Development of Environmental Indicators of Condition, Integrity, and Sustainability in the Coastal Regions of the US Great Lakes Basin (Great Lakes Environmental Indicators Project)

Principal Investigator: Gerald Niemi, Center for Water and the Environment (CWE), Natural Resources Research Institute (NRRI), University of Minnesota (UMN)
Co-Principal Investigators: Richard Axler, JoAnn Hanowski, George Host, Lucinda Johnson, Carol Johnston, John Kingston, CWE/NRRI; Ronald Regal, Department of Mathematics and Statistics; Carl Richards, Minnesota Sea Grant; Deborah Swackhamer, Department of Environmental and Occupational Health, UMN; Robert Howe, Department of Natural and Applied Sciences; University of Wisconsin-Green Bay (UW-GB)
Other Cooperators: Barbara Bedford, Charles Smith, Cornell University; Jan Ciborowski, University of Windsor, Canada; Jeffrey Johansen, Gerald Sgro, John Carroll University, Ohio; David Mladenoff, Joy Zedler, University of Wisconsin-Madison (UW-M); Eugene Stoermer, University of Michigan
US EPA Office of Research and Development (ORD) Cooperators: Steven Bradbury, Gerald Ankley, John Brazner, Philip Cook, Naomi Detenbeck, John Kelly, Russell Kreis, Mary Moffett, David Mount, Mid-Continent Ecology Division-Duluth (MED), MN and Grosse Isle, Michigan
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Description

Objectives/Hypothesis:

We have initiated a cooperative project consisting of eight universities and US EPA ORD, primarily the Mid-continent Ecology Division, to identify, evaluate, and recommend a portfolio of multi-scaled environmental indicators relevant to the coastal regions of the US Great Lakes basin. Our major question is "what environmental indicators will most efficiently, economically, and effectively measure the condition, integrity, and long-term sustainability of the basin." Our objectives are: 1) Identify environmental indicators that define the condition, integrity, and change of the ecosystems within the Great Lakes basin, 2) Test these indicators with a rigorous combination of existing data and field data to link stressors with environmental responses, and 3) Recommend a suite of hierarchically-structured indicators to guide managers toward informed management strategies.

Approach:

We will test the indicators with a combination of existing data, a pilot study, and a more comprehensive field study in years 2 and 3 that are linked with stressors of the basin. Year 4 will be dedicated to analysis and recommendation of a suite of hierarchically structured indicators. Our research plan uses EPA's ecological risk assessment paradigm to 1) illustrate the development of indicators, 2) test cause and effect between stressors and endpoints, and 3) provide essential linkages with EPA initiatives and programs. Indicators are divided into pressure (stressors) and state indicators (individual, population, community, and landscape-level endpoints or responses to the stressors). Major stressors include land use change, climate change, point and non-point discharges, exotic species, atmospheric deposition, and hydrological

modifications. State indicators focus on biotic populations and communities (amphibian, bird, diatoms, fish, macroinvertebrates, and aquatic plants), land cover, and water quality (contaminants, nutrients).

Stressor Identification:

We have formulated the problem by defining the major human threats to the basin and identifying the specific pressure indicators that affect the condition, integrity and change of the basin as measured by the state indicators (responses). The major threats to this system include stressors related to land use (e.g. agriculture, forestry, mining, lakeshore, urban, and other watershed development), climate change (expressed largely through water level fluctuations, tributary discharge, and habitat change), point and non-point source discharges, exotic species, atmospheric deposition, stratospheric/tropospheric ozone effects, and various hydrologic modifications (e.g. dredging, breakwaters, harbors, docks). Examples of specific stressors include chemical (e.g. contaminants, nutrients, salinity), hydrological (water table, stream flow), physical (sedimentation, temperature), habitat alteration (fragmentation, dredging), and biotic (predation, disease, over-harvest) factors.

Potential Indicators:

Coastal ecosystems across the basin vary greatly in their structure and function. Thus, unique state indicators are included that reflect the characteristic condition and integrity of the basin; state indicators are linked with stressors with an ultimate use of monitoring change within these ecosystems as well as being diagnostics of endpoints of societal concern. We identified a suite of state indicators that represent individual, population, community, and landscape-level endpoints, thereby representing the range of spatial and temporal scales necessary to cover the immense area of the Great Lakes basin. They include 1) climate, land use, and landscape characteristics for the entire basin (associated with habitat alteration and physical stressors), 2) water quality contaminant levels, and relative abundance and diversity of amphibian, bird, diatom, fish, macroinvertebrate, and plant communities in estuaries/bays and nearshore coastal waters (linked with all stressors), and 3) amphibian, bird, and plant communities in the land margins (primarily linked with habitat alteration, biotic, and physical stressors). Field sampling will employ a random stratified design using ecological provinces, watersheds, shoreline reaches, and ecosystem types as the basis for stratification.

Expected Results:

Our goal is to identify the relationship between stressors and ecosystem response, which would allow predictions of stressor impacts to be made. These will allow us to recommend the most efficient, cost-effective, reliable, and understandable indicators to scientists and managers. These indicators will be easily visible, simple to monitor, and will allow managers to easily communicate the environmental condition of the Great Lakes nearshore and coastal areas to the general public. The final product will allow managers to guide development of monitoring programs to measure change, and to identify areas in need of restoration or conservation strategies. The Great Lakes Sea Grant network will provide support and communicate these results to the Great Lakes community.

Indicator Selection and Recommendation:

Selection of indicators will occur following integration of assembled data, uncertainty and sensitivity analysis, and assessment of the ecological significance of the indicators. An important part of this phase is the assessment of redundancy among the indicators, cost effectiveness, environmental relevance, power of an indicator to detect environmental change, and recommendations on how the US Great Lakes basin can be improved in the management of human-induced stressors (e.g. prioritization and integration of Total Maximum Daily Loads-TMDLs). Since indicators are not static, an adaptive system capable of refining and updating the indicators must be in place for the ultimate success of this project and for the ultimate goal of protecting the integrity of the Great Lakes basin.