

**Atlantic Slope Consortium  
Annual Report Summary  
March 1, 2003 – February 28, 2004**

**EPA Grant Number:** R-82868401

**Center:** The Atlantic Slope Consortium

**Center Director:** Robert Brooks

**Title:** The Atlantic Slope Consortium - Developing Ecological Indicators for Aquatic Ecosystems of the Atlantic Slope Region

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**Institutions:** Pennsylvania State University, Smithsonian Environmental Research Center, Virginia Institute of Marine Sciences, East Carolina University, Environmental Law Institute, FTN Associates

**EPA Project Officer:** Barbara Levinson

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

**Project Amount:** \$6,000,000

**Research Category:** Environmental Indicators

### **Objective of Research**

The goal of the Atlantic Slope Consortium (ASC) is to develop and test a set of indicators in freshwater and coastal systems that are ecologically appropriate, economically reasonable, and relevant to society. Specific objectives, as presented in the original proposed scope of work, include: (1) develop and test ecological and socioeconomic indicators of aquatic resource condition, construct models that use environmental, geographic, and stressor data to predict indicator responses, and use models to link upstream watersheds and downstream estuaries; (2) develop large scale measures for characterizing landscape attributes and land-use patterns to serve as predictors of a range of environmental conditions; and (3) deliver a nested suite of indicators to managers, where the implications of aggregating models at various scales are considered, and for which reliability is known.

These objectives were restated in the project vision statement, developed collaboratively by the project team, as follows:

The ASC uses a universe of watersheds, covering a range of social choices (as reflected in differing land use/ land cover), and asks two questions:

1. How “good” can the environment be, given those social choices?
2. What is the intellectual model of condition within those choices, i.e., what are the causes of condition and what are the steps for improvement?

Following development and articulation of the vision statement, many of the project tasks were oriented to specific portions of this statement. This ensures that a common vision is consistently pursued throughout the project.

## **Progress Summary**

Year 3 of the ASC project included collection and analysis of field data, exploration of landscape-level indicators, socioeconomic surveys and modeling, and greater emphasis on integrating the various components of the project. A summary of these activities is given below. Additional details can be found in the reports for individual subprojects.

### *Estuarine Data Collection and Analysis*

In general, field data collection initiated in prior years continued in Year 3. Sampling included measurements of biota (e.g., estuarine fauna, birds, wetland vegetation, and stream macroinvertebrates) as well as abiotic condition (e.g., water quality, sediment, in-stream habitat). Shoreline surveys and measurement of optical properties also were undertaken. Data analysis has been ongoing and indicators are in various stages of development.

Estuarine faunal indicators. Analyses of estuarine faunal data, and associated physical and chemical habitat, have been focused on exploring the relationships among local, watershed, and regional-scale indicators, as well as linkages between abiotic and biotic indicators. For example, we identified important abiotic predictors of the distribution of two key indicators of estuarine health, blue crabs and bivalves. These abiotic predictors 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. In a separate but related effort, a Fish Community Index (FCI) was developed for nearshore fish based on 2002 data; this index is now being used to look for correlations with easily observed watershed and shoreline conditions.

Avian indicators. This project component aims 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; this will help link watershed processes to estuarine condition. An Index of Marsh Bird Community Integrity (IMBCI) has been developed, and a Water Bird Index of Biotic Integrity (IBI) is under development. The influence of land use on breeding Red-winged Blackbirds and other marsh nesting passerines is also being studied.

Wetland vegetation indicators. Data collected on macrophyte species composition in brackish wetlands as part of the bird surveys are being used to develop wetland vegetation indicators, with particular emphasis on the extent of *Phragmites australis* invasion. To help identify potential causes of this species' expansion, particularly linkages to nutrient enrichment, *Phragmites* leaf samples are being analyzed for nutrient and metals content.

Stream indicators. Continued sampling of benthic macroinvertebrates and related physical habitat parameters took place in the freshwater portion of estuarine segments, in collaboration with the Maryland Department of Natural Resources' Maryland Biological Stream Survey

(MBSS). These data, combined with existing data, are being used to calculate the coastal plain benthic Index of Biotic Integrity (IBI). An investigation of spatial considerations for linking watershed landcover to various stream indicators in Coastal Plain streams, based on existing MBSS data, has recently been completed.

Optical indicators. An optically based indicator of habitat suitability for submerged aquatic vegetation (SAV) was derived and applied to mesohaline subestuaries of Chesapeake Bay (Maryland and Virginia) with differing land uses, and in the North River, North Carolina. The indicator utilizes concentrations of optically active water quality parameters to determine whether sufficient light penetrates the water column for growth of SAV. In addition, collaborative studies were concluded with investigators in the ACE-INC EaGLes in Morehead City, NC. Comparisons have been made between optical properties at the more energetic sites studied by ACE-INC and the more protected sites being studied by ASC.

#### *Watershed Data Collection and Analysis*

Physical habitat/ landscape indicators. A sampling protocol for Stream, Wetland, and Riparian (SWR) areas, developed collaboratively by the ASC team in Year 2, was applied at twenty points in each of 24 watersheds in the study region. These data have been entered into a MS Access database, and analysis is currently underway. To allow for cross-comparisons between the SWR data and landscape-level metrics, information was generated on landcover characteristics in a 1-km circle surrounding each SWR point, and for each HUC-14 watershed, from the National Land Cover Data (NLCD). Existing biological datasets, including benthic macroinvertebrate data from EMAP and the MBSS, will be used to validate assessments of aquatic ecosystem health generated by physical habitat metrics (at the site level), and by landscape metrics (in 1-km circles and at the watershed scale).

In addition, as an outgrowth of developing the SWR protocol, a preliminary assessment procedure was developed for headwater riparian systems in North Carolina. This assessment protocol is being revised to reflect reference conditions in North Carolina watersheds and to meet specific needs of the North Carolina Wetland Restoration Program (WRP) program.

Landscape indicators. An existing nutrient discharge model and GIS are being used to explore the efficacy of geographic data (beyond physiographic province and land use/land cover) in predicting nutrient discharges. Factors being explored include the spatial arrangement of landscape features, particularly source areas and riparian forests; the effects of improved hydrologic characterization; and the influence of wetlands. Attention has also been focused on identifying the ways that choice of geographic data sources and their resolution, and choice of specific metrics effect predictions of nutrient discharge. This modeling will allow linkages between geographic data and water chemistry data, and ultimately, biological condition.

#### *Human Dimensions Working Group*

The Human Dimensions Working group developed two innovative approaches for ranking the relative efficiency of communities in the region in producing a high quality of life and environment. One is based on data envelopment analysis and uses minimal value judgments.

The second imposes stronger value judgments derived from observed human residential (i.e., human habitat) choices. Secondary data was used for proof-of-concept; the group is currently moving toward an application to communities in ASC watersheds.

The working group also (1) produced frameworks for combining economic and environmental data water quality policy analysis in the specific context of designing pollution trading programs for point and nonpoint sources of water pollution and managing invasive species that threaten aquatic resources; (2) developed theory to guide the interpretation of economic and environmental data for sustainability analysis; (3) explored the use of stochastic frontier analysis for assessing the efficiency of land use change; and (4) examined institutional and legal obstacles to effective integration of ecological indicators into decisionmaking.

Finally, the working group is exploring methods and results to estimate societal value of various types of economic and environmental information for water quality management, and methods for data collection. Methods and results are being developed on the value of information for managing nitrogen loads in the Susquehanna River Basin of Pennsylvania. Team members continue to refine the methods and apply them to ASC watersheds.

#### *Development of ASC “Messages”*

The ASC management team met during the summer of 2003 to set strategies for pulling together the various components of ASC research. Out of this meeting came four “messages” that the group saw emerging from the research to date. These messages will serve as organizing themes for the final year and a half of the project. These messages were as follows:

1. A taxonomic key of indicators, using land use categories as surrogates for social choices, can be used to: (a) assess condition, (b) diagnose condition, (c) measure management performance, and (d) communicate ecological condition to the public and stakeholders. This taxonomic key indicates there are both multiple ecological states and multiple reference conditions that satisfy various social choice categories.
2. Correspondence or linkage has been established among coastal watershed indicators and near-field estuarine indicators for various social choice categories. This correspondence provides insight into the effects of different watershed management practices on estuarine ecosystems.
3. Correspondence or linkage has been established among upstream watershed indicators and associated stream and downstream aquatic ecosystem indicators for various social choice categories. In addition, the scaling relationships have been established for aggregating watershed indicators from 14 => 11 => 8 digit HUCs to downstream water quality indicators.
4. Social well-being indicators can be empirically linked with environmental quality indicators, for various social choice categories. The consequences of social choices on both social well-being and the environment can be assessed.

These messages correspond roughly to the original sub-proposal and working group structure of the ASC. The main difference is that Message 1 integrates across components of the project, and Message 2 relates to both the estuarine and optical indicators sub-proposals. These messages will form the core of the final ASC report.

### **Future Activities**

The final year of the project will be devoted to analyzing data collected in prior years, interpreting results, and pulling together the pieces of the project into an integrated whole. There will be an increased focus on manuscript preparation and submittal, as well as final report preparation.

### **Publications and Presentations**

#### *Publications*

Balog, A. 2003. User perspectives on environmental indicators for aquatic ecosystems: Results from water quality officials in the Mid-Atlantic states. M.S. Environmental Pollution Control.

Biber, P. D., H. W. Paerl, C. L. Gallegos, W. J. Kenworthy and M. S. Fonseca. 2004. Evaluating indicators of seagrass stress to light limitation in North Carolina. In S. A. Bortone [eds.], Estuarine Indicators Workshop. CRC Press, in press.

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.

Borisova, T. 2003. Coping with uncertainty in water quality management through choices of policy instruments and information investments, Ph.D., Agricultural, Environmental, and Regional Economics.

Cai, Y. 2003. Integrating environmental and socioeconomic indicators of quality of life assessment using data envelopment analysis, M.S., Agricultural, Environmental, and Regional Economics.

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).

Horan, R., and J. Shortle. When two wrongs make a right: Second best point-nonpoint trading ratios. Revise and resubmit from the American Journal of Agricultural Economics.

Horan, R., J. Shortle and D Abler. Forthcoming. The coordination and design of point-nonpoint trading programs and agri-environmental policies. Resubmission in review for publication in *Agricultural and Resource Economics Review*.

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 C. J. Richardson. 2003. Integrating bioassessment and ecological risk assessment: an approach to developing numerical water-quality criteria. *Environmental Management* 31:795-809.

Marshall, E., Y. Cai, and J. Shortle. The efficiency of quality of life provision in the Mid-Atlantic states. *Agriculture and Resource Economics Review*. Under review.

Marshall, E., and J. Shortle. Forthcoming. Urban development impacts on ecosystems. In S. Goetz, J. Shortle, and J. Bergstrom Eds., *Land Use Problems and Conflicts: Causes, Consequences and Solutions*. Routledge Publishing.

Molineros, J. 2003. Land allocation inefficiency in four South American countries: The problem of deforestation, M.S., *Agricultural, Environmental, and Regional Economics*.

Patil, G. P., J. Bishop, W.L. Myers, C. Taillie, R. Vraney, and D. H. Wardrop. Detection and delineation of critical areas using echelons and spatial scan statistics with synoptic cellular data. *Environmental and Ecological Statistics*, in press.

Ranjan, R., L. Marshall, and J. Shortle. Optimal renewable resource management in the presence of endogenous risk of invasion. Revise and resubmit for publication in *Environmental and Resource Economics*.

Wardrop, D.H., J.A. Bishop, M. Easterling, K. Hychka, W.L. Myers, G.P. Patil, and C. Taille. Use of landscape and land use parameters for classification and characterization of watersheds in the Mid-Atlantic across five physiographic provinces. *Environmental and Ecological Statistics*, in press.

### *Presentations*

Abrahams, N. and J. Shortle. 2003. The performance of compliance measures and instruments in nitrate nonpoint pollution control under uncertainty. Presented at the NAREA workshop, Linkages Between Agricultural and Conservation Policies, Portsmouth, NH, June 2003.

Balog, A., J. Kipp, J. Shortle, A. Fisher, R. O'Connor, J. Finley, and E. Marshall. 2003. Human dimensions of ecological indicators. Presented at the U.S. EPA workshop on Tools for Assessing Regional Environmental Vulnerability, Valley Forge, PA, May 2003.

Balog, A., J. Kipp, J. Shortle, A. Fisher, R. O'Connor, J. Finley, and E. Marshall. 2003. Human dimensions of ecological indicators. Presented at the Annual Meeting of the Ecological Society of America, Atlanta, GA, August 2003.

Bason, C. W. and M. M. Brinson. 2003. Effects of beaver impoundments on water quality in the coastal plain. Oral presentation at the 2003 Society of Wetland Scientists meeting in New Orleans, LA.

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. 3<sup>rd</sup> 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.

Borisova, T. J. Shortle, R. Horan, and D. Abler. 2003. The value of information for water quality risk management. Presented at Annual Meeting of the Risk Society, Washington, DC, October 2003. Revised and to be submitted soon to *Water Resources Research*.

Borisova, T, J. Shortle, R. Horan, and D. Abler. 2003. The value of ecological and economic information in water quality management. Presented at the Annual Meeting of the American Agricultural Economics Association, Montreal, Canada, July 2003.

Brinson, M. M. 2004. General landscape scale concepts. Presented at a workshop: GIS-Based Functional Assessment of Stream in North Carolina, Raleigh, NC. Organized by the Ecosystem Enhancement Program of North Carolina, 21 January 2004.

Horan, R., J. Shortle, and D. Abler. 2003. The coordination and design of point-nonpoint trading programs and agri-environmental policies. Presented at the NAREA workshop on Linkages Between Agricultural and Conservation Policies, Portsmouth, NH, June 2003.

Ranjan, R., J. Shortle, and E. Marshall. 2003. Optimal renewable resource management in the presence of endogenous risk of invasion. Presented at the Annual Meeting of the Northeastern Agricultural and Resource Economics Association, Portsmouth, NH, June 2003.

Ranjan, R., J. Shortle, and E. Marshall. 2003. The environmental Kuznets Curve: When the environment exhibits hysteresis. Presented at the Annual Meeting of the American Agricultural Economics Association, Montreal, Canada, July 2003.

Rheinhardt, R.D., M.M. Brinson, R.R. Christian, K.H. Miller, and G.F. Meyer. 2003. Developing and calibrating an indicator for biogeochemical condition of headwater riparian ecosystems. Poster presented at the Bodega Bay EaGLes meeting in December 2003.

Rheinhardt, R.D., M.M. Brinson, R.R. Christian, K.H. Miller, and G.F. Meyer. 2003. A series of presentations on reference sites in the Little Contentnea Creek watershed that preceded a half-day field trip demonstrating a preliminary assessment method. Presented to NCWRP in December 2003.

Shortle, J. 2003. The theory of performance based policy instruments. Invited Presentation at the workshop on Performance Based Environmental Policies for Agriculture, sponsored by the Farm Foundation, Winrock International, and USDA-ERS, Washington, DC, March 2003.

**Supplemental Keywords:** indicators, integrated assessment, aquatic ecosystem, wetland, stream, estuary, watershed, biological integrity, landscape ecology, scaling, socio-economic, decision-making, GIS, Mid-Atlantic.

**Relevant Web Site:** [www.asc.psu.edu](http://www.asc.psu.edu)