2002 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. Axler[1], JoAnn M. Hanowski[1], George E. Host[1], Robert W. Howe[2], Lucinda B. Johnson[1], Carol A. Johnston[1], John C. Kingston[1], Ronald R. Regal[3], Carl Richards[4], Deborah L. Swackhamer[5]
Cooperators: John R. Kelly[6], Janet Keough[6], David Mount[6], Paul Bertram[7], John Schneider[7]
Institutions: [1]Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota Duluth; [2]University of Wisconsin, Green Bay; [3]University of Minnesota Duluth; [4]Minnesota Sea Grant College Program; [5]University of Minnesota Twin Cities; [6]US EPA Mid-Continent Ecology Division, Duluth; [7] US EPA Region 5, Chicago, IL
EPA Project Officer: Barbara Levinson
Project Period: January 10, 2001 to January 9, 2005
Research Category: Estuarine and Great Lakes Program (EaGLe)

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 the use of key indicators as input for modeling efforts to predict the future of the coastal region.

Approach: The primary focus during the past year was to identify suitable stress gradients for each subcomponent to sample in order to link biological responses with stress. This was accomplished by compiling a total of 229 data layers on stress information that was publically available in digital format throughout the US Great Lakes watershed. These data were compiled in a geographic information system. These data layers represent broad categories of stress such as land use, population density, pesticide use, point source discharge, non-point sources, soil characteristics, atmospheric deposition, proportion of roads, and shoreline characteristics.

Because the US Great Lakes coastal region is vast, we also identified specific sections of the shoreline to focus our sampling. This consisted of calculating a combination of shoreline reaches and the watershed. We identified all sections of the shoreline that were associated with 2nd order and higher streams. We then identified a new unit we term "segment shed." This was a combination of the watershed area that drained a 2nd order or higher stream and the area which was the mid-point distance with an adjacent 2nd order or higher stream. The entire US Great Lakes coastal zone contained 762 segment sheds. These included the following: 102 in Lake Erie, 148 in Lake Huron, 157 in Lake Michigan, 90 in Lake Ontario, 12 in Lake St. Clair, and 236 in Lake Superior. An additional 17 segment sheds are found in connecting channels between the lakes.

We employed a variety of multivariate statistical techniques including principal components analysis to reduce the dimensionality in these data and cluster techniques to identify groups of sites with similar and dissimilar stress characteristics. A random stratified sampling design was then used to select sampling sites for each subcomponent of the study. Early in the analyses we also separated the US Great Lakes coast into northern and southern ecological provinces. The northern regions of the US Great Lakes coast (e.g., Lake Superior, northern lakes Michigan and Huron, and the eastern portion of Lake Ontario) are dominated by forested regions and low population density. The southern region is dominated by agricultural land and high population density, especially near the larger metropolitan areas such as Chicago, Detroit, Cleveland, and Buffalo.

Final selection of study sites was pursued to maximize overlap, and thus integration, among the different subcomponents of the study. For instance, because of the nature of the biological response, the contaminants subcomponent can sample the fewest sites, while the bird and amphibian subcomponent can sample hundreds of sites. Hence, all subcomponents will sample the contaminant sites, but not all subcomponents can sample all sites sampled by the bird and amphibian group.

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 upon completion of the data gathering phase. In addition, all study components have documented points of sampling using current geopositioning instruments to insure spatial integrity and allow visualization of sample sites and overlap.

This co-operative agreement with US EPA's Office of Research and Development, includes regular conference calls (every 2-to-3 weeks) and individual face-to-face meetings on an as-needed basis for each subcomponent. This generally occurs on a monthly basis and more frequently during the field sampling period (April to September). US EPA's Mid Continent Ecology Division is also coordinating their sampling of the Great Lakes to overlap with our study design. Their primary focus, however, is to examine nutrient gradients in the coastal region of the Great Lakes.

Additional Information: Each subcomponent, as described in their detailed reports, is processing field samples, compiling data, and completing preliminary analyses of data. Furthermore, the investigators have given a host of presentations (collectively totals over 30 this past year), are in various stages of manuscript preparation, and have included a host of graduate (2 completed and 12 in progress) and undergraduate students in the various projects. The GLEI investigators participated in the biannual Great Lakes "State of the Lakes Ecosystem Conference" during the past year and provided detailed commentary and feedback on the conference results.

Each of the components has been adhering to and refining its quality assurance and quality control objectives. Overall budgets are on target with several additional adjustments being implemented. These include: 1) more effort has been required in the area of organizing the data using geographic information systems and in statistical analyses of the stress gradients, and 2) there is on-going concern that exposure data during sampling are limited such as for water quality. Our inability to assess submerged aquatic vegetation along the coastal region remains a concern, but we are exploring the use of remote sensing imagery (e.g., the recent Quickbird satellite) through our supporting study funded by the National Aeronautics and Space Administration to resolve some of these issues. Budget targets for women and minority owned businesses are also being met.

One additional omnipresent concern for which there is no clear solution is the fluctuation in Great Lakes water levels. During 2001-2002 and anticipated in 2003 are record lows in water levels, which are especially pronounced in Lake Huron and Lake Michigan. These water levels have tremendous influence on the Great Lakes coastal ecosystems such as wetlands and have prohibited boat access to some portions of the Great Lakes. These water level fluctuations will need to be incorporated and put into perspective in the development of environmental indicators of the Great Lakes coastal zone.

Progress Summary: The primary focus of this the second year of a four year effort has been field sampling to test the hypotheses of stress and response relationships. An elaborate compilation of existing data into a geographic information system was completed, a sophisticated multivariate analysis was applied to the resulting spatial data, and a series of sites were selected in a restricted random fashion. 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. Integration among the subcomponents include theoretical developments, participation in joint workshops/symposia, coordinated site selection, and central management of databases for ease of analyses. During the past year over 30 presentations were given to scientific managerial and public audiences and both internal and public websites have been developed. The first peer-reviewed paper has been published and a host of papers have been submitted or are in preparation. Two graduate theses were completed and twelve graduate theses are in progress.

Future Activities: Preparations are being made for the second intensive sampling year in 2003. Adjustments in some of the sampling sites have been made to insure appropriate testing of stress-response relationships. Investigators are participating in a variety of national symposia including annual meetings of the Society for Conservation Biology, International Association of Great Lakes Research, and the Ecological Society of America. An all-GLEI investigators meetings is planned for November 2003, an all-EaGLe meeting is planned for December 2003, and the GLEI-Senior Research Advisory Group will meet in March 2004.

Publications and Presentations: Total Count: 11

Type	Citation
Journal Article	Johnston, CA, P Meysembourg. Comparison of the Wisconsin and National Wetlands Inventories. Wetlands 2002, Volume 22, Number 2 (June), Page: 386-405.
Presentation	**Niemi, G. J.** Great Lakes Environmental Indicators Project. Great Lakes Fisheries Commission. Duluth, MN, 25 February 2002.
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. Western Great Lakes Research Conference. Marquette, MI, 2-3 April 2002.
Presentation	**Niemi, G. J.** Overview of Great Lakes Environmental Indicators Project. Cornell University, Ithaca, NY, 25 April 2002.
Presentation	Niemi, G. J. Overview of Great Lakes Environmental Indicators Project. New York Department of Conservation, US EPA, Region 2. Albany NY, 26 April 2002.
Presentation	**Johnson, L.B.** Overview of Great Lakes Environmental Indicators Project. Research needs planning meeting for a Lake Erie basin habitat strategy. Lake Erie Millennium Plan. Windsor, Ontario, 15 May 2002.
Presentation	**Niemi, G**., R. Axler, V. Brady, N. Danz, J. Hanowski, T. Hollenhorst, 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 Program. International Association of Great Lakes Research, Winnipeg, Manitoba, 5 June 2002.
Presentation	**Niemi, G.** Invited. Overview of Great Lakes Environmental Indicators Project. State of the Lakes Ecosystem Conference, Cleveland, OH, 16 October 2002.
Presentation	**Johnson, L.B.** Lake Superior Canaries: Detecting Ecological Change. Sea Grant: Superior Science for You, EPA MED, Duluth, MN, 15 January 2003.

Presentation	**Niemi, G.J.**, keynote speaker. Development of Environmental Indicators for the US Great Lakes Coastal Region. Midwest SETAC, Rhinelander, WI, 29-30 January 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 Symposium at ASLO Aquatic Science Meeting, Salt Lake City, UT, 9-14 February 2003.

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

Relevant Websites: http://glei.nrri.umn.edu