

EPA Grant Number: R-82868401

Subproject: 001

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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Project Period: March 1, 2001 through February 28, 2005

Project Amount: See main project abstract

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

This subproject has been broken down into a number of interactive teams, each focusing on a different component of the estuarine system. The activities of each of these teams in 2003 are discussed below.

1. Estuarine faunal team (SERC): Hines, King, Craige, Sparks

1.1. Data collection and analysis

Sampling of nearshore zones of the estuarine segments in 2003 followed protocols used in 2002. A total of 132 nearshore stations in 22 estuarine segments were sampled in July and August 2003. In addition to nearshore sampling, bottom trawls of deepwater areas of 13 subestuaries were conducted in September and October 2003.

To date, all physical, chemical, and fish data collected during the nearshore and trawl surveys have been entered into the SERC database. QA/QC has also been completed and analyses have begun. Benthic invertebrate samples are currently being processed.

Although numerous other analyses are still underway, the estuarine faunal team has produced a manuscript on the effects of watershed land use and shoreline habitat on blue crabs and bivalves in the estuarine segments. The paper has been accepted (pending minor revisions) for publication 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.

1.2. Synergy and integration with other working groups and institutions

The SERC estuarine team has been working closely with the VIMS estuarine team of the ASC. SERC and VIMS both have adopted a study design that focuses on nearshore areas of small estuarine segments of the mid-Atlantic slope. A subset of estuarine segments is being studied by both groups. SERC and VIMS also coordinated estuarine sampling methods so that many data will be compatible for integrated analyses and publications. Moreover, these data are compatible with many existing datasets (e.g., Chesapeake Bay Program, Maryland Department of Natural Resources), which will allow both groups to apply existing indexes of estuarine condition (e.g., benthic IBIs) as well as link to data spanning much larger spatial scales (e.g., large watersheds, regions).

Outside of the ASC, the SERC estuarine working group has been in communication with the Great Lakes EaGLes Center (GLEI). As data analyses progress during 2004, the two groups will be in a position to contrast similar indicators between two very different estuarine environments. The SERC estuarine working group has also been active in developing synergistic relationships with state agencies in the Chesapeake Bay region, including collaboration with the Maryland Department of the Environment (MDE) on fish tissue data collection and analysis, and identification of benthic samples.

2. Avian Research Team (SERC): Marra, DeLuca.

2.1 Data collection and analysis

The goal of the avian research team is to develop indicators of watershed condition using individual-, population-, and community-level attributes of wetland, riparian and water bird assemblages. Sampling riparian bird communities was a new addition in 2003 and will help link watershed processes to estuarine condition.

During the 2003 breeding season, point counts were conducted in wetlands and riparian zones of 20 estuarine segments that represented a range of land cover types. These data will be used to characterize avian abundance and species richness among the estuarine segments. To measure abundance and species richness of open-water foraging birds at each wetland study site we conducted water transect surveys in each sub-estuary of every watershed.

Habitat measurements were also made. To measure marsh bird habitat, vegetation measurements were taken at each of the point-count locations that were not measured in 2002. Measurements included species composition, horizontal structure, and vertical structure. To measure riparian bird habitat, vegetation measurements were taken for segments in five study watersheds. Measurements included canopy cover, canopy height, ground cover, number of stems <8 cm DBH, and tree species with >8 cm DBH.

Bill DeLuca completed his master's thesis in May 2003 (see *Publications*). The avian team completed marsh data analysis and developed an Index of Marsh Bird Community Integrity (IMBCI). Results from a nonparametric changepoint analysis indicated that marsh bird

community integrity was significantly reduced when the amount of urban/suburban development within 500 m and 1000 m of the marsh exceeded 14% and 25%, respectively. There was no effect of land use on marsh condition at the watershed scale. These findings have been submitted to *Wetlands* (see *Publications*).

Data entry and quality assurance have been completed for water bird surveys, riparian bird and riparian bird habitat data. Currently, a Water Bird Index of Biotic Integrity (IBI) is being developed and preliminary results show index sensitivity to urban development at the watershed scale and to cropland at local scales. We plan to submit these results for publication in April 2004.

2.2 Synergy and integration with other working groups and institutions

The SERC avian team has been coordinating efforts with the SERC estuarine faunal team, and vice-versa. In Years 2 and 3, both teams sampled the same estuarine segments to facilitate integration of indicators. Consequently, water-foraging bird data are being linked to fish abundance, habitat, and water quality estimates. The SERC avian team has also been working with Tim O'Connell from the PSU watershed group. Tim has provided expertise on avian IBI development and both groups have discussed ways to integrate their IBI results from a variety of different habitats.

3. Wetland and Stream Assessment Team (SERC): Whigham, King, Sparks

3.1 Data collection and analysis

The SERC wetland/stream team undertook several research activities during Year 3.

Stream bioassessment. As part of a collaborative effort with the Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS), SERC sampled 62 streams from 22 estuarine segments in spring of Year 3. SERC is utilizing new and existing MBSS data to characterize condition of streams in the estuarine segments, and to better understand the effect of land use on stream ecosystems in this region. These data will be used to calculate the coastal plain benthic IBI. Ryan King, Matt Baker, Dennis Whigham, Don Weller, and Tom Jordan have completed a manuscript with DNR biologists on spatial considerations for linking watershed landcover to various stream indicators in coastal plain streams using existing data from the MBSS (see *Publications*).

Wetland vegetation sampling. The SERC avian team collected data on macrophyte species composition in brackish wetlands from the estuarine segments to support their bird surveys. These data will also be used by the SERC wetland/stream team to develop wetland vegetation indicators, with particular emphasis on the extent of *Phragmites australis* invasion. To help identify potential causes of *Phragmites* expansion, particularly linkages to nutrient enrichment, *Phragmites* leaf samples were collected from the estuarine segments this summer for leaf-tissue nutrient and metals analysis. All samples were analyzed for C, N, and P.

Riparian assessments. Bill Sipple was hired to conduct riparian assessments as part of the unified ASC stream, wetland, and riparian (SWR) indicator study. Bill completed 20 site assessments in each of the Back River (developed), Southeast Creek (agricultural), and St. Mary's River

(forested) watersheds. These data were collected following the SWR protocol developed by ASC. Data were submitted to PSU in mid-2003 for entry into the ASC SWR database.

3.2. Synergy and integration with other working groups and institutions

The SERC wetland/stream team is working closely with the SERC watershed/spatial analysis team to develop linkages between spatial data and site-level stream assessment data. One current activity is the application of a variety of distance-weighting schemes to landcover data to identify the most influential scales and patterns of watershed landcover on stream biological condition. A second planned activity is the integration of results from the SERC spatial team's summary of land-use patterns in estuarine segments to estuarine water quality and biological indicators.

The SERC wetland/stream team also anticipates integrating with PSU to explore how relationships between land use in coastal plain streams may differ in other physiographic provinces where most of PSU's work has been conducted.

A significant synergistic activity outside the ASC has been the collaboration with the MD DNR and integration with the MBSS, as previously described. MD DNR has provided guidance on using much of the public-domain data and has been quick to provide SERC with in-house data. This working relationship has been mutually beneficial, as the SERC stream data have also been submitted to DNR and the Maryland Water Monitoring Council (MWMC) for their databases. It has also increased visibility of the EaGLes program.

4. Estuarine Shallow Water Fish Habitats (VIMS)

4.1 Data collection and analysis

During June–August 2003, we surveyed 12 watersheds with varying land uses within the Chesapeake Bay estuarine region and Albemarle Sound, North Carolina. Of these watersheds, two that were sampled in 2002 were reassessed in 2003 due to the lack of historic data in these regions. Many of the watersheds selected will coincide with efforts at SERC and PSU in assessing the health of estuarine wetland systems.

Our sampling protocols targeted zooplankton, macroinvertebrate and fish communities, water quality measures, sediment type, and shoreline and physical habitat assessments. Within each watershed we sampled five sites, corresponding with historic beach seine locations when present. At these locations, all of the above components were sampled except for the fish communities, which are to be represented by ongoing survey efforts. In watersheds containing less than five historic seine sites, we randomly sampled sites to supplement the seine data sets. We then utilized the same protocol followed in the historic surveys to sample fish communities; we also sampled all of the above listed components.

Abundance of fish and zooplankton communities has been enumerated for both sample years. Additionally, biomass measures were estimated for zooplankton communities. Macroinvertebrate abundance and biomass estimates are near completion; suspended sediment analyses were completed; and sediment typing is near completion.

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. As a first step in the calculation of fish community metrics, 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 sample year.

In 2002, links among habitat conditions were supported in the relationships between in-stream and shoreline condition, as well as shoreline and adjacent watershed land use. Shoreline condition and in-stream habitat measures were significantly correlated, indicating a negative association between shoreline alterations and available in-stream 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 a Fish Community Index (FCI) developed based on 2002 data. Seven of the eight tested fish metrics exhibited similar trends in correlation and were thus combined into the final FCI. Habitat condition metrics developed at multiple spatial scales (in-stream 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. In-stream 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. Preliminary analyses of fish community data from 2003 sampling indicate similar trends in correlation as evident in 2002.

Future Activities

Estuarine Faunal Team (SERC). Nonparametric changepoint analysis will be used in conjunction with CART to estimate ecological thresholds and provide risk estimates associated with increasing levels of stressors in the estuarine segments, which include indicators developed by other working groups in other portions of the watersheds. Ordination techniques will be used to examine multivariate community patterns and their relationships with abiotic or other biotic variables. A nearshore fish IBI has been developed using VIMS shoreline seine data. SERC plans to employ this IBI to explore its applicability to estuarine segments. A joint manuscript, led by VIMS, on fish and possibly benthos is also being planned for 2004.

Avian Research Team (SERC). Spring of Year 4 will largely be dedicated to preparing a manuscript on the Water Bird IBI and another manuscript on the influences of land use on breeding Red-winged Blackbirds and other marsh nesting passerines. Data collection in Year 4 will be restricted to completing the riparian bird habitat sampling and continuing to monitor the marsh bird communities of the nine intensely studied estuarine segments.

Wetland and Stream Assessment Team (SERC). SERC stream data will be used to characterize condition of the stream network of each estuarine segment and evaluate the potential for a linkage between stream and estuarine health. Linkages between stream ratings and estuarine indicators measured by the estuarine faunal, avian, and optical properties teams will be explored. In addition, several manuscripts are in preparation: (1) a King et al. manuscript on spatial considerations and stream indicators, (2) a King et al. manuscript that will identify levels of watershed land use, particularly urban/suburban development, that result in ecological thresholds in coastal plain and piedmont streams, (3) a King and Whigham manuscript on the linkage between watershed land use and N and P concentrations in *Phragmites*, and (4) a Whigham et al. manuscript on the estuarine segment approach to evaluating watershed effects on estuarine indicators. This paper will draw on results from all ASC institutions and will present an integrated, synthetic overview of our studies of stream, wetland, and estuarine indicators.

Publications and Presentations

Publications

Bilkovic, D.M., C.H. Hershner, M.R. Berman, K.J. Havens and D.M. Stanhope. Evaluating nearshore communities as indicators of ecosystem health. *Estuarine Indicators Workshop Proceedings*, CRC Press, Inc. *Submitted*.

DeLuca, W. V. 2003. Multi-scale factors influencing marsh bird communities of the Chesapeake Bay: Developing a marsh bird community index. M. S. Thesis, George Mason University, Fairfax, Virginia.

DeLuca, W. V., C. E. Studds, L. L. Rockwood and P. P. Marra. Influence of land use on the integrity of marsh bird communities of the Chesapeake Bay, USA. *Wetlands*. (Under review).

DeLuca, W. V., C. E. Studds, P. P. Marra. Land use effects on breeding marsh passerines. *Journal of Field Ornithology*. (Plan to submit Spring 04)

DeLuca, W. V., R. S. King, P. P. Marra, and C. E. Studds. Factors influencing waterbird communities of the Chesapeake Bay, USA. *Estuaries or Waterbirds*. (In preparation.)

King, R. S., A. H. Hines, F. D. Craige, and S. Grap. Regional, watershed, and local correlates of blue crab and bivalve abundances in subestuaries of Chesapeake Bay. *Journal of Experimental Marine Biology and Ecology*, in press.

King, R. S. and D. F. Whigham. Watershed land use influences nutrient concentrations of *Phragmites australis* leaves in subestuaries of Chesapeake Bay. *Wetlands*. (In preparation.)

Whigham, D.F., M. Baker, D.M. Bilkovic, W.V. DeLuca, C.L. Gallegos, A.H. Hines, T.E. Jordan, R. King, P.P. Marra and D.E. Weller. Linking land-use to stream, wetland, and estuarine indicators. *In prep*.

Presentations

Berman, M. R., D. M. Bilkovic, T. Rudnický and C. Hershner. Evaluating shoreline conditions at different spatial scales: implications as an ecological indicator. Using Science To Assess Environmental Vulnerabilities, a ReVA-MAIA Conference, Valley Forge - King of Prussia, PA, May 13-15, 2003.

Bilkovic, D.M., M.R. Berman, C.H. Hershner, K.J. Havens, D.M. Stanhope and L.Varnell. Evaluating estuarine indicators of ecosystem condition in the nearshore of Chesapeake Bay. 3rd Annual Estuarine and Great Lakes Indicator Development (EAGLE) meeting, Bodega Bay, CA, December 3-5, 2003.

Bilkovic, D.M., M.R. Berman, C.H. Hershner, D. M. Stanhope, K.J. Havens and L.Varnell. Evaluating shoreline conditions as indicators of ecosystem health in estuarine nearshore. Estuarine Research Federation Conference, Seattle, WA, September 14-18, 2003.

Bilkovic, D.M., C.H. Hershner, M.R. Berman, K.J. Havens, and D. M. Stanhope. Evaluating nearshore communities as indicators of ecosystem health. Estuarine Indicator Workshop in Sanibel Island, FL, October 29-31, 2003.