribution and abundance of *Hexagenia* mayfly larvae and Dreissenid mussels in Lake Erie during the summer 2013

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As part of the Lake Erie Intensive Year collaborative program, we participated in lakeside surveys to document zoobenthic distribution and abundance throughout the lake. A total of 17 sites were sampled using Ponar grabs or diver-assisted airlift samplers between 27 May 2013 and 19 June 2013 from either the CCCS *Limnos* (open waters) or from small boats (nearshore samples). Samples were field-rinsed in a 250-um mesh sieve bucket and then preserved in buffered formal-ethanol solution. Benthos were identified and enumerated in the lab.

Hexagenia mayfly larvae were found predominantly in the Western Basin, as were both *Dreissena bugensis* and *Dreissena polymorpha*. The muddy substrate of Lake Erie's western basin is conducive for *Hexagenia* mayfly larvae burrows. *Hexagenia* larvae (primarily *Hexagenia limbata*) were collected at 5 of 17 sites sampled in the western basin. The pattern of distribution is similar to their distribution in 2010. In the western basin, the dreissenid community was made up of approximately 19% *D. polymorpha* and 81% *D. bugensis*. These are similar to the relative proportions observed in 2010. The eastern and central basins were dominated by *D. bugensis* as has been observed in previous surveys.

NOTES:

Western Lake Erie phytoplankton community composition: factors influencing HAB species dominance and inter-bay comparison

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Cyanobacteria blooms, some producing the liver toxin microcystin, have become an annual occurrence in several areas of the Laurentian Great Lakes. Significant research has been conducted exploring controls on bloom size and intensity. However, many questions remain about bloom species composition and potential for toxin production. We tracked phytoplankton composition across a nutrient gradient in three bays: the western basin of Lake Erie; Saginaw Bay, Lake Huron; and Grand Traverse Bay, Lake Michigan. Taxonomic trends were tracked from June through October. Cell count, nutrient, and physical conditions were compared for patterns within bays across physical and resource availability gradients and patterns were contrasted across bays. Considerable among year variation in phytoplankton species dominance was observed at study sites in Lake Erie along with biomass and community composition shifts across the within lake nutrient gradient. Among bays, phytoplankton biovolume generally followed trends in nutrient concentration, however, shifts in community composition and discontinuities in this relationship suggest the potential for rapid system change if nutrients increase or decrease.

NOTES:

Olfactory responses to novel putative pheromone components in the sea lamprey (*Petromyzon marinus*)

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To effectively manage the invasive sea lamprey populations of the Laurentian Great Lakes, abatement strategies utilizing pheromones to disrupt migration and reproduction of sea lampreys while leaving other organisms unaffected are under investigation. The effectiveness of these methods lies in the knowledge of how potent these pheromones are at eliciting predictable behavioural responses in lampreys. While several putative male sex pheromone and larval migratory pheromone components have been elucidated in the past few years, the relative effectiveness of these biologically relevant molecules at stimulating the neural circuitry responsible for locomotion has yet to be determined. As such, this work aims to assess the potency of these putative pheromone components for eliciting and maintaining neural activity in peripheral and central components of the olfactory system and thereby inform the implementation of newly elucidated putative pheromone components for sea lamprey population management strategies.

FUNDING ACKNOWLEDGMENTS: Great Lakes Fishery Commission, NSERC

NOTES:

Potential factors regulating primary production in the western basin of Lake Erie, examined using temporal comparisons and generalized linear models

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Eutrophication in freshwater resources is a critical threat to both human and ecosystem health. In response to eutrophication in Lake Erie in the 1960s, target total phosphorus (TP) loadings of 11 000 metric tonnes per annum were met by the mid-1980s, corresponding with a decrease in chlorophyll *a* (chl *a*) and phytoplankton biomass concentrations. However, primary production has not been consistently measured over the same period. Since the mid-1990s, cyanobacterial blooms have reappeared in the western basin of Lake Erie, leading to further questions regarding the drivers of these blooms. In the summer of 2014 and 2015, primary production, chl *a*, and phytoplankton biomass, along with other potential regulating factors including [TP], were measured at a nearshore and offshore site in the western basin of Lake Erie. When compared to historical studies, the carbon assimilation ratio (primary production: chl *a*) from June- September increased significantly from 2.51 mg C/ mg chl *a*/ h in 1970 to 8.41 mg C/ mg chl *a*/ h in 2015, due to a greater decrease in chl *a* compared to primary production. Similarly, chl *a*: biomass decreased significantly from 5.5 mg/g in 1970 to 2.5 mg/g in 2015, due to a greater decrease in chl *a* compared to biomass. These changes occurred alongside a significant decrease in [TP]. Generalized linear models (GLMs) found that while depth, water temperature and chl *a* were always included as regulating factors of primary production in 2014 and 2015, [TP] was never included. This suggests that other factors besides TP must be considered as potential regulators of primary production in the western basin of Lake Erie.

NOTES:

Behavioural and chemical studies of reproductive male round goby (*Neogobius melanostomus*) pheromones

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The round gobies are an invasive teleost fish in the Great Lakes. Populations are now extensive. We have investigated pheromone communication in this species by identifying released steroids and investigating round goby responses to synthetic analogues. Fractionation of reproductive male conditioned water and urine, analysis by ELISA and mass spectrometry showed that reproductive males released levels of 11-O-ETIO-3-S that were likely to be detected by the round goby olfactory system. Behavioural tests have examined female preference for these compounds by placing female round gobies in the middle of a four-way maze that received either of these steroids released by reproductive males: 1) 3α-hydroxy-5β-androstane-11,17-dione-3-sulfate (11-O-ETIO-3-S), previously shown to be synthesized by the testes, present in the urine of males and detected at very low concentrations by the olfactory epithelium of this species; or 2) 3α-hydroxy-5β-androstane-11,17-dione (11-O-ETIO), the non-sulfated version of the same steroid, which has also previously been shown to be made and released into the water by males (in this case via the gills rather than the urinary bladder) and detected by the olfactory epithelium; or 3) 3α,17β-hydroxy-5β-androstan-11-one-3-sulfate (17-S), a steroid also previously shown to be present in male urine, but not detected by the olfactory epithelium or 4) solvent only. Reproductive females showed a significant attraction to 11-O-ETIO-S and non-reproductive females showed a significant attraction to 11-O-ETIO. No females (of either stage) showed an attraction to 17-S. We suggest that individual compounds released by reproductive males have unique roles with regards to attraction and courtship during reproductive behaviour. Individual compounds could therefore be targeted for specific and purposeful management strategies.

NOTES:

Tolerance of the lamprey olfactory system to copper roadway runoff waters to the Great Lakes

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In fishes, olfaction mediates a variety of behaviours necessary for survival and reproduction. Environmental contaminants, specifically copper, are able to disrupt a broad range of olfaction-mediated behaviour, and can cause long-lasting damage due to physiological and genetic changes at low concentrations. To investigate effects of copper on olfaction, the sea lamprey (*Petromyzon marinus*), an invasive fish species in the Laurentian Great Lakes, was exposed to environmentally relevant copper concentrations of 0, 5, 10 and 30 µg Cu-L. Three techniques were used to measure the effects of exposure of contamination: (i) immunohistochemical analysis of olfactory epithelium, (ii) local field potential recordings in odor-evoked responses, and (iii) gene transcription response to copper toxicity. Impairment in olfactory epithelium was demonstrated through loss of dendritic extension of olfactory sensory neurons, as well as a dose-dependent reduction in olfactory response to male sex pheromone odors. Differentially expressed genes were identified following exposure in each concentration. Low levels of copper measured in urban waterways were found to impair olfactory senses of the sea lamprey.

NOTES:

Composition of dissolved organic phosphorus and carbon from tributary headwaters to Lake Erie's central basin

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Dissolved organic matter (DOM) can play a number of roles in lake ecosystems, from limiting light penetration to acting as a carbon source. DOM can also be a source of other nutrients including phosphorus (P). Dissolved organic phosphorus (DOP) is a potentially bioavailable form of P that is poorly understood, however DOP may become increasingly significant with changing climate and practices such as no-till agriculture and tile drainage. DOM and DOP can both come from allochthonous sources and be produced or transformed in aquatic ecosystems. Our work attempts to address our lack of knowledge of DOP in Lake Erie and its tributaries, with a focus on how DOM and DOP quantity and composition change along the continuum from tributary headwaters to offshore Lake Erie. We characterized lake and tributary DOM using absorbance and fluorescence spectroscopy and measured two forms of DOP representing internal and external sources. We observed a rapid decrease in dissolved organic carbon and a change in DOM quality at the tributary mouth and nearshore with a shift towards more degraded and recently-derived DOM in the lake. We also found that tributary DOM had a more terrestrial character during high flow periods. While most forms of P (including the terrestrial form of DOP) also decreased at the river mouth, the microbial form of DOP remained more stable across the river-to-lake continuum. Unlike DOM, neither form of DOP correlated significantly with tributary discharge. Overall, trends in P and DOP are less clear than those of DOM, suggesting more complex and dynamic transformations from tributary to Lake Erie.

NOTES:

Fish community food web structure across a production gradient in Lake Erie

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Lake Erie resource management goals include sustaining populations of economically valuable cool-water species such as percids, in part, via regulation of nutrients to achieve mesotrophic conditions. Via indirect effects on habitat, climate-driven increases in water temperature over the past half-century may impede efforts to achieve this goal. To provide insights on potential future trophic status, we investigated distribution, diet, prey availability, and stable isotopes for fish communities from mesotrophic and oligotrophic sub-basins of Lake Erie during 2011 to 2013. In general, spatial variation was greater than temporal variation, with trends of lower fish, zooplankton, and macroinvertebrate density in the oligotrophic eastern sub-basin. Though seasonal distributions were affected by hypoxic episodes in the mesotrophic central basin, fish diets within the same guild were similar between sub-basins. Stable isotope indicators reinforced the diet results and revealed that the largest contributions to fish biomass were often benthic and terrestrial sources of primary production. In both sub-basins, non-native Rainbow Smelt and Yellow Perch exhibited a disproportionately high abundance relative to their intermediate trophic level, highlighting the hypothesis that they may exert middle-out control of the fishery food web in central and eastern Lake Erie. Our findings have implications throughout the Great Lakes where various sub-basins are impacted by cultural eutrophication.

NOTES:

Variation in net ecosystem productivity and component measures along a distance gradient in a Great Lakes coastal wet meadow zone

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Great Lakes coastal wetlands provide essential ecosystem services such as nutrient retention, water purification and function as a nursery for fishes and other aquatic biota. The wet meadow zones of wetlands are characterized by shallow water and anoxic soil, which determine the resident flora and fauna. Ecosystem metabolism plays an important role in determining community composition and serves as a metric for understanding stressors. Open-water sondes were used to estimate variation in net ecosystem productivity (NEP; estimated from diel periodicity of dissolved oxygen concentrations and temperature) at water depths of 10-50 cm along a distance gradient. *In situ* chambers (n=5) were placed at 10-m intervals along each of 4 transects to determine phytoplankton and benthic contributions to NEP, and to determine turnover of autotrophic structure. Along each transect, whole-zone metabolism became greater with increasing distance from shore. Benthic metabolism tended to exceed that of planktonic sources; however, planktonic production was more often a larger contributor to wet meadow NEP, whereas benthic production was largely offset by respiration. Planktonic primary production tended to increase with distance from shore, whereas benthic primary production tended to decrease, suggesting that as distance from shore increased, autotrophic production changed from benthic dominance to planktonic. However, little of the NEP was explained by these two component measures. Instead, macrophytes accounted for much of the production. Additionally, physical factors, such as horizontal and wind-driven advection, contributed substantial variation to NEP estimates.

NOTES:

Effects of invasive *Phragmites australis* on wetland avian communities

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Located on the North shore of Lake Erie, Long Point, ON provides habitat to thousands of breeding and migrating birds, including marsh-nesting species in decline throughout the Great Lakes. However, on-going invasion by *Phragmites australis* threatens the ecological integrity of these marshes. *Phragmites australis* invasion can reduce floral diversity, limit the amount of light that reaches the marsh substrate, fill in open-water pools and reduce interspersion which may impact the quality of marsh habitat for birds. We evaluate bird occupancy in these wetlands, comparing bird diversity and abundance in *P. australis* with bird diversity and abundance in the vegetation communities that P. australis is displacing: cattail marsh, meadow marsh, and open-water marsh. We also examine community composition and functional traits to better capture the effects of *P. australis* invasion. In 2015, total bird abundance was lower in *P. australis* than cattail marsh, with little difference in bird species richness among vegetation types. However, bird community composition was distinct among the vegetation types, and *P. australis* supported a subset of bird species found within cattail and meadow marsh habitat, rather than novel species. *Phragmites australis* habitat supports birds with traits such as shrub-nesting or ground or foliage gleaners, but excludes many marsh-nesting birds. Marsh-nesters of conservation concern are restricted to remaining cattail, meadow marsh, and open-water habitat. While *P. australis* habitat supports an adequate number of birds, with continued expansion the bird community in marshes may become impoverished. Further, community composition and functional traits should be considered when evaluating the effects of biological invasions.

NOTES:

Operational Lake Erie hypoxia forecasting for public water systems decision support

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Episodes of low dissolved oxygen are common during the summer in the bottom water of the central basin of Lake Erie, a source of drinking water for millions of people. Lake dynamics, including seiche, internal waves, and wind-induced upwelling-downwelling, can cause changing water quality at public water system intakes over a period of a few hours. In order to maintain the quality of treated water, treatment processes may need to be adjusted in response to changes in temperature, dissolved oxygen (DO), pH, organic matter, iron, or manganese at the inlet. We are beginning a 5-year project to develop a hypoxia forecast model that can provide a real-time nowcast and five-day forecast of temperature and dissolved oxygen for public water systems on Lake Erie in order to provide plant managers with advance notice of events that are likely to produce changing water quality at their inlets. Underwater sensor deployments will support model development by monitoring oxygen conditions, and will provide an unprecedented view of the complex lake dynamics that control the development and movement of hypoxic lake bottom water.

NOTES:

A study of solitary chemosensory cells in the sea lamprey, *Petromyzon marinus* during upstream migration and spawning

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The lamprey is an invasive species in the Great Lakes with a phasic lifecycle. They possess a diffuse chemosensory system composed of microvillous solitary chemosensory cells (SCCs) located on papillae along the gill pore, oral disc and tail. The function of the chemosensory system is unknown in lamprey. The objectives of this study were to assess the abundance of gill pore SCCs throughout the phasic life cycle, and to characterize biochemical properties and innervation patterns. Scanning electron microscopy was utilized to identify and quantify SCCs on the surface of gill papillae. The highest SCC density was observed during the later stages of the life cycle, when lampreys are migrating upstream, selecting nesting sites and spawning compared to earlier stages where SCC abundance was lower and feeding behaviours are occurring. Immunohistochemistry experiments revealed prominent calretinin and serotonin labeling which shows homology to previously identified taste cells and to SCCs in other vertebrates. Labeling for phospholipase C (also seen in mammalian SCCs) suggests that chemosensory signal transduction occurs by a conserved IP3 mediated cascade. All papillae examined were highly innervated shown by acetylated tubulin fibers approaching the base of the SCCs, which is also similar in arrangement to the taste system. This study suggests that SCC function is important during the end of the sea lamprey life cycle and shows homology between lamprey SCCs and more derived vertebrates. Future work could identify the pathway of SCCs transduction and its link to end of life behaviours. This could be exploited for sea lamprey population management.

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NOTES:

Making the connection: understanding sources and transformations of nutrients in agricultural landscapes from headwaters to the Great Lakes

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The lower Great Lakes are experiencing a resurgence of nuisance and harmful algal blooms. While the causes of the current issues are not fully established, it is likely that changes to the timing and types of nutrients from a variety of sources and inputs delivered to the Lakes are important. This work reports on three new initiatives to understand how the interplay of land management, climate, and physiography influences nutrient export across Southern Ontario's agricultural landscape. In the absence of direct input from agricultural producers, scientists and policy makers have to make assumptions about land management when conducting regional scale assessments. A study has begun to collect agricultural land management information in eleven 'sentinel' agricultural watersheds across Southern Ontario through producer interviews. A regional-scale mathematical model is being developed to evaluate the relationship between agricultural land management, physiography, and watershed nutrient loading from agricultural watersheds throughout Southern Ontario. The model will explicitly incorporate information from headwater sentinel watersheds across the Province to improve regional assessments. A 3-year research project to improve our understanding of phosphorus forms, transformations and removal mechanisms along the Thames River valley has also begun. The Thames River constitutes the single largest input of phosphorus to the Western Basin of Lake Erie from Canada. A primary goal of the project is to identify potential opportunities for phosphorus removal or storage that can be implemented in addition to source area management to reduce nutrient losses. Together, these initiatives will synthesize a regional scale understanding of the connection of agricultural headwaters to the Great Lakes.

NOTES:

Reducing phosphorus loss from agricultural lands to lakes: progresses and perspectives

Tiequan Zhang and C.S. Tan

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Agricultural lands have been deemed the primary non-point source of phosphorus (P) pollution causing the increased severity in toxic and nuisance algal blooms in the Great Lakes, particularly the Lake Erie, over the past two decades. Pathways of P loss include surface runoff and erosion and subsurface tile drainage, both of which are ultimately driven by management practices, although they are a function of soil source (e.g. soil P status) and transport (e.g. hydrological conductivity) factors. Efforts have been made to develop beneficial management practices (BMP) to mitigate soil P loss, while sustaining crop productivity, including P-based manure addition, crop rotation, buffer strip, wetland system, conservation tillage, cover crop, and use of soil legacy P. For instance, use of legacy P in high-P soils can reduce P loss by 36%, while identical crop yields are produced, relative to P addition. However, benefits of the BMPs are often found process-specific, or temporally and/or spatially limited. Such as, conventional tillage may increase dissolved P and subsurface total P loss, while it reduces particular P loss through surface processes. This presentation will review both advantages and drawbacks of the key BMPs that are currently available, with the implication for water quality impacts and future research needs discussed.

NOTES:

The Lake Erie Millennium Network – Member Organizations

The Lake Erie Millennium Network is a series of events dealing with Lake Erie environmental issues. The objectives are threefold:

- to summarize the status of Lake Erie;
- to collectively document the research and management needs of users and agencies; and
- to develop a framework for a binational research network to ensure coordinated collection and dissemination of data to address the research and management needs

Binational meetings are held every two years. The goals of the meetings are:

1. to exchange information;
2. to generate plans for studying/implementing solutions; and
3. to build on our initiative to implement a binational research strategy to ensure coordinated collection and dissemination of data to address the continuing research and management needs.

Conveners:

The conveners are research institutions whose members actively interact and collaborate with the broader Lake Erie community of researchers, managers, and public groups. They will ultimately become the four nodes of the binational research network. The parent organization of each convener is also a sponsor of the Millennium Network. The Conveners are:

- the University of Windsor
- Large Lakes Research Station, US Environmental Protection Agency, Grosse Ile
- Environment and Climate Change Canada
- Ohio Sea Grant – F.T. Stone Laboratory, Ohio State University

Sponsors:

Funding for activities is solicited from organizations who have a responsibility or mandate related to the status of Lake Erie. Agencies who have elected to formally participate and contribute financial support are acknowledged as sponsors. The participation of sponsors' representatives at workshops and meetings is fundamental to identifying management and research issue that guide the direction of the Millennium Network. Past and current sponsors include:

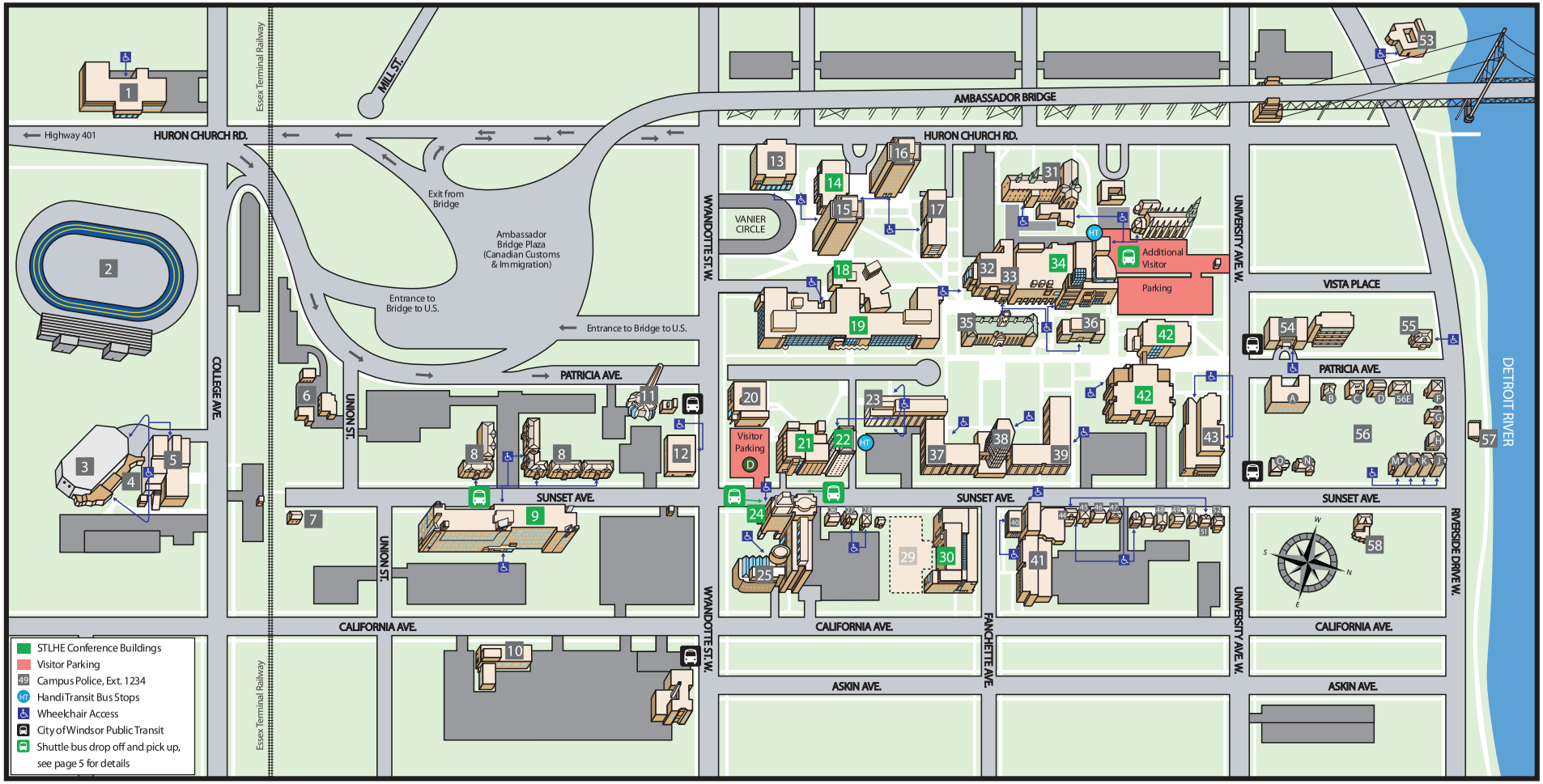
Campbell Scientific
DTE Energy
Essex Region Conservation Authority
Great Lakes Commission
Great Lakes Fishery Commission
Great Lakes Science Center – USGS
Hoskin Scientific Limited
International Joint Commission
Lake Erie Lakewide Area Partnership
(Environment and Climate Change Canada & US EPA-GLNPO)
Lake Erie Protection Fund
Michigan Sea Grant
Municipality of the City of Windsor
New York Sea Grant
Ohio Sea Grant
Ontario Ministry of Environment & Climate Change
Ontario Ministry of Agriculture, Food and Rural Affairs
Ontario Ministry of Natural Resources & Forestry
Pennsylvania Sea Grant

Collaborators:

Collaborating agencies are organizations that are active participants in the planning, information transfer, or research aspects of the Millennium Network. Collaborators provide in-kind and/or technical support that furthers the goals of the Network. Past and current collaborators include:

Citizens Environment Alliance of Southwestern Ontario
Cornell University Biological Field Station
Detroit River Cleanup Committee
Detroit River International Wildlife Refuge
Ducks Unlimited Canada
Essex County Stewardship Network
Great Lakes Environmental Research Laboratory - NOAA
Great Lakes Lab. For Fisheries and Aquatic Science - DFO Great Lakes Program – SUNY Buffalo
Great Lakes Science Center, USGS
Great Lakes Research Consortium
Greater Detroit American Heritage River Initiative
Michigan Department of Environmental Quality
Ohio Department of Natural Resources
Ohio Environmental Protection Agency
Ontario Commercial Fisheries' Association
Water Environment Federation

NOTES:



Campus Map

Computers are available at the Leddy Library Main Computer Lab. Printing and photocopying services also available at Leddy (42) as well as Lambton Tower (22) - Room 2103.

LAKE ERIE MILLENNIUM NETWORK

Binational Research and Monitoring for the Millennium

Environment Canada
Environnement Canada

University of Windsor

The Ohio State University Sea Grant NOAA
Stone Laboratory

United States Environmental Protection Agency