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Center: The Atlantic Slope Consortium—Developing Ecological Indicators for Aquatic Ecosystems of the Atlantic Slope Region

Center Director: Robert Brooks

Title: Integrated Assessment of Estuarine Ecosystems

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Research Category: Environmental Indicators

Objective

This is one of four subprojects under the Atlantic Slope Consortium (ASC) center. The overall objective of the estuarine component of the ASC is to develop indicators for elements of hydrologically linked estuarine ecosystems, including aquatic animals, estuarine and coastal wetlands, and coastal waterbirds.

Progress Summary

In 2004, researchers focused on data analysis and interpretation for indicator development, and continued to prepare manuscripts for publication. Papers have been published on a number of the indicators described below (see list of publications); members of this subproject also gave a large number of presentations in 2004 (see list of presentations). In addition, local organizations (e.g., watershed associations) and the Chesapeake Bay Program have expressed interest in knowing more about estuarine indicators that have been developed as part of this study.

This subproject has been broken down into a number of interactive teams, each focusing on a different component of the estuarine system. Their progress toward indicator development is described below.

Estuarine faunal team (SERC)

Blue crabs and bivalves. The estuarine faunal team has published a manuscript on the effects of watershed land use and shoreline habitat on blue crabs and bivalves in estuarine segments in the *Journal of Experimental Marine Biology and Ecology*. The paper presents these taxa as key indicators of estuarine health, but also identified important abiotic predictors of their distribution that are easily measured and thus may serve as cost-effective indicators for targeting features for conservation or identifying areas that are likely to be degraded.

PCBs in White Perch. A paper has been published in *Environmental Science and Technology* on findings of a study on PCBs in white perch. Using data collected in 2002, total PCBs in white perch were related to the amount and spatial arrangement of developed land in watersheds that

discharge into 14 subestuaries of Chesapeake Bay. Simple regressions were used to test for relationships between unweighted or distance-weighted developed land-use measures, including four different representations of developed land. Total PCBs ranged between < 10 and more than 600 ng/g. Based on EPA guidelines, all subestuaries with > 4% distance-weighted commercial land in their watersheds are highly likely (95% probability) to have White Perch with total PCBs that would result in a consumption advisory of no more than 1 meal of white perch per month.

Avian Research Team (SERC)

Bird Indices. The goal of the avian research team has been to develop indicators of watershed condition using individual-, population-, and community-level attributes of wetland, riparian and water bird assemblages. Data collection on birds and their associated habitat was completed in 2003. Indicator development has included an Index of Marsh Bird Community Integrity (IMBCI) and an Index of Water Bird Community Integrity (IWBCI). Results of the marsh bird component of the study were published in *Wetlands* in 2004. Additional publications are in progress.

Stream and Wetland Assessment Team (SERC)

Stream macroinvertebrates and land cover. Analyses of the relationship between stream macroinvertebrates and land cover characteristics in Coastal Plain streams have resulted in at least two publications in 2004-05. This study used existing and new data collected in collaboration with the Maryland Biological Stream Survey (MBSS). Stream biota was related to land-cover using an extension of the partial Mantel test and the spatial arrangement between land-cover and streams was analyzed with several techniques. Stream biota was found to be influenced directly and indirectly by many factors, especially watershed development. Biotic assemblages changed markedly between 21 and 32% watershed development, and beyond 32% the probability was almost 100% that all streams would be biologically impaired. This number dropped to 18-23% when development near the stream was emphasized by using distance weights. A threshold analysis showed that it takes relatively little development to drastically alter the species composition of stream macroinvertebrates.

To date, all samples collected in the 2002 and 2003 field seasons have been processed except for a portion of the benthic samples collected by SERC in 2003. Processing of the remaining SERC benthic samples will be completed in the summer of 2005.

Wetland vegetation. The SERC avian team collected data on macrophyte species composition in brackish wetlands from the estuarine segments to support their bird surveys. These data were used by the SERC wetland/stream team to develop wetland vegetation indicators, with particular emphasis on the extent of *Phragmites australis* (Common Reed) invasion. To help identify potential causes of *Phragmites* expansion, particularly linkages to nutrient enrichment, *Phragmites* leaf samples were analyzed for C, N, and P. Nitrate concentrations in *Phragmites* leaves ranged from approximately 1.5 – 3.3% and concentrations were highest (2.5-3.3%) in leaves of plants in subestuaries that received runoff from developed watersheds. *Phragmites* was also more abundant in wetlands that were in subestuaries that were downstream of watersheds

that received runoff from developed watersheds. A manuscript describing these results has been prepared for submission to *Wetlands*.

Estuarine Shallow Water Habitats (VIMS)

During two field seasons, surveys were completed in estuarine watersheds to assess linkages between habitat and biotic community integrity in the nearshore. The primary research question was, can nearshore habitat be linked with biotic community integrity, and are these accurate indicators of aquatic ecosystem health?

Nearshore estuarine surveys were conducted in twenty-three watersheds in 2002-2003, and the associated laboratory components have been completed. Biotic communities (fish, macrobenthics) have been enumerated and indices estimated, and analyses of auxiliary physical and chemical parameters, such as suspended sediments, are complete.

Fish Communities

Eight metrics were assessed for consistency as indicators of aquatic ecosystem health based on fish community structure and function. Metrics were chosen that represent key aspects of fish community integrity, as well as the elements of life history that are dependent on estuarine condition. Fish species were placed into several guilds based on their documented life histories. Guilds were constructed based on reproductive strategy, trophic level, primary life history, habitat preference, and origin. Fish community metrics were then calculated for each survey year. Seven of the eight tested fish metrics exhibited similar trends in correlation and were thus combined into the final Fish Community Index (FCI).

Links among habitat conditions were supported in the relationships between subtidal habitat and shoreline condition, as well as shoreline and adjacent watershed land use. Shoreline condition and subtidal habitat measures were significantly correlated, indicating a negative association between shoreline alterations and available subtidal structural habitat, such as submerged aquatic vegetation and woody debris. Dominant watershed land use was reflected in shoreline land use conditions for all three of the categories.

Shallow-water estuarine condition was evaluated using the Fish Community Index (FCI). Habitat condition metrics developed at multiple spatial scales (subtidal habitat, shoreline condition and watershed land use) were evaluated for correlation to the FCI. Biotic responses were correlated with habitat condition in the nearshore and along the shoreline. Subtidal habitat had the strongest correlation with FCI scores and could discriminate among categorized habitat values. Shoreline and watershed land use condition were able to discriminate FCI scores in only highly altered habitat conditions. Analyses of the data sets suggest that fish community structure and the easily observed landscape conditions (watershed and shoreline) may be correlated. This association may provide the basis for development of a diagnostic indicator of estuarine condition.

Macrobenthic Communities

Two indices of macrobenthic biological integrity, 1) benthic index of biological integrity in the nearshore (B-IBIN); and 2) abundance biomass comparison (W-value), were evaluated for

associations with environmental and shoreline condition, and riparian and watershed land use. Comparisons between nearshore measures of the B-IBI with offshore values (> 2 m; Chesapeake Bay benthic index of biological integrity (B-IBICB)) were conducted to assess the relevance of this established index in shallow-water habitats. Nearshore macrobenthic communities were represented by a total of 94 species, and dominated by the phyla Arthropoda, Annelida and Mollusca. Temporal variability in environmental conditions and macrobenthic abundance and biomass may be attributable to the notable increase in precipitation in 2003 that led to nutrient influxes and algal blooms.

For all the biotic indices, the highest scores were associated with forested watersheds (W-value, B-IBIN, B-IBICB). Nonparametric changepoint analysis indicated a significant reduction in B-IBIN and W-value scores when the amount of developed shoreline exceeded 10 % and developed watershed exceeded 12 %, respectively. Both indices show promise for the discernment of watershed level impacts in nearshore environs. Watershed and shoreline land use may be effective integrative measures of stress that are able to infer the state of degradation in a system. Future research that leads to refinement of the B-IBI for shallow-water habitat, and incorporates shoreline and watershed land use measures may lead to viable management tools with particular applications on small watershed scales.

Future Activities

Future activities include preparation of the final report and preparation of additional manuscripts.

Publications and Presentations

Publications

Bilkovic, D.M., M. Roggero, C.H. Hershner and K.H. Havens. Influence of Land Use on Macrobenthic Communities in Nearshore Estuarine Habitats. *Submitted to Estuaries May 2005.*

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Presentations

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Bilkovic, D.M., C.H. Hershner, M.R. Berman, K.J. Havens, D.M. Stanhope and L.Varnell. September 30 - October 01, 2004. Evaluating Estuarine Indicators of Ecosystem Condition in the Nearshore of Chesapeake Bay. 4th Annual Estuarine and Great Lakes Indicator Development (EAGLE) meeting in Duluth, MN.

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King, R.S., M.E. Baker, D.F. Whigham, D.E. Weller, P.F. Kazyak, M.K. Hurd. Watershed urbanization and ecological thresholds in streams: influences of physiography, watershed size and spatial arrangement of impervious cover. Texas River and Reservoir Management Society Meeting, Waco, TX. May 2005.

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King, R. S., D. F. Whigham, et al. Linking watershed land use to ecological indicators in streams and subestuaries of Chesapeake Bay. Maryland Stream Monitoring Roundtable Meeting, Baltimore, Maryland. February 2004 (Invited).

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