

2003 Progress Report: Development of Environmental Indicators of Condition, Integrity, and Sustainability in the US Great Lakes Basin

EPA Grant Number: R828675-00

Center: [Great Lakes Environmental Indicators Project](#)

Center Director: [Gerald J. Niemi](#)

Investigators: Richard P. Axler¹, JoAnn M. Hanowski¹, George E. Host¹, Robert W. Howe², Lucinda B. Johnson¹, Carol A. Johnston¹, John C. Kingston¹, Ronald R. Regal³, Carl Richards⁴, Deborah L. Swackhamer⁵

Cooperators: John R. Kelly⁶, Janet Keough⁶, David Mount⁶, Paul Bertram⁷, John Schneider⁷

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EPA Project Officer: Barbara Levinson

Project Period: January 10, 2001 to January 9, 2005

Project Amount: \$6,000,000

RFA: [Environmental Indicators in the Estuarine Environment Research Program \(2002\)](#)

Research Category: [Ecological Indicators/Assessment/Restoration](#)

Description:

Objective: The major question being addressed is “What environmental indicators can be developed to efficiently, economically, and effectively measure and monitor the condition, integrity, and long-term sustainability of the coastal region?”

Our specific objectives include:

- identification of environmental indicators that will be useful to define the condition, integrity, and change of the ecosystems within the coastal region,
- testing these indicators with a rigorous combination of existing data and field data to link stressors of the coastal region with environmental responses, and
- recommendation of a suite of hierarchically structured indicators to guide managers toward informed management decisions.

The final product will provide information for managers to communicate with the public on the condition and integrity of the coastal region, to guide development of monitoring programs to measure change, to identify areas in need of restoration or conservation strategies, and to use as key indicators for input into modeling efforts to predict the future of the coastal region.

Approach: The primary focus during the past year has been to complete field sampling. All of the project subcomponents successfully completed their field sampling efforts. The bird and amphibian group sampled over 600 sites in 2002 and 2003. The fish and macroinvertebrate group sampled 112 sites in 2002 and 2003. The diatom and water quality team has sampled 240 sites from 2001 to 2003. The wetland vegetation group has sampled 86 sites from 2001 to 2003. The contaminants group has sampled 22 sites across the Great Lakes basin. In addition, over 40 sites were visited by each of four project components: fish and macroinvertebrates, wetland vegetation, bird and amphibian, and diatom groups. Most of the sites sampled by the contaminant group were also sampled by the remaining four groups. All of the groups have been

completing their sample processing and all are in the process of analyzing their respective data.

The compilation of data for each subcomponent has been developed through central administration of the project to insure data compatibility and ease of analysis among the study components. In addition, all study components have documented points of sampling using current geopositioning (GPS) instruments to insure spatial integrity and allow visualization of sample sites and overlap. Over 12,000 GPS points have been recorded during field sampling within the coastal region of the Great Lakes.

This co-operative agreement with US EPA Office of Research and Development includes regular conference calls and individual face-to-face meetings on an as-needed basis for each subcomponent. This generally has occurred on a monthly basis and more frequently during the field sampling period (April to September). US EPA Mid-Continent Ecology Division has also coordinating their sampling of the Great Lakes to overlap with our study design. Their primary focus, however, was to examine nutrient gradients in the coastal region of the Great Lakes.

Additional Information: The investigators have given a host of presentations which collectively totals about 50 this past year. In particular, GLEI investigators made presentations at six major national/international science meetings. These included meetings of the American Society of Limnology and Oceanography, International Association of Great Lakes Research, Society for Conservation Biology, Ecological Society of America, North American Benthological Society, and the Society of Environmental Toxicology and Chemistry. In addition, about ten presentations were made to managers or the general public. A major emphasis of current efforts is the preparation of peer-reviewed publications. To date, GLEI investigators have published or submitted eight papers to peer-reviewed journals and many additional manuscripts are in preparation. Seventeen graduate students have been involved in GLEI-associated research and eight of these have successfully defended.

Each of the components has been adhering to and refining its quality assurance and quality control objectives. We have requested a one-year extension to the project to January 9, 2006. We have also requested additional funding to support the efforts of Dr. Valerie Brady in her coordination role for the entire EaGLE program and for Dr. Terry Brown who has completed an extensive amount of work in designing and coordinating the databases for the EaGLE program. Budget targets for women and minority owned businesses are also being met.

Progress Summary: The primary focus of the third year of this four year effort has been field sampling to test the hypotheses of stress and response relationships. Field sampling was successfully completed using multi-factor gradients across the Great Lakes for each of the five subcomponent projects. The resulting data are being processed and compiled. Field data have verified that many of the stress gradients (e.g., nutrients) are reasonable. A manuscript describing the experimental design for the project has been accepted in the journal *Environmental Monitoring and Assessment*. In addition, many papers are now being submitted or are in preparation. For example, two major papers are in final revision. One paper is a review of "Applications of Ecological Indicators" and is an invited paper to *Annual Review of Ecology, Evolution, and Systematics*. Another paper was jointly prepared by all five of the EaGLE programs and EPA personnel and is in revision to *Environmental Health Perspectives*.

Future Activities: The primary emphases over the next year will include the following 1) complete processing of all field samples, 2) compile and analyze the data gathered, and 3) prepare presentations and manuscripts for peer-reviewed publications. GLEI investigators will be making presentations at several national/international science meetings this year. These include the International Association of Great Lakes Research, the Society of Environmental Toxicology and Chemistry, North American Benthological Society, and the Society of Wetland Scientists. A GLEI investigators meeting is planned for November or December of 2004. A meeting of all EaGLE projects is scheduled for September 30 to October 2, 2004 in Duluth. GLEI investigators decided to reschedule the GLEI senior research advisory group meeting that was originally scheduled for March 2004. The investigators felt that time and money would be better allocated to a meeting in one more year when more data and analyses would be completed.

Publications and Presentations: Total Count: 4 published or accepted, 4 submitted, and more than 8 in preparation.

<u>Type</u>	<u>Citation</u>
Journal	Axler, R., J. Henneck, A. Kireta, J. Sgro and J. Kingston. Surrogate water quality indicators for use in monitoring the Great Lakes coastal zone. <i>Environmental Monitoring and Assessment</i> . In preparation.
Journal	Ciborowski, J.J.H., J. Schuldt, L.B. Johnson, G.E. Host, C. Richards, N. Danz, T. Hollenhorst. Reference conditions and axes of environmental stress - developing, integrating, and evaluating indicators of environmental conditions at Great Lakes coastal margins. For submission to <i>Ecological Applications</i> .
Journal	Danz, N.P., R.R. Regal, G.J. Niemi, V.J. Brady, T. Hollenhorst, L.B. Johnson, G.E. Host, J.M. Hanowski, C.A. Johnston, T. Brown, J. Kingston, J.R. Kelly. 2004. Environmentally stratified sampling design for the development of Great Lakes environmental indicators. <i>Environmental Monitoring and Assessment</i> . In press.
Proceedings	Ector L., J.C. Kingston, D.F. Charles, L. Denys, M.S.V. Douglas, K. Manoylov, N. Michelutti, F. Rimet, J.P. Smol, R.J. Stevenson, J.G. Winter. 2004. Freshwater diatoms and their roles as ecological indicators. Proceedings of the 17 th International Diatom Symposium 2002, Ottawa, Canada (M. Poulin, ed.), pp.469-480, Biopress Limited, Bristol. In press.
Journal	Frieswyk, C.B., C.A. Johnston, J.B. Zedler. Measuring dominance among co-occurring plants. <i>Ecology</i> . Submitted.
Journal	Grandmaison, D.D., G.J. Niemi. Landscape influence on Red-winged Blackbird (<i>Agelaius phoeniceus</i>) nest success in Great Lakes coastal wetlands. <i>The Auk</i> . Submitted.
Journal	Grigorovich, I., E. Mills, C. Richards, D. Breneman, J. Ciborowski. European valve snail <i>Valvata piscinalis</i> (Müller) in the Great Lakes basin: cryptic occurrence and spread. For submission to <i>Journal of Great Lakes Research</i> . In

preparation.

- Journal Hanowski, J., R. Howe, G. Niemi. Sampling effectiveness of calling anuran surveys. In preparation.
- Journal Hanowski, J., R. Howe, R. Regal, G. Niemi, N. Danz. Quantifying sources of variability in wetland breeding bird surveys; effects on sampling design. In preparation.
- Journal Johnston, C.A. 2003. Shrub species as indicators of wetland sedimentation. *Wetlands* 23:911-920. (Funded by completed EPA Grant No. R804823, but related to the current research)
- Journal Kang, M., J.J.H. Ciborowski, L.B. Johnson, T.R. Hrabik, C. Richards, J. Schuldt. The relationship between anthropogenic disturbance and the distribution of a nonindigenous species, *Echinogammarus ischnus* Stebbing, 1898 (Amphipoda: Gammaridae), at Great Lakes coastal margins. For submission to *Biological Invasions*. In preparation.
- Journal Kercher, S.M., C.B. Frieswyk, J.B. Zedler. 2003. Quality control approaches reveal effects of sampling teams and estimation methods for assessing plant cover in temperate herbaceous wetlands. *Journal of Vegetation Science* 14:899-906.
- Journal Niemi, G.J., M. McDonald. Application of ecological indicators. *Annual Review of Ecology, Evolution, and Systematics*. Submitted.
- Journal Miller, C.M., G.J. Niemi, J.M. Hanowski, R.R. Regal. Effects of anthropogenic development on breeding bird abundance and communities. *The Auk*. In preparation.
- Journal Niemi, G.J., D. Wardrop, R. Brooks, S. Anderson, V. Brady, H. Paerl, C. Rakocinski, M. Brouwer, B. Levinson, M. McDonald. Rationale for a new generation of ecological indicators for coastal waters. *Environmental Health Perspectives*. Submitted
- Journal Niemi, G.J., J.M. Hanowski, N. Danz, R. Howe, M. Jones, J. Lind, D. Mladenoff. 2004. Hierarchical scales in landscape responses by forest birds. In *Landscape Ecology and Wildlife Habitat Evaluation: Critical Information for Ecological Risk Assessment, Land-Use Management Activities, and Biodiversity Enhancement Practices, ASTM STP 1458*, L.A. Kapustka, H. Gilbraith, M. Luxon, and G.R. Biddinger, Eds., American Society for Testing and Materials, West Conshohocken, PA.
- Journal Price, S.J., D.R. Marks, R.W. Howe, J. Hanowski, G.J. Niemi. The importance of spatial scale for conservation and assessment of anuran populations in coastal wetlands of the western Great Lakes. *Landscape Ecology*. In review.
- Journal Stoermer, E.F., J.L. Pappas. Atypical *Tabularia* in coastal Lake Erie. For

submission to *Diatom Research*. In preparation.

- Presentation Adams, A.D., R.A. Lehr, M.F. Simcik, D.L. Swackhamer, S. Diamond, D.R. Mount. Photo-induced toxicity of polycyclic aromatic hydrocarbons in larval fish of the coastal Great Lakes. Is it ecologically relevant? Society of Environmental Toxicology and Chemistry. Austin, TX. Scientific audience, approx. 200 people. 9-13 November 2003.
- Presentation Adams, A.D., R.A. Lehr, M.F. Simcik, D.L. Swackhamer, S. Diamond, D.R. Mount. Photo-induced toxicity of polycyclic aromatic hydrocarbons in the coastal Great Lakes. International Association of Great Lakes Research, Chicago, IL. Scientific audience, approx. 100 people. 22-26 June 2003.
- Presentation Adams, A.D., R.A. Lehr, M.F. Simcik, D.L. Swackhamer, S.A. Diamond, D.R. Mount. Photo-induced polycyclic aromatic hydrocarbon toxic potentials of larval fish habitat. Midwest Society of Environmental Toxicology and Chemistry. 29-30 January 2003.
- Presentation Bourdaghs, M. 2003. The relationship between sampling area, species richness, and the Floristic Quality Assessment Index. Society for Conservation Biology. Duluth, MN. 28 June-2 July 2003.
- Presentation Bourdaghs, M., C.A. Johnston. 2003. The relationship between sampling area, species richness, and the Floristic Quality Assessment Index. EPA EaGLE meeting, Bodega Bay, CA. 3-6 December 2003.
- Presentation Brady, V.J., L.B. Johnson, D.H. Breneman, J.J.H. Ciborowski, T.R. Hrabik, C. Richards, J. Schuldt. Relative influence of landscape characteristics and anthropogenic stress on fish communities in Great Lakes coastal wetlands. International Association of Great Lakes Research. Chicago, IL. Scientific audience, approx. 100 people. 22-26 June 2003.
- Presentation Brazner, J.C., et al. Fish assemblages as indicators of Lake Superior coastal wetland condition. International Association of Great Lakes Research. Chicago, IL. Scientific audience, approx. 100 people. 22-26 June 2003.
- Presentation Breneman, D. Developing environmental indicators for Great Lakes coastal margins. Great Lakes Fisheries Commission. Milwaukee WI. Scientists/fed, state managers. 17-18 March 2003.
- Presentation Breneman, D., V.J. Brady, J.J.H. Ciborowski, T.R. Hrabik, C. Richards (presenter), J. Schuldt, L.B. Johnson. Developing Great Lakes environmental indicators using wetland fish communities. North American Benthological Society. Athens, GA. 27-31 May 2003.
- Presentation Ciborowski, J.J.H., et al. Reference conditions, degraded areas, stressors, and impaired beneficial uses: conceptual integration of approaches to evaluating human-related environment pressures. Aquatic Toxicity Workshop, Ottawa, ON.

September 2003.

- Presentation Ciborowski, J.J.H., et al. Reference conditions, degraded areas, stressors, and impaired beneficial uses: conceptual integration of approaches to evaluating human-related environment pressures. International Association of Great Lakes Research. Chicago, IL. Scientific audience, approx. 100 people. 22-26 June 2003.
- Presentation Ciborowski, J.J.H. Overview of Great Lakes Environmental Indicators Project. Lake Erie Lamp Workgroup, Lake Ontario Interdisciplinary Science Conference, Great Lakes Research Consortium. Syracuse NY. Scientists/federal, state managers. 13 March 2003.
- Presentation Danz, N. et al. Using multiple anthropogenic stressors to characterize Great Lakes Coastal ecosystems. International Association for Great Lakes Research. Chicago IL. Scientific audience, approx 200 people. 22-26 June 2003.
- Presentation Danz, N.P., L.B. Johnson, G.J. Niemi, R.R. Regal, J. Schuldt, V. Brady, J. Brazner, M. Bourdaghs, C. Johnston, T. Brown, J.M. Hanowski. 2003. Integrating a fish, bird, and plant wetland indicator using regional ecological normalization. Society for Conservation Biology. Duluth MN. Scientific audience. 28 June-2 July 2003.
- Presentation Danz, N.P., L.B. Johnson, G.J. Niemi, R.R. Regal, J. Schuldt, V. Brady, J. Brazner, M. Bourdaghs, C. Johnston, T. Brown, J.M. Hanowski. 2003. Integrating a fish, bird, and plant wetland indicator using regional ecological normalization. EPA EaGLE meeting, Bodega Bay, CA. 3-6 December 2003.
- Presentation Erb, J.L., R.A. Lehr, J.L. Wittliff, R. Allen, J.G Downward, R.H. Smith, D.L. Swackhamer, E.M. Priuska. Effects of Great Lakes water samples on estrogen receptor and aryl hydrocarbon receptor activity as measured by a biosensor. International Conference of Pharmaceuticals and Endocrine Disrupting Chemicals in the Water. Minneapolis, MN. Scientific audience, approx. 120 people. 19-21 March 2003.
- Presentation Erb, J.L., J.G Downward, E.M. Priuska, J.L. Wittliff, R.A. Lehr, D.L. Swackhamer, E. Garber, G. Larson, J. Magner. Receptor-based biosensor responses correlate with fish vitellogenin production and frog developmental abnormalities. Frontiers in Assessment Methods for the Environment. Minneapolis, MN. Scientific audience, approx. 100 people. 10-13 August 2003.
- Presentation Frieswyk, C.B., J.B. Zedler. 2003. Many types of dominance. Society for Conservation Biology. Duluth, MN. 28 June-2 July 2003.
- Presentation Grandmaison, D.D. Landscape indicators of nest predation in Great Lakes coastal wetlands. International Association for Great Lakes Research. Chicago IL. Scientific audience, approx. 100 people. 22-26 June 2003.
- Presentation Hanowski, J., R. Howe, C. Smith, D. Marks, S. Price. What can birds and

amphibians indicate about the ecological condition of coastal ecosystems?
Ecological Society of America. Savannah GA. Scientific audience. 7 August 2003.

- Presentation Howe, R., J. Karr, A. Wolf. Historical and recent approaches to the assessment of ecological condition. Ecological Society of America. Savannah GA. Scientific audience. 7 August 2003.
- Presentation Howe, R., M. Jones, N. Danz, J. Hanowski, G. Niemi, D. Ewert, J. Davis. A GIS framework for bird conservation and monitoring in western Great Lakes forests. Society for Conservation Biology. Duluth MN. Scientific audience. 28 June-2 July 2003.
- Presentation Host, G.E., T. Hollenhorst, L. Johnson, J. Schuldt, J. Ciborowski, C. Richards. Use of GIS and remotely-sensed data for *a priori* identification of reference areas for Great Lakes coastal ecosystems. Association of American Geographers. New Orleans LA. 4-7 March 2003.
- Presentation Hrabik, T., L. Johnson, V. Brady, D. Breneman, J. Ciborowski. Quantifying the influence of landscape characteristics on fish communities in coastal riverine wetlands for use as indicators. EaGLE meeting. American Society of Limnology and Oceanography. Salt Lake City UT. 9-14 February 2003.
- Presentation Hrabik, T.R., V.J. Brady, D.H. Breneman, J. Ciborowski, C. Richards. Quantifying the influence of landscape characteristics on fish communities in coastal riverine wetlands for use as indicators. American Association of Limnology and Oceanography. April 2003.
- Presentation Johnson, L.B. Lake Superior canaries: detecting ecological change. Sea Grant: Superior Science for You. Duluth MN. 15 January 2003.
- Presentation Johnson, L.B. Lake Superior canaries: detecting ecological change. Sea Grant: Superior Science for You. Grand Portage Ontario. 16 January 2003.
- Presentation Johnston, C.A., P. Meysembourg, T. Hollenhorst. GIS-derived indicators of environmental stressors and ecosystem responses of Great Lakes coastal wetlands. Society for Conservation Biology. Duluth, MN. 28 June-2 July 2003.
- Presentation Johnston, C.A., B.L. Bedford, M. Bourdaghs, T. Brown, C. Frieswyk, L. Vaccaro, J. Zedler. Plants as environmental indicators in Great Lakes coastal wetlands. Ecological Society of America. Savannah, Georgia. 3-8 August 2003.
- Presentation Kang, M., J.J.H. Ciborowski, L.B. Johnson, T.R. Hrabik, C. Richards, J. Schuldt. The invasibility of stressed sites by exotic benthic macroinvertebrates in the Great Lakes: a test of hypotheses using *Echinogammarus ischnus*. International Association for Great Lakes Research. Chicago IL. Scientific audience. 23 June 2003.

- Presentation Kelly, J.R., P.M. Yurista, J.M. Morrice. Variability, pattern, and sensitivity of ecological indicators for nearshore regions of the Great Lakes. EaGLe meeting. American Society of Limnology and Oceanography. Salt Lake City, UT. 9-14 February 2003.
- Presentation Kingston, J., D. Engstrom, E. Swain, E.F. Stoermer, J. Johansen, G. Sgro, K. Yanko, A. Kireta, R. Axler. Paleolimnological assessment of ecosystem condition in Great Lakes drowned river mouths. Society for Conservation Biology, Duluth, MN. 28 June-2 July 2003.
- Presentation Kingston, J.C., K.S. Yanko, G.V. Sgro, J.R. Johansen, E.F. Stoermer, R.A. Axler, A.R. Kireta. Diatom indicators of ecological condition for the coastal zone of the Laurentian Great Lakes. International Association of Great Lakes Research. Chicago IL. 22-26 Jun 2003.
- Presentation Lehr, R.A., J.L. Erb, A.D. Adams, M.F. Simcik, D.L. Swackhamer. Assessing the potential for endocrine disruption in the Great Lakes. International Association for Great Lakes Research. Chicago, IL. Scientific audience. 22-26 June 2003.
- Presentation Lehr, R.A., A.D. Adams, J.L. Erb, I. Knoebl, N.D. Denslow, G.T. Ankley, M.F. Simcik D.L. Swackhamer. Monitoring environmental estrogens in the Great Lakes. Society for Environmental Toxicology and Chemistry. Austin, TX. Scientific audience, approx. 70 people. 16-19 November 2003.
- Presentation Miller, C., K. Stroom, C. Richards, G. Niemi, J. Hanowski. Negative response of birds and aquatic macroinvertebrates to urban development in western Lake Superior. International Association for Great Lakes Research. Chicago IL. Scientific audience. 22-26 June 2003.
- Presentation Morrice, J. Algal responses to nutrient loading in Great Lakes coastal wetlands. International Association for Great Lakes Research. Scientific audience, approx. 100 people. Chicago IL. 22-26 June 2003.
- Presentation Niemi, G. Review of Great Lakes environmental indicators. Environmental Statistics, guest lecture. Oregon State University, Corvallis. Approx. 15 graduate students. 21 October 2003.
- Presentation Niemi, G. Review of Great Lake environmental indicators. Nature Conservancy, Great Lakes Program. Chicago, IL. Approx. 5 people. 30 October 2003.
- Presentation Niemi, G.J., keynote speaker. Development of environmental indicators for the US Great Lakes coastal region. Midwest Society of Environmental Toxicology and Chemistry. Rhinelander, WI. 29-30 January 2003.
- Presentation Niemi, G.J. Development of environmental indicators for the US Great Lakes coastal region. Region 5 STAR Environmental Research Seminar. Chicago IL. Scientists/managers, approx. 17 people. 17 June 2003.

- Presentation Niemi, G., N. Danz, R. Regal, T. Hollenhorst, V. Brady, T. Brown, L. Johnson, J. Hanowski. Experimental design for linking stress with response in the Great Lakes coastal ecosystem. Ecological Society of America. Savannah GA. Scientific audience. 7 August 2003.
- Presentation Niemi, G., R. Axler, V. Brady, J. Hanowski, G. Host, L. Johnson, C. Johnston, J. Kingston, R. Regal, C. Richards, D. Swackhamer, R. Howe, J. Ciborowski, S. Bradbury. Development of environmental indicators for the US Great Lakes coastal region. EaGLE meeting. Bodega Bay CA. 3-6 December 2003.
- Presentation Niemi, G., R. Axler, V. Brady, N. Danz, J. Hanowski, T. Hollenhorst (speaker), G. Host, L. Johnson, C. Johnston, J. Kingston, R. Regal, C. Richards, D. Swackhamer, R. Howe, J. Ciborowski, S. Bradbury. Development of environmental indicators for the US Great Lakes coastal region. Northern Minnesota GIS User Group. Duluth MN. 30 February 2003.
- Presentation Regal, R., N. Danz, G. Niemi, V. Brady, T. Hollenhorst, T. Brown, K. Dib. Environmentally stratified sampling for the development of Great Lakes environmental indicators. Association of Environmental Engineering and Science Professors. Minneapolis MN. Scientific audience. 13 Aug 2003.
- Presentation Simcik, M.F., A.D. Adams, R.A. Lehr, D.L. Swackhamer, S.A. Diamond, D.R. Mount. Phototoxicity of polycyclic aromatic hydrocarbons in coastal Great Lakes waters. EaGLE meeting. American Society of Limnology and Oceanography. Salt Lake City UT. Scientific audience. 9-14 February 2003.
- Presentation Stoermer, E.F., J.L. Pappas. Atypical *Tabularia* in coastal Lake Erie. 2003 North American Diatom Symposium.
- Presentation Swackhamer, D.L. Coffee beans, laundry soap, and fish sexuality. Superior Science for You Speakers Series, Minnesota Sea Grant. Grand Marais, MN. 10 April 2003.
- Presentation Swackhamer, D.L. Coffee beans, laundry soap, and fish sexuality. Superior Science for You Speakers Series, Minnesota Sea Grant. Duluth, MN. 9 April 2003.
- Presentation Swackhamer, D.L. (plenary speaker). Developing ecological indicators of chemical stress to nearshore environments of the Great Lakes. Midwest Society of Environmental Toxicology and Chemistry. Stevens Point WI. 29 January 2003.
- Presentation Swackhamer, D.L. Feminized fish and environmental estrogens: Is there a link? Undergraduate Chemistry Lecture Series, University of Minnesota, Minneapolis. 12 March 2003.
- Presentation Thompson, J.A., J.A. Morrice, S.L. Batterman, A.M. Cotter, G.S. Peterson, N. Danz. Wetland morphologic and biogeographic influences on algal responses to

nutrient loading in Great Lakes coastal wetlands. North American Benthological Society. Athens GA. Scientific audience. May 2003.

- Presentation Trebitz, A., J. Brazner, D. Tanner. Fish-habitat relationships in Great Lakes coastal marshes. Society for Conservation Biology. Duluth MN. Scientific audience. 28 June-7 July 2003.
- Presentation Vacarro, L. Plant functional diversity in wetlands and the potential impacts on decomposition and nutrient cycling. Natural Resources Graduate Student Association Symposium. Cornell University, Ithaca NY. 24 January 2003.
- Presentation Wolter, P., G. Niemi, C. Johnston. Development of environmental indicators for the US Great Lakes basin using remote sensing technology. EaGLE meeting. Bodega Bay, CA. 3-6 December 2003.
- Presentation Yurista, P.M. et al. Zooplankton size-spectra in Great Lakes coastal waters. International Association for Great Lakes Research. Chicago IL. Scientific audience. 2-26 Jun 2003.
- Presentation Yurista, P.M., J.R. Kelly, S.E. Miller. Zooplankton size-spectra as an indicator in Great Lakes coastal waters. EaGLE meeting. American Society of Limnology and Oceanography. Salt Lake City, UT. Scientific audience. 9-14 February 2003.

Training Future Scientists (to date)

Undergraduate interns: 48

Undergraduate honors theses: 3

Graduate students: 36

Graduate student projects: 17

Graduates defended: 8

Undergraduate Theses Students

Andriash, K. Contrasting zoobenthic community composition in riverine vs. protected wetlands of the Great Lakes coastal margins. GLEI Hon BSc thesis. In preparation.

Foley, C. In progress. The associations between larval Odonata and habitat structure as indicators of anthropogenic stress in great lakes coastal margin wetlands. Hon. BS thesis, University of Windsor.

Ladwig, Laura. Spatial relationship between *Typha* spp. and *Phragmites australis* in Green Bay coastal wetlands. GLEI senior thesis. In preparation.

MS Theses

Adams, Andrew. Photo-enhanced toxicity of polycyclic aromatic hydrocarbons to larval fish in the coastal Great Lakes. GLEI MS thesis. In preparation.

Bhagat, Y. In progress. Classifying fish communities to assess environmental condition at Great Lakes shorelines: a comparison of multimetric and multivariate approaches. MS thesis, University of Windsor.

Bourdaghs, M. An evaluation of the floristic quality assessment index for use in Great Lakes coastal wetlands. GLEI MS thesis. In preparation. Current position: Works for the Minnesota Pollution Control Agency.

Ferguson, M. In progress. Analysis of the benthic diatom flora in variable habitat regions of the Laurentian Great Lakes. MS thesis. John Carroll University, Cleveland, Ohio

Grandmaison, D. Landscape factors affecting productivity of breeding birds in Great Lakes coastal wetlands. MS thesis. University of Minnesota Duluth.

Iverson, K. GIS-derived indicators of wetland vegetation condition. GLEI PhD dissertation. In preparation

Johnson, C. 2003. Predicting the vegetational composition of a wetland created from dredged material in Duluth-Superior Harbor. MS thesis. University of Minnesota Duluth

Kang, M. 2004. The invasibility of stressed sites by exotic benthic macroinvertebrates in the Great Lakes: a test of hypotheses using *Echinogammarus ischnus*. MS thesis. University of Windsor, Ontario, CA.

Marks, D. Habitat and landscape associations of breeding birds in Great Lakes coastal wetlands. University of Wisconsin-Green Bay. 2003 123 pp.

Miller, C. Effects of anthropogenic development on breeding bird abundance and communities. University of Minnesota Duluth. Finished February 2003.

Peterson, A. Evaluation of the Ohio rapid assessment methods on wetlands of the Great Lakes basin: a comparative analysis of bird assemblages and wetland quality. University of Minnesota Duluth. In preparation.

Price, S. Anuran-habitat associations in coastal wetlands of the western Great Lakes. University of Wisconsin-Green Bay. 2003. 85 pp.

Yanko, K. 2002. An analysis of the benthic diatom flora of the Laurentian Great Lakes, and their use as indicators of water quality. GLEI MS thesis. John Carroll University, Ohio, 156 pp.

Postdoctoral Fellows

Grigorovich, I. 2003. Great Lakes environmental indicators - distribution and implications of nonindigenous invading species at Great Lakes coastal margins.

Gathman, J. 2003-2004. Great Lakes environmental indicators - multivariate analysis of zoobenthic distribution at Great Lakes coastal margins.

Holland, J. 2003-2004. Great Lakes environmental indicators - role of scale in indicator sensitivity.

PhD Dissertations

Frieswyk, C. Ecosystem resilience and the behavior of *Typha* species in Lake Michigan coastal wetlands. GLEI PhD dissertation. In preparation.

Kang, M. The influence of entry sequence on invasion success and the importance of scale for biotic resistance to biological invasion. PhD thesis, University of Windsor. In preparation.

Lehr, R. Use of estrogen equivalents to explain vitellogenin induction in fathead minnows (*Pimephales promelas*) exposed to a complex wastewater effluent. Water Resources Science, University of Minnesota, February 2004.

Vaccaro, Lynn. Understanding a wetland's vulnerability to invasion: A comparison of *Typha* production, nutrient use and decomposition in distinct hydrogeologic settings. GLEI PhD dissertation. In preparation.

Supplemental Keywords: coastal, disturbance, indicators, Great Lakes, stress, water, landscapes, amphibians, birds, contaminants, diatoms, fish, insects, vegetation, wetlands, macrophytes

Relevant Websites: <http://glei.nrrri.umn.edu>