USGS
science for a changing world

The U.S. Geological Survey Chesapeake Bay Science Program

Problems Facing the Nation's Largest Estuary

The Chesapeake Bay, the Nation's largest estuary, has historically supported one of the most productive fisheries in the world. The bay serves as the spawning ground for 70 to 90 percent of the striped bass in the Atlantic Ocean. The 64,000-square-mile watershed of the bay provides vital habitat for migratory birds using the Atlantic Flyway (fig. 1). In addition to supporting aquatic communities and wildlife, the bay's watershed serves the economic and recreational needs of 15 million people. Unfortunately, the commercial, economic, and recreational value of the bay and its watershed has been degraded by poor water quality, loss of habitat, and overharvesting of living resources. Additionally, the bay was listed under the Clean Water Act as an "impaired water body" in 1999 due to excess nutrients and sediment. Improvements in the water-quality conditions must be made by 2010 or regulatory approaches to achieve these standards will be implemented.

Restoration of the Chesapeake Bay and Chesapeake 2000

Since the early 1980's, the Chesapeake Bay Program (CBP)—a partnership among Maryland, Virginia, Pennsylvania, the District of Columbia, Federal Government agencies, and the Chesapeake Bay Commission—has been formulating and implementing goals to restore living resources, minimize habitat loss, and reduce the amount of nutrients, sediment, and toxic substances entering the bay (fig. 2). While progress has been made, the CBP has recognized the need for enhanced restoration efforts. Therefore, the CBP completed "Chesapeake 2000," a new agreement that revises and establishes new restoration goals for the next 10 years for the bay and its watershed. The restoration goals focus on achieving sound land use to reduce nutrients, sediments, and toxics entering the bay to restore living resources and their associated habitats. The goals are challenging and in many cases may be difficult to achieve without increased scientific information documenting the human and environmental causes of the ecosystem degradation. Such information is critical to effectively formulate strategies to meet and measure the achievement of the restoration goals.

The Role of the U.S. Geological Survey

The U.S. Geological Survey (USGS), one of the original CBP Federal partners, has the critical role of providing unbiased scientific information to be used in formulating, implementing, and assessing the effectiveness of restoration goals in the bay and its watershed. The USGS Chesapeake Bay Science Program is meeting this role through a combination of research, monitoring, modeling, and interaction with partners in the CBP and the Department of Interior (DOI). The success of the USGS effort depends on the coordination of multiple USGS programs and scientists conducting studies of the bay and its watershed.

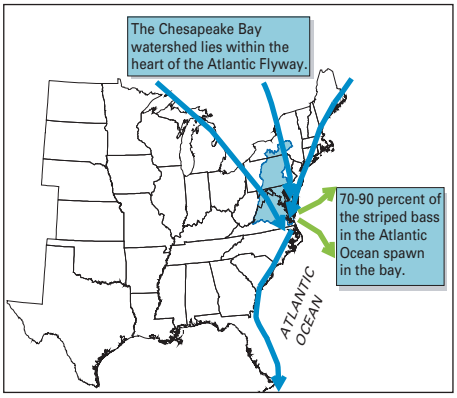

Figure 1. The Chesapeake Bay, the Nation's largest estuary, is the spawning ground for most of the striped bass in the Atlantic Ocean. The bay's watershed provides vital habitat and food for migratory birds using the Atlantic Flyway. Degradation of the water quality and habitat is causing declines in many of the bay's living resources. Ecosystem restoration goals are specified in "Chesapeake 2000," an agreement among the Federal Government, jurisdictions in the watershed, and the Chesapeake Bay Commission.

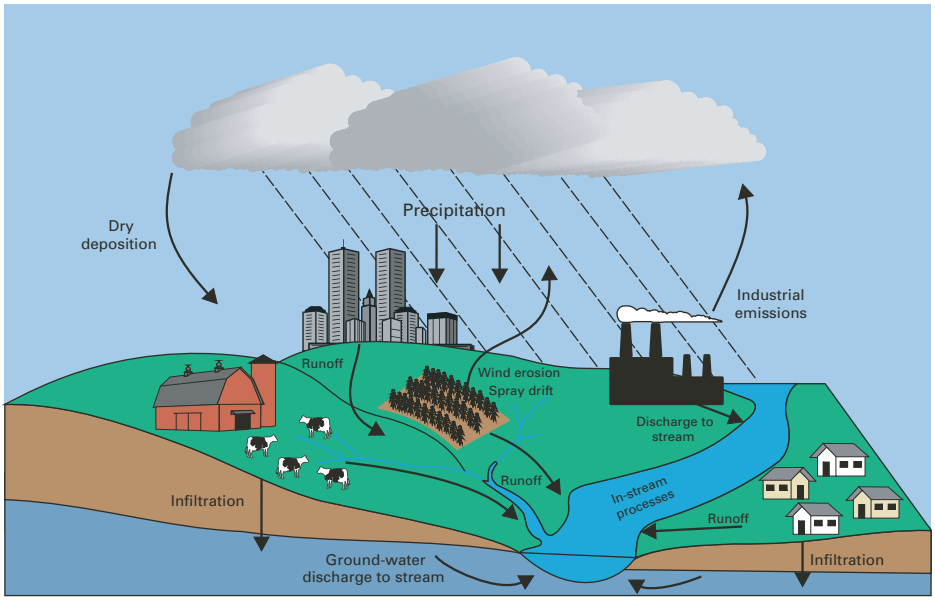

Figure 2. Nutrients from urban, suburban, and agricultural sources enter the ground water and streamflow that discharge into the Chesapeake Bay. Once in the bay, the overabundance of nutrients causes algal blooms, which block sunlight and lower dissolved-oxygen levels. The low dissolved-oxygen levels have caused fish kills, and the reduced sunlight has caused die off of submerged aquatic vegetation. The Chesapeake Bay has been listed as an "impaired water body" under the Clean Water Act and must meet standards by 2010. USGS science is being used to help formulate and implement actions to reduce nutrients and sediment and document water-quality improvements.

USGS efforts began in the 1980's and significantly increased in the mid-1990's, when the USGS adopted the Chesapeake Bay watershed as one of its national place-based study areas. The increased USGS study of the sources and transport of nutrients to the bay was critical to assess the restoration goals related to nutrient reduction and improvement in conditions for submerged aquatic vegetation (SAV) and living resources (fig. 3).

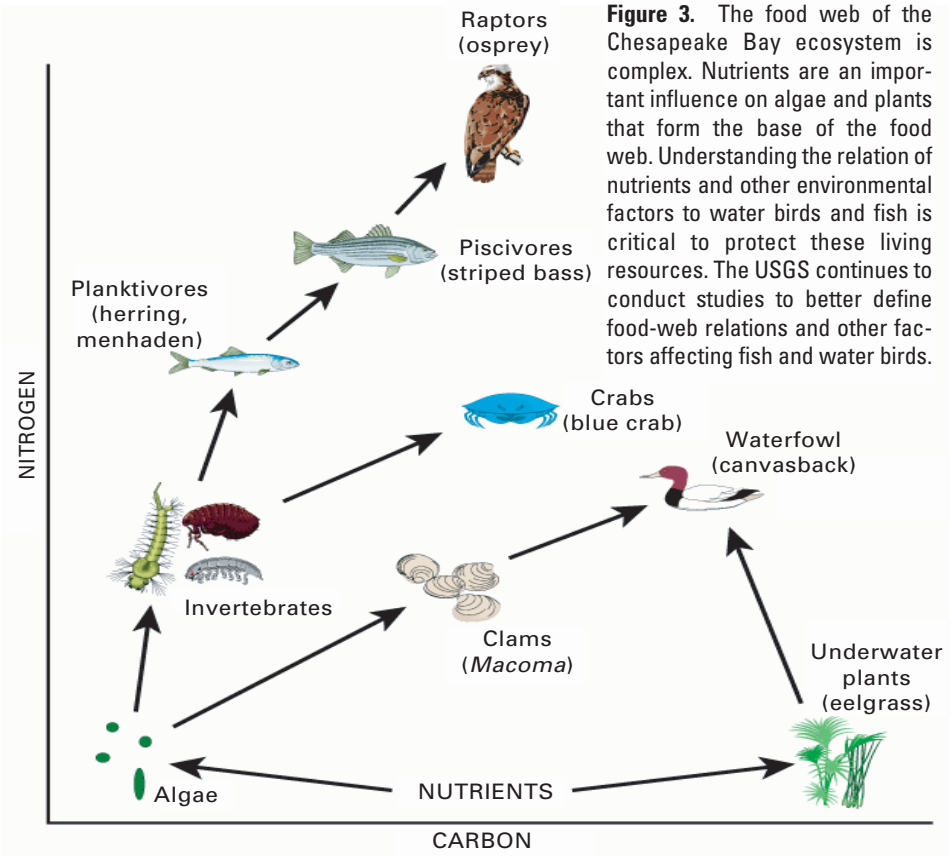

Figure 3. The food web of the Chesapeake Bay ecosystem is complex. Nutrients are an important influence on algae and plants that form the base of the food web. Understanding the relation of nutrients and other environmental factors to water birds and fish is critical to protect these living resources. The USGS continues to conduct studies to better define food-web relations and other factors affecting fish and water birds.

Meeting the Science Needs of Chesapeake 2000

To support the expanded scientific needs of Chesapeake 2000 and DOI partners, the USGS Chesapeake Bay Science Program revised its objectives and goals and increased the involvement of other USGS Programs and projects in studies of the complex interactions among land use, water quality, vital habitat, and living resources. The overall objective of the USGS Chesapeake Bay Science Program is to provide resource managers with the critical scientific information needed to understand the complex relation between the human-induced influences (population growth, land-use change, and restoration efforts) and natural controls (climate variability and environmental framework) on water quality, vital habitats, and living resources in the bay and its watershed (fig. 4). The USGS will conduct investigations under six science goals (table 1). Study areas will include the entire watershed and several "focus areas"—the lower Eastern Shore/Pocomoke River, the Potomac River and estuary, and the lower Susquehanna River and the upper bay (fig. 5).

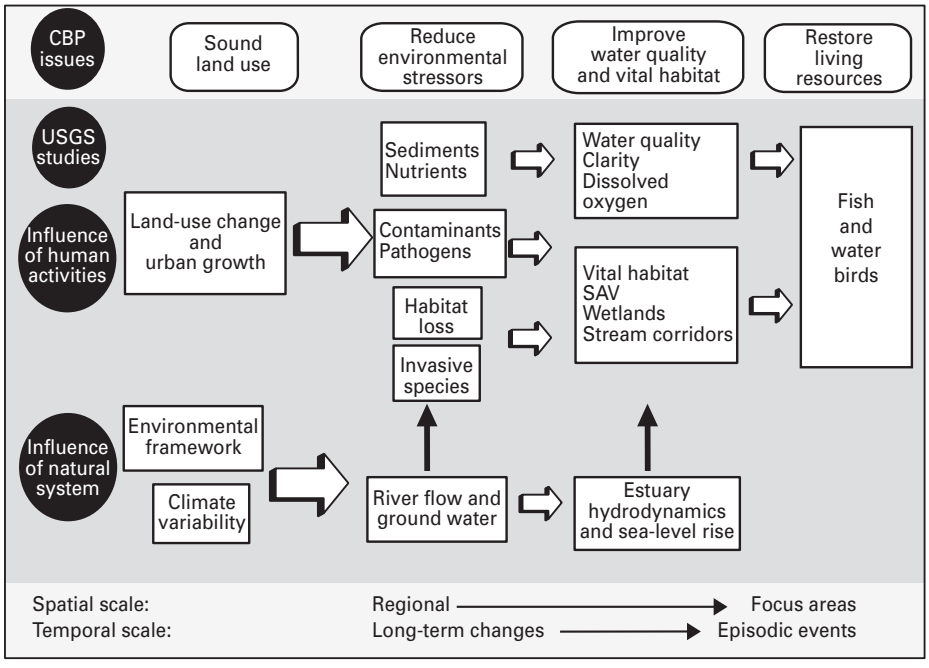

Figure 4. The Chesapeake Bay Program (CBP), using "Chesapeake 2000" as a guide, is working to implement sound land-use practices to reduce pollutants and habitat loss in the bay and its watershed. These actions are aimed at improving water quality and vital habitat to support living resources. The USGS is taking a multidisciplinary approach to provide critical science information that will be used to help formulate, implement, and assess the effectiveness of restoration efforts.

USGS Programs and Partnerships in the Chesapeake Bay

The USGS Chesapeake Bay Science Program involves multiple USGS Programs and collaborates with many Federal, State, and academic partners through involvement in the Chesapeake Bay Program and related activities. USGS Programs from the major disciplines (Biology, Geology, Mapping, and Water Resources) are active in conducting science within the bay and its watershed. Table 2 shows the USGS programs supporting Chesapeake Bay restoration and describes their efforts.

The USGS interacts with many partners in the CBP, including the U.S. Fish and Wildlife Service, National Park Service, U.S. Environmental Protection Agency (USEPA), U.S. Department of Agriculture (USDA), National Aeronautics and Space Administration (NASA), Maryland Department of Natural Resources, Virginia Department of Environmental Quality, Maryland Geological Survey, Susquehanna River Basin Commission (SRBC), Maryland Department of the Environment, the Interstate Commission on the Potomac River Basin, the Virginia Department of Conservation and Recreation, Virginia Institute of Marine Sciences, and George Mason University.

Table 1. Scientific issues and scope of the USGS Chesapeake Bay Science Program goals.

USGS Science Program goal and scientific issue	Scope of science goal
Improve watershed and land-use data to understand changes in water quality and living resources.—Land-use change is the primary factor causing water-quality and habitat degradation in the bay and its watershed. Human populations and associated urban areas are expected to grow to 18 million people by 2020 in the bay watershed. Enhanced information is needed to explain changes in water quality, habitat, and living resources and to improve management models.	• Documenting the sediment, nutrient, and toxic sources associated with urban, suburban, and agricultural lands and compiling information on watershed characteristics that affect the movement of these pollutants. • Providing an assessment of historical land-use changes to explain changes in water quality, living resources and associated habitat. • Applying the information to improve management models.
Understand the impact of sediment on water clarity and biota.—The bay was listed as an "impaired water body" under the Clean Water Act because of poor water clarity. Submerged aquatic vegetation (SAV) has declined drastically over the past 30 years primarily due to poor water clarity, caused by excess sediment and nutrients. While nutrient sources and transport have been studied since the 1980's, little is known about sediment sources and delivery to the bay. The CBP needs information on the sources of sediment affecting water clarity so that sediment-reduction measures can be formulated and water clarity improved by 2010. Additionally, an assessment is needed to determine whether SAV species are recovering, based on anticipated improvements in water clarity.	• Investigating the sources, transport, delivery, and deposition of sediment to the bay. • Assessing the relation of sediment and nutrient enrichment to water clarity, SAV, and other biota in shallow habitats. • Documenting the factors affecting the presence of SAV species and any improvements because of the new water-clarity standards. • Improving predictive models, monitoring, and decision-support systems to help States develop and evaluate the effectiveness of sediment-reduction strategies.
Enhance the prediction and monitoring of nutrient delivery to the bay.—The bay was also listed as an "impaired water body" under the Clean Water Act because of low dissolved oxygen, which has killed fish and other organisms. Nutrient sources in the watershed must be further reduced to meet new dissolved-oxygen standards by 2010. To successfully meet the new standard, enhanced predictive tools are needed to simulate the relation between nutrient sources and delivery to the bay, monitoring must be expanded to document and evaluate water-quality improvement, and studies must be conducted to understand the processes affecting nutrient delivery to the bay.	• Partnering with the CBP to refine the Chesapeake Bay Watershed Model (Phase 5) to improve simulation of nutrient sources and their delivery to the bay. • Linking information on ground-water discharge, loads, and residence times to improve simulation of nutrient delivery to streams in the watershed model. • Developing a watershed-monitoring network to document improvements in water quality and enhance monitoring and trend analysis of nutrients in the watershed. • Conducting investigations of stream nutrient dynamics to determine their effect on biological communities.
Assess the occurrence of toxic constituents and emerging contaminants.—As part of Chesapeake 2000, the CBP has developed a strategy for toxics that will eliminate the impact of toxic substances on the living resources of the bay or on human health. Technical information needs include (1) documenting contaminant sources, loads and impacts from animal agriculture, pesticide use, and ground water and (2) understanding the potential for contaminants to cause toxic impacts on aquatic-dependent wildlife in the bay and its watershed.	• Enhancing information on occurrence and impact of emerging contaminants. • Collecting data on the contaminant concentrations in both surface and ground water associated with different types of land use in areas of the Potomac River Basin and Delmarva Peninsula. • Assessing the impact of contaminants and other environmental stressors on the health of fish and water birds (see next science goal).
Assess the factors affecting the health of fish and water birds.—Restoration of living resources, including oysters, crabs, fish, and their associated habitat is the highest priority of Chesapeake 2000. Also, the Department of Interior is developing conservation measures to protect water birds in the Atlantic Flyway. Scientific information is needed to understand the complex relation of living resources and associated habitats to environmental factors in the bay and its watershed.	• Investigating the effect of endocrine-disrupting chemicals on fish-egg quality and survival. • Assessing the factors affecting the health of adult fish, including the occurrence of fish lesions. • Understanding the effect of contaminants, habitat loss, and food-web changes on water bird populations.
Disseminate information and enhance decision-support tools.—The primary audience for the USGS Chesapeake Bay Science Program is the CBP. The CBP, consisting of Federal (more than 25 agencies), State (6 States and the District of Columbia), and local customers and partners, requires USGS research, monitoring, and predictive models of the Chesapeake Bay and its watershed to help formulate and evaluate restoration strategies. USGS Chesapeake Bay science information is also relevant to the restoration of other ecosystems throughout the United States. Therefore, multiple approaches and associated infrastructures are needed to provide information not only to the CBP but also to other audiences, including scientific organizations, representatives of Congress, the Department of the Interior, and groups within the USGS.	• Developing decision-support tools through the integration of predictive model results, monitoring data, and ancillary information. The predictive models will include (1) joint USGS-CBP enhancement of the bay watershed model that simulates nutrient and sediment delivery to the bay and (2) the USGS SPARROW models. • Disseminating decision-support information through development of a World Wide Web-based GIS (geographic information system) and integration with CBP Chesapeake Information Management System (CIMS) delivery approaches (such as "watershed profiles"). • Increasing participation in CBP subcommittees and workgroups to enhance the exchange of information.

Table 2. USGS programs supporting the Chesapeake Bay restoration efforts.

USGS program	Role in support of bay restoration
Biology program areas related to fisheries and aquatic resources, contaminants, wildlife, invasive species, and ecosystems.	Research on vital habitats, including submerged aquatic vegetation (SAV), wetlands, invasive species, and selected living resources, such as fisheries and water birds.
Coastal and Marine Geology Program.	Research sediment sources and dynamics affecting water clarity and habitats.
National Cooperative Geologic Mapping Program.	Create maps of geologic and geomorphic characteristics of sediment transport and deposition.
Earth Surface Dynamics Program.	Research the effects of land-cover change and climate variability on sediment deposition and subsequent effects on water clarity and SAV and other biological communities.
Landscape Analysis Program.	Research to document relation of land-cover and land-use changes to changes in water quality and living resources.
Hydrologic Networks and Analysis Program.	Quantify the amount of stream flow, nutrients and sediment entering Chesapeake Bay.
Hydrology Research and Development Program.	Study the relation of sediment sources, transport, and delivery to shallow-water habitats for SAV. Research characterizing abundance and extent of SAV coverage in relation to sediment, seasonal water quality, and hydroclimatology. Research on nutrient cycling in surface-water and ground-water systems.
Cooperative Water Program.	Enhance surface-water monitoring efforts to document sediment and nutrient loads, trend analysis, factors affecting loads and trends, and predictive models.
National Water-Quality Assessment (NAWQA) Program.	Work with Potomac/Delmarva study unit to understand nutrient and contaminant processes.
Global Climate Change Program.	Research the effect of sea-level rise on habitat.
Regional place-based studies.	Supports all USGS Chesapeake Bay science goals by integrating scientific investigations and supplying information to CBP.

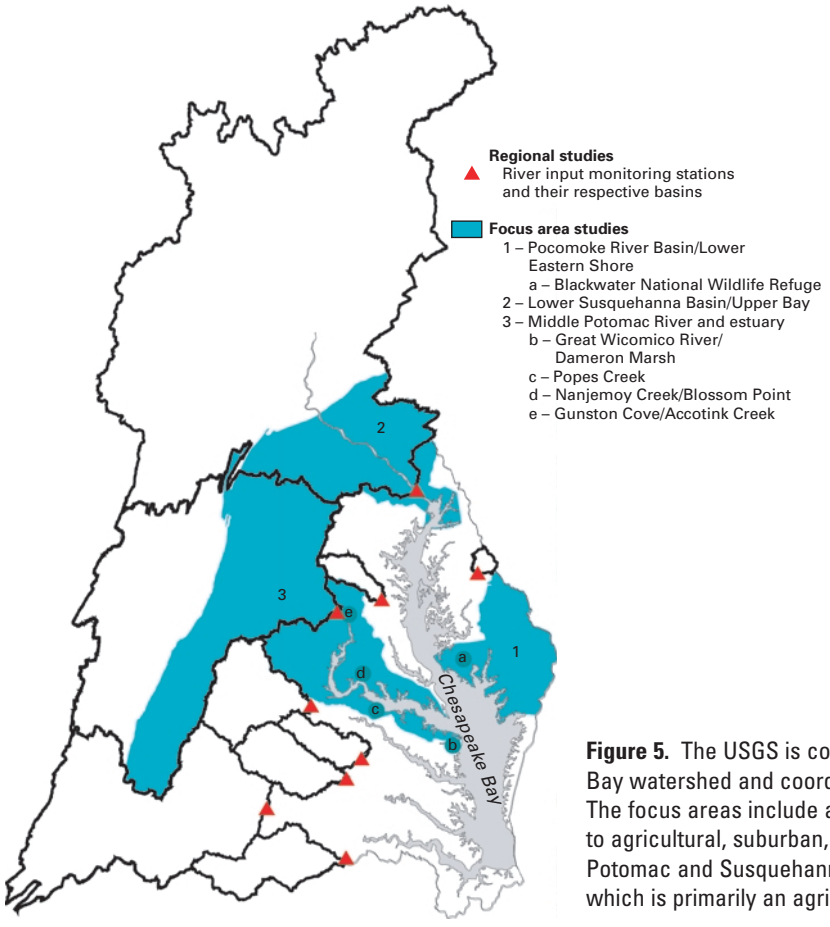

Figure 5. The USGS is conducting regional studies of the entire Chesapeake Bay watershed and coordinating multiple disciplines in three focus areas. The focus areas include areas of high nutrients, sediments, and toxics due to agricultural, suburban, and urban land use. The western extent of the Potomac and Susquehanna focus areas corresponds to the Great Valley, which is primarily an agricultural region.

For more information, please contact:
Scott W. Phillips
USGS Chesapeake Bay Coordinator
U.S. Geological Survey
8987 Yellow Brick Road
Baltimore, MD 21237
Telephone: (410) 238-4252
E-mail: swphilli@usgs.gov

Visit the USGS web site "Activities in the Chesapeake Bay Region" at http://Chesapeake.usgs.gov