United States Environmental Protection Agency

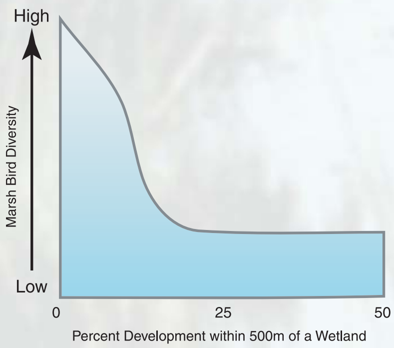
New Tools Measure Chesapeake Bay Health

Introduction

The areas where the Chesapeake Bay's tributaries meet the Bay form the shallow-water ecosystems that provide breeding areas and protection for many of the seafood delicacies and waterfowl that humans cherish. These areas, called sub-estuaries, receive and process inputs (sediment, chemicals, sewage, fertilizer, etc.) from local watersheds that are mixed and exchanged with material from the Bay. Research has shown that human activities directly influence these shallow-water ecosystems. Any degradation of these systems impacts our quality of life – our health, what we eat, where we swim, what we observe, and the aesthetic quality of what we view.

Points at which major changes can be measured are considered thresholds. Based on the percentage of development/impervious surfaces (e.g., highways, streets, parking lots and buildings) and distance from the water, thresholds have been identified to determine how much and where development can occur before the estuary begins to severely degrade. Thresholds can also be used to help identify where management and restoration could reverse the consequence of previous stress from development.

Marsh bird diversity, polychlorinated biphenyls (PCBs) in white perch, and abundance of submerged aquatic vegetation (SAV) are three ecological indicators linked to land-use that are being investigated by the Smithsonian Environmental Research Center (SERC) as part of the Atlantic Slope Consortium (ASC). These studies provide strong evidence that the environmental and ecological conditions of estuaries depend on the land use in their associated watersheds. Scientists suspect that numerous other responses in estuaries are also related to development. Future research, combined with the work done by ASC, will help in better understanding the impacts of development on these estuaries.



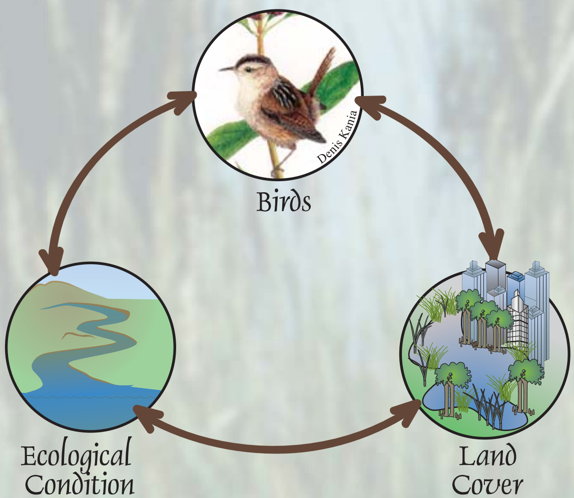
Marsh Bird Diversity

Development of the land alters the habitat needed for birds to breed. The types of birds found in an area indicate both the ecological condition and the type of land-cover found in that area. As the land-cover of an area changes, habitat and the types of birds also change.

Ecological Indicator: The diversity of birds that breed in wetlands is an ecological indicator of estuarine health.

Ecological Effect/Impact: Researchers from SERC have found that there is a precipitous drop (threshold) in the diversity of the bird community that breeds in estuarine wetlands when more than 14% of the land is developed in the area that is within 500 meters of a wetland boundary.

Environmental Application: Land use planners at the local, state, and national level; environmental advocacy organizations; fish and wildlife agencies; restoration agencies and consultants can use this information when planning for development and restoration activities. By understanding the implications of placement and pattern in the watershed, appropriate buffer (riparian) zones can be designed into development and restoration plans.



DeLuca, W. V., C. E. Studds, L. L. Rockwood, and P. P. Marra. 2004. Influence of land use on the integrity of marsh bird communities of Chesapeake Bay, USA. Wetlands 24(4):837-847.

Photo of Least Bittern used with permission of photographer, Robert Bennetts

Symbols for diagrams (left: Ecological Condition/Land Cover) courtesy of the Integration and Application Network (www.ian.umces.edu/symbols), University of Maryland Center for Environmental Science.

Bird (marsh wren) illustration used with permission of artist, Denis Kania

PCBs in White Perch

Polychlorinated biphenyls (PCBs) are mixtures of chlorinated compounds that have no known natural sources; they were banned from production in the USA in 1977. Until then, PCBs were used as coolants and lubricants in electrical equipment because they are good insulators and do not burn easily. PCBs entered the air, water, and soil during their manufacture, use, and disposal from accidental spills and leaks during transport and from leaks or fires in products containing them. They do not readily break down in the environment and they remain there for long periods of time. They are widely distributed in aquatic ecosystems and remain sufficiently high in many water bodies to contaminate the food web and result in consumption advisories for valuable fish and shellfish species.

White perch are an ideal indicator species because they spend most of their lives within or near specific sub-estuaries. They are semi-anadromous, moving into freshwater tributaries to spawn and back into sub-estuaries to feed. This life cycle continuously exposes them to runoff from the watershed.

Ecological Indicator: The level of PCBs in white perch is an ecological indicator of aquatic condition.

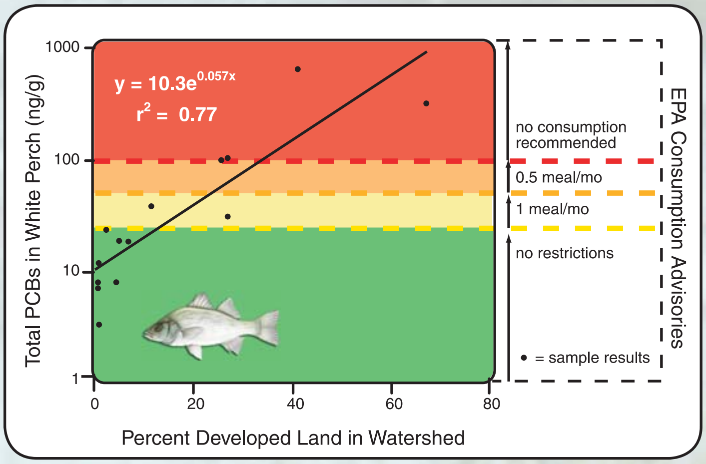


Figure 1. Total PCBs in white perch in relation to percent developed land in the watershed.

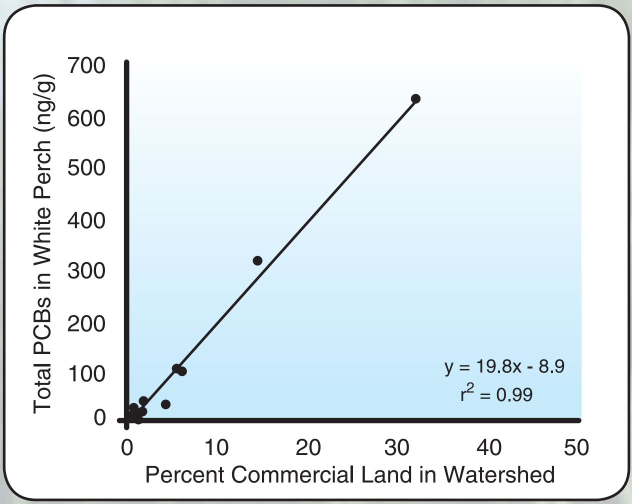


Figure 2. Total PCBs in white perch in relation to percent commercial land weighted by its proximity to the subestuary.

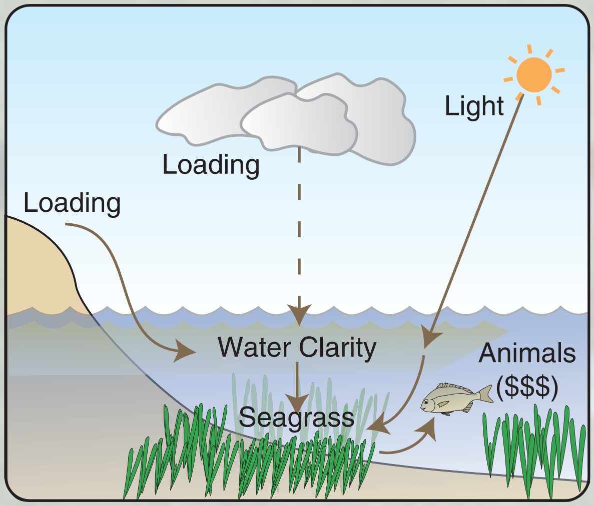
Ecological Effect/Impact: White perch are eaten by humans as well as larger fish, birds, and mammals. PCB levels bio-accumulate in animals (such as white perch) and, therefore, can reach thousands of times higher than the levels found in water. The health effects associated with human consumption of PCBs include acne-like skin conditions and neurobehavioral and immunological changes in children. PCBs are also known to cause cancer in animals.

SERC's research demonstrates that levels of PCBs in white perch are strongly linked to the percent of development in a watershed, with dangerous PCB levels attained at a relatively low percent of development (Fig. 1). PCB levels in these fish begin to exceed EPA recommended levels for restricting food consumption before development reaches 20% of the watershed area. The levels of PCBs in white perch are more highly influenced by the percent of commercial development closer to the shoreline than by commercial development farther away (inverse distance weighted – IDW) (Fig. 2). This relationship exists for watersheds with less-intensive residential/suburban development as well as watersheds with highly polluting urban/commercial development. SERC's models show that type of land use, particularly development, and its proximity to the estuary's tributaries have important impacts on the PCB levels in white perch.

Environmental Application: The field sampling and laboratory testing of fish currently used to prepare consumption advisories is very costly. The SERC models can predict PCB concentrations in white perch at a significantly reduced cost. PCB consumption advisories have been developed for several Chesapeake sub-estuaries, but there is great interest in using this method to assess others. Other contaminants frequently co-occur with PCBs and SERC's models will also be useful for identifying and predicting them.

King, R.S., J.R. Beaman, D.F. Whigham, A.H. Hines, M.E. Baker, and D.E. Weller. 2004. Watershed land use is strongly linked to PCBs in white perch in Chesapeake Bay subestuaries. *Environmental Science and Technology* 38:6546-6552. DOI 10.1021/es049059m.

Submerged Aquatic Vegetation



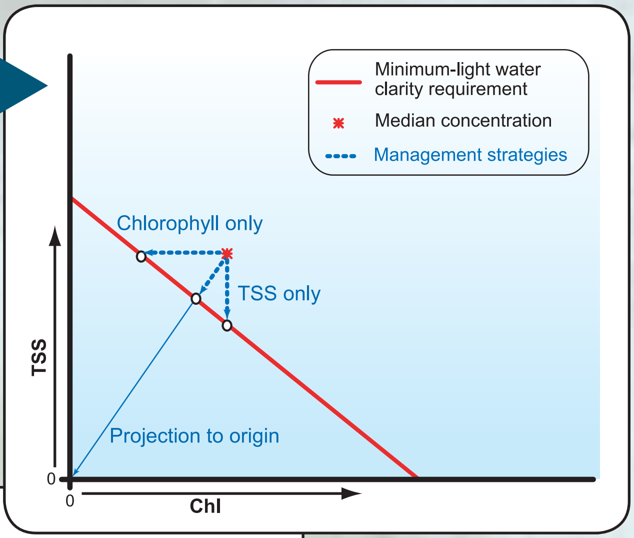
www.ian.umces.edu/symbols

A healthy community of underwater plants known as submerged aquatic vegetation (SAV) or seagrass is essential for a healthy Chesapeake Bay. These plant communities provide food for waterfowl and shelter for shellfish, invertebrates, and fish. Ecosystem services provided by SAV abound. Microscopic algae living on the grass blades are the base of a food chain that leads up to blue crabs, shrimp, bay barnacles, white perch, croaker, and a myriad of other species we care about. SAV helps stabilize bottom sediments, provides a protective nursery for many aquatic organisms and is a valuable food source for waterfowl.

Ecological Indicator:
Researchers at SERC have developed a bio-optical model based on total suspended solids (TSS) and algal chlorophyll (Chl) for monitoring the optical properties of the water column in the Chesapeake Bay. The new procedures have produced a diagnostic tool for setting water clarity targets for seagrass protection.

Ecological Effect/Impact:
Seagrasses need relatively high amounts of light to grow and survive. Decreased light penetration limits the growth and distribution of seagrasses. Turbidity, chlorophyll, and color naturally decrease light with greater depth. Increases in sediment and nutrients from development on the land can lead to algal blooms and coatings on seagrass leaves, which block light and can ultimately kill the SAV.

Figure 3. Target minimum water clarity requirements for seagrass survival are found along the red line on this graph. To assess a site, the median concentrations for Chl and TSS are plotted on the graph. This example shows three TSS and Chl reduction strategies (blue dotted lines) that could meet the minimum light requirements at this site.



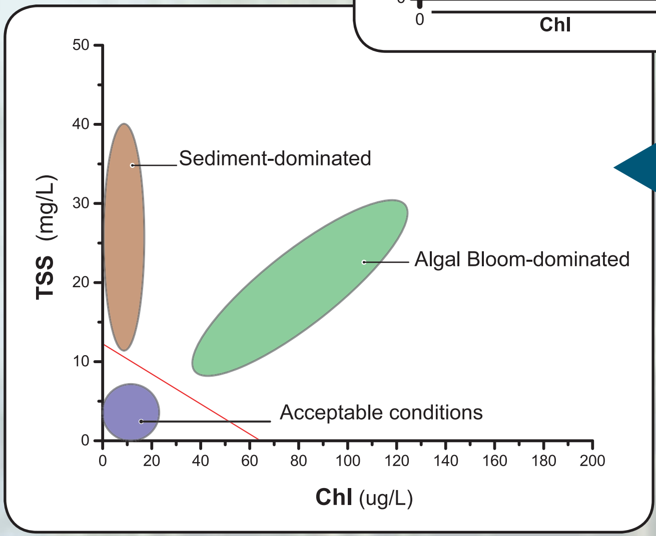


Figure 4. Stresses related to water-clarity conditions fall into sediment-dominated, or algal bloom-dominated regions. Acceptable water clarity conditions for SAV occur below the red line of minimum light requirement.

Environmental Application: State and federal watershed managers in the Chesapeake Bay region are using this tool to make management decisions on reducing suspended solids and chlorophyll to obtain minimum water clarity for seagrass survival.

Gallegos, C.L. 2001. Calculating optical water clarity targets to restore and protect submersed aquatic vegetation: Overcoming problems in partitioning the diffuse attenuation coefficient for photosynthetically active radiation. *Estuaries* 24, 381-397.

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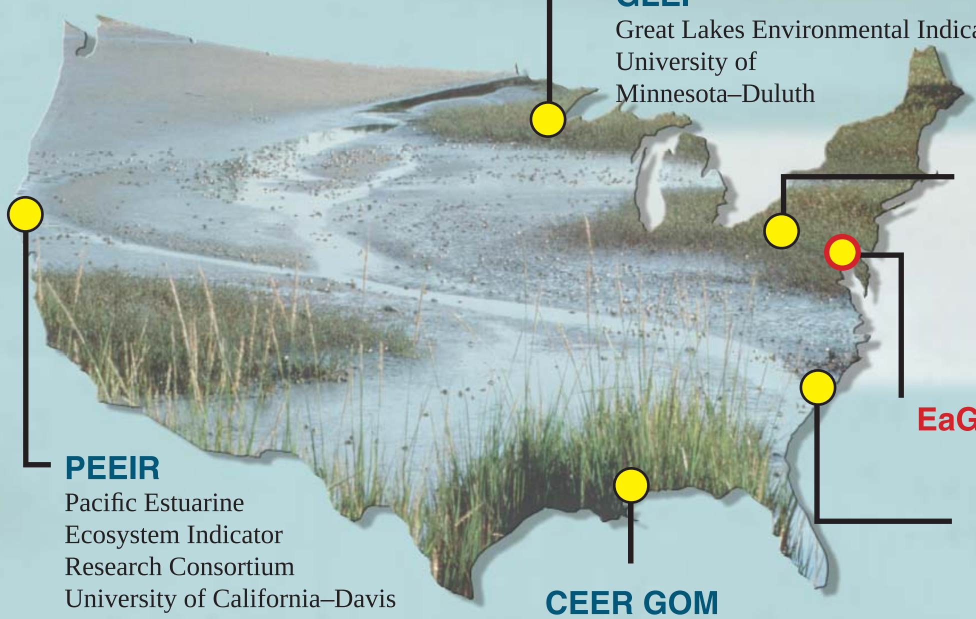

GLEI
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University of Minnesota–Duluth

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- Smithsonian Environmental Research Center
- Virginia Institute of Marine Sciences
- East Carolina University
- Environmental Law Institute

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Direct and indirect effects of human activities have taken a toll on the nation's estuaries, yet few direct linkages have been identified between human activities on land and responses in estuarine ecosystems. The Atlantic Slope Consortium is one of five national projects funded by EPA's EaGLe program. The goal of the EaGLe program is to develop the next generation of ecological indicators that can be used in a comprehensive coastal monitoring program.

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