Annual Report - January 10, 2001 to January 9, 2002

DEVELOPMENT OF ENVIRONMENTAL INDICATORS OF CONDITION, INTEGRITY, AND SUSTAINABILITY IN THE US GREAT LAKES BASIN

EPA Grant Number R82-8675

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GENERAL SUMMARY

This project was officially initiated on January 10, 2001. The overall question and objectives of the project have not changed. The major question to be 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: 1) identification of environmental indicators that will be useful to define the condition, integrity, and change of the ecosystems within the coastal region, 2) testing these indicators with a rigorous combination of existing data and field data to link stressors of the coastal region with environmental responses, and 3) 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.

We identified a suite of environmental (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 coastal region. These indicators include 1) climate, land use, and landscape characteristics for the entire basin; 2) water quality contaminant levels, and relative abundance and diversity of amphibian, bird, diatom, fish, invertebrates, and plant communities in estuaries/bays and nearshore coastal waters; and 3) amphibian, bird, and plant communities in the coastal land margins. We have employed a random stratified sampling design to select sample sites using ecological provinces, a combination of watersheds and shoreline reaches (hereafter called segment sheds), and geomorphic types for stratification. An important aspect 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. 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 coastal region. This project is integrated with the Great Lakes State of the Lakes Ecosystem Conferences and the Great Lakes Sea Grant network.

The focus of the first year efforts has been on pilot studies for each of the project components and the development of a rigorous sampling framework. This included the compilation of over 200 data layers of existing information across the Great Lakes coastal and watershed regions. These data layers were organized in a geographic information system for each of over 700 segment sheds and will form the basis for study site selection for intensive field studies in 2002 and 2003.

Each of the components has been adhering to and refining its quality assurance and quality control objectives. Overall budgets are on target with several adjustments being implemented. These include: 1) additional monies have been allocated to initial coordination and implementation of the project, 2) additional effort has been expended in the compilation of the data layers on disturbance gradients for the sampling design, and 3) no pilot data were gathered for the eastern region of the Great Lakes for birds and amphibians because of problems in successfully implementing a subcontract by May 2001. It is anticipated that budget adjustments will be compensated for during subsequent years of the study. Some budget concerns have also been identified for support in gathering background water quality data and our inability to effectively measure submerged aquatic vegetation. We are working with the US EPA Mid-continent Ecology Division and we are exploring the use of remote sensing imagery as part of 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 on target. Overall key personnel involved in the project have not changed.

One additional major concern for which there is no clear solution is the fluctuation in Great Lakes water levels. During 2001 and anticipated in 2002 are 50-year 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.

SUMMARY OF PROJECT COMPONENTS

Amphibian and Bird Component

Co-Principal Investigators - JoAnn Hanowski (NRRI/UMD), Robert Howe (U of Wisconsin, Green Bay), Charles Smith, (Cornell U)

The overall goal is to develop environmental indicators based on amphibian and breeding bird communities in the US Great Lakes coastal region. A total of 512 areas and 1132 survey counts were completed during the 2001 pilot study in the Lake Superior and Lake Michigan coastal regions. These samples included areas in coastal wetlands, coastlines of the Great Lakes, and the adjacent (within 1 km of the coastline) upland area. Birds were sampled in all areas and amphibians in coastal and adjacent upland wetlands. Sample methods were developed and analyzed which included determination of relevant spatial area, placement of samples within the sampled area, frequency and timing of sampling, and considerations of observer variability. Protocols, data sheets, instructions for sampling, definitions, and database (ACCESS) implementation were developed. All data have been entered using quality assurance/control

protocols (e.g., double entry and error-checked). Statistical analyses of pilot study data indicated that 1) amphibian trapping and searching data provided limited biological information and was not cost-effective, 2) observer bias for bird community metrics was minimal, and 3) three sub-samples (counts) per wetland is the most cost-effective and will provide reasonable estimates of bird communities within wetlands.

Contaminants Component

Co-Principal Investigators - Deb Swackhamer and Matt Simcik (U of Minnesota, Twin Cities)
US EPA-MED Cooperators: Dave Mount, Gary Ankley, Russ Erickson, Phil Cook, Steve Diamond, and Larry Burkhard

The overall objective is to develop two indicators for assessing stress to coastal ecosystems caused by contaminants. One indicator will be based on photo-induced polycyclic aromatic hydrocarbon (PAH) toxicity to larval fish and the second to develop an indicator of endocrine disruption in fish from exposure to chemical mixtures that mimic estrogen. PAHs and chemicals with potential for endocrine disruption are ubiquitous contaminants in many coastal ecosystems, including the Great Lakes. Goals for 2001 were largely focused on establishing and validating field methods and assumptions. Exposure of organisms to UV light and PAHs has the potential to excite certain PAHs that are internal to the organism (bioaccumulated) and cause acute cell damage and death. Larval fish are considered to be sensitive organisms because of their transparency to light, because they may have significant light exposure during this early life stage, and because they have not yet developed enzyme systems capable of metabolizing PAHs. This indicator will be developed by collecting the following information from study sites and the lab: PAH concentrations in larval fish and in sediments to determine the exposure and biota-sediment accumulation factor (BSAF), toxicity of the sediment to our test organism (Oligochaeta: *Lumbriculus*), and UV dose to surface-dwelling organisms.

Pilot studies were completed in the summer of 2001 on Green Bay and southern Lake Superior in coordination with the Water Quality (WQ) Component and the Fish and Invertebrate Component. These pilot studies focused on field method development and QA issues, such as determining the minimum amount of sample needed for our analytical detection limits. We determined that dip nets with a mesh size of 500 um or less were the most efficient method tested for the collection of larval fish and that several hundred grams of material was sufficient. The methodology for indexing photo-induced toxicity potential using *Lumbriculus* exposed to field collected sediments has been well established. Summer research at MED included developing methods for exposing larval fish *in situ* at contaminated sites, which will be integral to establishing the connectivity of sediment chemistry, *Lumbriculus* response, and effects on larval fish.

The development of the endocrine disruption indicator based on environmental estrogen exposure requires a link between the occurrence of specific chemicals in coastal regions and environmental estrogen exposure to fish as indicated by a serum protein, vitellogenin (vtg). Vtg is a precursor to egg-yolk formation, and can be induced in both males and females in response to activation of the estrogen receptor. Vtg induction in males is an unambiguous indicator of exposure to exogenous and environmental estrogens. Our plan called for collecting bullheads from sites and measuring vtg in males to establish environmental estrogen exposure, and to measure contaminants in sediments and water to establish which suite of chemicals is a good

predictor of vtg induction. Our efforts thus far have focused on establishing methods to collect sufficient numbers of wild bullheads to demonstrate environmental estrogen exposure. Pilot studies in 2001 revealed that fyke nets were the most effective method for collections at sites where bullheads were plentiful. To ensure sufficient data collection at all sites, we will also deploy caged fathead minnows and assay their mRNA for vtg production to complement the data from wild fish. We have also designed the necessary experiments needed to develop and validate the vtg assay for the 2002 field season.

Diatom and Water Quality Component

Co-Principal Investigators: John Kingston and Richard Axler (NRRI, UMD); Jeff Johansen and Gerald Sgro (John Carroll University, Cleveland, OH); Eugene Stoermer (University of Michigan)

US EPA-MED Cooperators: Russell Kreis, Jo Thompson

The overall objective is to develop environmental indicators based on diatom communities in the coastal region of the US Great Lakes. The water quality component will provide background information on general conditions of the study sites selected for intensive study and aid in the interpretation of biological and chemical data gathered from the respective sites. Sampling of natural substrates in the Great Lakes coastal regions during the pilot phase was effective except for occasional problems on massive rock substrates. Most of our samples were gathered in sandy substrates. A large number of samples were gathered during the pilot phase to examine variability measurements and to potentially reduce sampling efforts in the future. Diatoms and water quality (WQ) were primarily gathered in association with the Fish and Invertebrate Component. A summary of the samples gathered include the following: 1) Lake Michigan (Green Bay): 97 diatom samples, 34 WQ samples, and 52 WQ profiles; 2) Lake Superior: 138 diatom samples, 57 WQ samples, 98 WQ profiles; 3) Lake Ontario: 35 diatom samples, 32 WQ samples, 32 WQ profiles, and 4) additional samples by John Carroll University, Cleveland, Ohio: 136 diatom samples, 83 WQ samples and profiles from Lakes Ontario, Erie, Huron, and Michigan. Water quality data consist of measurements such as temperature, dissolved oxygen, EC 25, water clarity (secchi and turbidity tube depths), nutrients (TN, NO3-N, NH4-N, TP, OP), chlorophyll-a, total suspended solids, turbidity, DOC, color, and chloride. These data are being examined for variability among and within sampling units. Relationships for possible surrogate measures of turbidity, total suspended solids, DOC, and chlorophyll-a are being examined. Measurements were also being made for UVB and UVA, but cost-effectiveness and usefulness of gathering these data are being explored. Diatom and water quality analyses are being processed and quality assured. Field sampling for 2002 will take place at about 120 sites, including most sites selected by the Fish and Invertebrate Group.

Fish and Invertebrate Component

Co-Principal Investigators - Lucinda Johnson (NRRI/UMD), Carl Richards (Sea Grant, Biology/UMD), Tom Hrabik (Biology/UMD) Jan Ciborowski (U. Windsor) - Co-Principal Investigators

US EPA - Cooperators - John Brazner, Naomi Detenbeck, Jack Kelly, John Morrice, Anett Trebitz, Mike Sierzen, Dan Tanner

The overall objective is to develop environmental indicators based on the fish and invertebrate communities in the US Great Lakes coastal region. A total of 14 areas were sampled during the

summer of 2001 including 6 in Lake Superior, 4 in Lake Michigan, and 4 in Lake Ontario. The combination of samples and transects within an area provides a good indication of zoobenthic community composition across a study site. As with diatoms, sampling of hard substrate has proven challenging. In addition, analyses are being completed to address the various options on how to most efficiently and economically sample fish and quantitatively assess habitat that is relevant to fish and invertebrates within the Great Lakes coastal region. Samples are currently being processed, quality assurance assessed, and sites for the 2002 field season are being selected. 2002 field sampling will take place at 60 sites; sites are located on all the five Great Lakes.

Wetland Vegetation Component
Co-Principal Investigators - Carol Johnston (NRRI/UMD), Joy Zedler (U of Wisconsin, Madison), Barbara Bedford (Cornell U)

The overall goal is to develop environmental indicators for wetland vegetation communities in the US Great Lakes coastal region. Three teams visited 29 wetland sites in the Great Lakes coastal region in 2001. A site was defined as a mostly contiguous cluster of National Wetland Inventory (or regional equivalent) units (polygons) classified as containing an emergent wetland type. Some reaches contained more than one site, but only one site per segment shed was surveyed. Duluth sites (Lake Superior between Duluth and Ashland) were generally smaller, Green Bay (western Lake Michigan) had some larger sites, and New York (eastern Lake Ontario) primarily encountered cattail beds. Within each site a target number of 1x1 m quadrats to be arranged along a transect were determined based on the site's area. Transects were then placed randomly in the site using ArcView; transect orientation was from dry to wet as determined by aerial photograph. Each transect extended from the landward limit of the emergent vegetation to the edge of the open water. GPS units were preloaded with the endpoints of the transects and used to locate the transects in the field.

Within each quadrat, water depth, tussock height, dominant vegetation height, and substrate (clay/silt/sand/organic) were recorded. Each species present was recorded and assigned to a percentage area cover class. In addition to plant species, cover types such as open water, standing water, bare soil, herbaceous litter, woody litter, driftwood, and brown moss were recorded. Locating transects with GPS units in the field was successful. Changes in lake levels since aerial photographs were taken meant that suggested transect positions sometimes had to be shifted in the field. Data have all been entered, quality assurance/control is being implemented, and some preliminary analyses have been performed to examine the potential relevance of using native and exotic plant distributions as environmental indicators of stress gradients. Sites are being selected for the 2002 field season.