

# 1 Chesapeake Bay

## Overview

The Chesapeake Bay has the largest water area of more than 100 estuaries<sup>1</sup> in the United States and the third largest in the world.<sup>2</sup> It is located on the east coast of the U.S., stretching about 322 km from Havre de Grace, Maryland to Virginia Beach, Virginia. The Bay's width varies between around 6.4 km, near Aberdeen in Maryland, to 48.3 km near Cape Charles, Virginia.<sup>1</sup> It holds more than 68.1 km<sup>3</sup> of water, supports over 3,600 species of plant and animal life, and 17.8 million people live, work, and play within the Chesapeake Bay Watershed.<sup>2</sup>

## Location

### Basic information<sup>1,12</sup>

Surface area : 11,603 km<sup>2</sup>

Volume : 68.1 km<sup>3</sup>

Average depth : 6.4 m

Maximum depth : 53 m

## Nature

### <Background>

The Bay receives about half of its water volume from the Atlantic Ocean. The rest drains into the Bay from a 166,000 km<sup>2</sup> catchment area, which includes parts of six states – New York, Pennsylvania, Delaware, Maryland, Virginia, West Virginia – and all of the District of Columbia. Three rivers – the Susquehanna, Potomac and James rivers – collectively provide more than 80% of the Bay's fresh water source, the Susquehanna being the largest river accounting for nearly 50% of the total fresh water inflow.<sup>1</sup>

### ☐ Climate

Because of its mid-latitude location, the Chesapeake Bay enjoys a rather moderate climate, with an average temperature of around 13°C. The Chesapeake Bay also has a moderating effect on the area, keeping summer and winter temperatures from reaching extremes. The average annual rainfall is 1,143 mm, which occurs mainly during the spring and late autumn.<sup>3</sup>

### ☐ Topography

The Bay was created about 10,000 years ago due to melting glaciers that flooded the Susquehanna River Valley.<sup>4</sup> Most of the Bay is shallow, with more than 2,800 km<sup>2</sup> having a depth less than 2 m. Its average depth, including all tidal tributaries, is about 6.4 m but a few deep troughs reach 53 m deep.<sup>1,12</sup> These are thought to be remnants of the ancient Susquehanna River.<sup>1</sup>

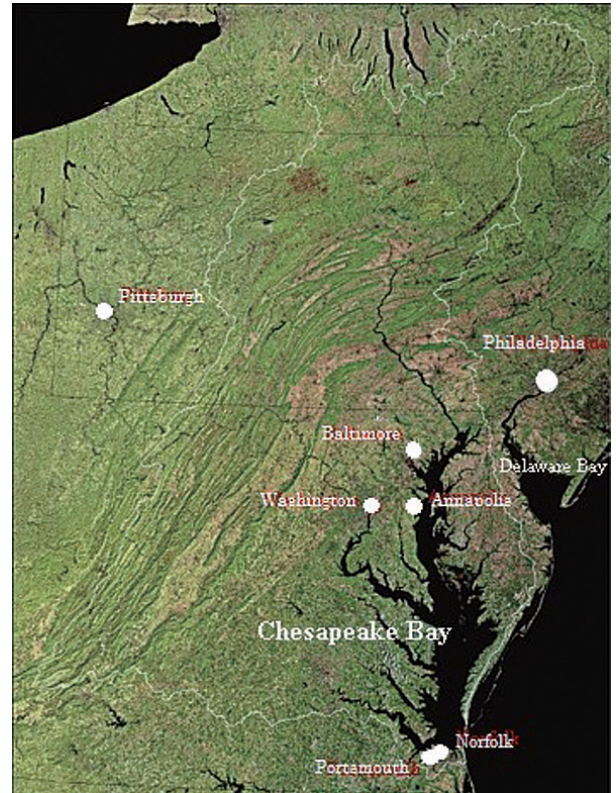
### ☐ Hydrology

Fifty major tributaries pour freshwater into the Chesapeake Bay, providing about 193 million m<sup>3</sup> of water each day.<sup>1,2</sup> Most of this water comes from the northern and western tributaries such as the Susquehanna and Potomac rivers, and the remaining amount comes from the eastern shore. About half of the Bay's water volume is comprised of salt water from the Atlantic Ocean.<sup>1</sup>

The Bay's salinity gradually increases from the north to south. Salinity ranges from freshwater (less than 0.5 ppt) at the Bay's head, to water of nearly oceanic salinity (25–30 ppt) at the Bay's mouth. Most of the water in the bay is brackish – a mixture of salt and fresh water – with a salinity between 0.5 and 25 ppt. Salinity also fluctuates widely between seasons and years, due to the changes in fresh water volume inflowing from its rivers.<sup>1</sup>

Circulation of the Bay's water is mostly driven by the movement of fresh water and salt water, and a zone of maximum turbidity is created where the two types of water meet. This area contains and mixes important materials and nutrients for many organisms.<sup>1</sup>

The factors of salinity, temperature, and circulation in the Bay combine to create two layers with distinct characteristics: a top layer with warmer, lighter fresh water that flows down toward the ocean, and the bottom layer with saltier denser water flowing upwards. This phenomenon – called stratification – varies seasonally and on rainfall. Rapid vertical mixing of the two layers usually occurs in the autumn, which helps to distribute nutrients and oxygen across the two layers.<sup>1</sup>



### <Surrounding environment>

The Chesapeake Bay provides food, water, cover, and nesting or nursery areas to a large number of migratory and resident wildlife species. More than 3,600 species of plants, fish and animals, including 348 species of finfish, 173 species of shellfish and over 2,700 plant species depend on the Bay.<sup>1,2</sup> Habitat types include hardwood forests in the Appalachian mountains to saltwater marshes.<sup>2</sup>

In addition, the Chesapeake Bay region is home to 29 species of waterfowl and is a major resting ground along the Atlantic Migratory Bird Flyway. Every year, one million waterfowl winter in the Bay's basin.<sup>1</sup>

#### □ Habitats

Approximately 6,000 km<sup>2</sup> of wetlands remain in the Bay's catchment, which is less than half of the wetlands that were present during colonial times.<sup>5</sup> Of the remaining wetlands, 14% are tidal and 86% are non tidal. Moreover, 68% of the wetlands in the Bay watershed are forested.<sup>1</sup> Between 2010 and 2013, about 24 km<sup>2</sup> of wetlands were restored on agricultural land. The new Chesapeake Watershed Agreement set a goal to restore 344 km<sup>2</sup> wetlands between 2014 and 2025.<sup>6</sup>

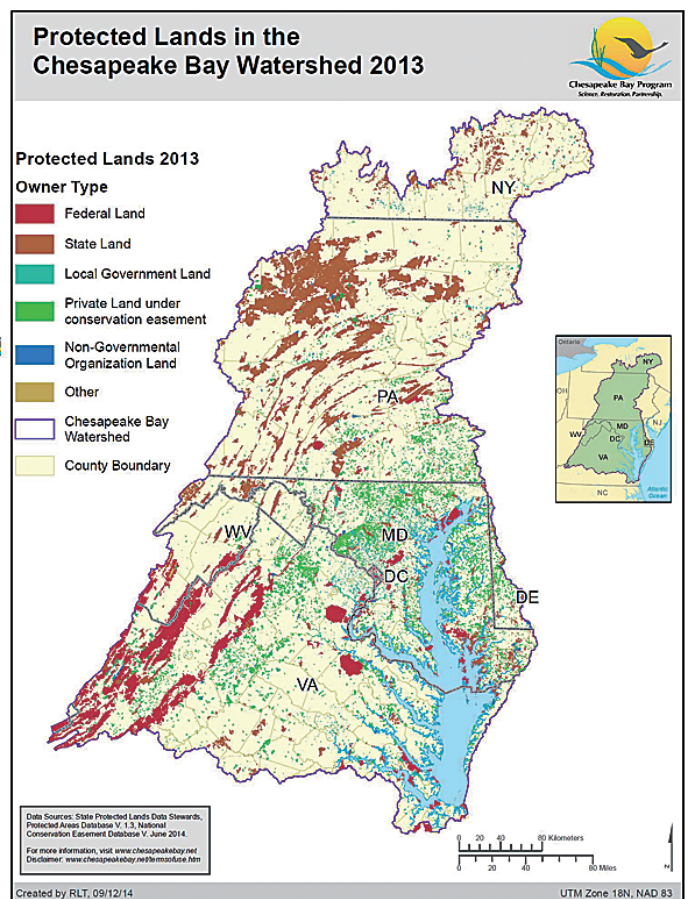
More than sixteen species of Submerged Aquatic Vegetation (SAV) are commonly found in the shallow waters of the Chesapeake Bay or in its streams, creeks and rivers. They serve an important role in the Bay's ecosystem, providing food and habitat for wildlife species, producing oxygen for aquatic organisms, purifying the water by absorbing pollution, and slowing erosion.<sup>1</sup> More than 2,400 km<sup>2</sup> of SAV may have existed in the Chesapeake Bay at its most pristine state. In 2013, 241.64 km<sup>2</sup> of SAV were mapped in the Bay and its tributaries. Between 2012 and 2013, SAV increased 24% from 195.0 km<sup>2</sup> to 241.6 km<sup>2</sup> in total.<sup>7</sup>

#### □ Biota

In the Bay the following species are the most monitored for their "ecological, historical, and/or commercial and recreational importance": blue crab, menhaden, oysters, striped bass (rockfish), alosines (shad, herring, and alewife), and invasive catfish (blue and flathead). The distribution of blue crab (*Callinectes sapidus*) is different based on age, sex, and season. It is more abundant in shallow-water during warm temperatures, and in deeper areas during the winter. Currently, the Chesapeake Bay blue crab stock is depleted, and overfishing is not occurring.<sup>5</sup> Atlantic menhaden (*Brevoortia tyrannus*) are an important prey for both fish and predatory birds such as osprey and eagles. Menhaden also act as filter feeders, consuming phytoplankton and zooplankton. The native Eastern oyster (*Crassostrea virginica*) provides a habitat for plants and animals in addition to ecosystem services such as water filtration and nitrogen removal. Striped bass (*Morone saxatilis*), also referred to as rockfish, are anadromous, and spend the majority of their adult life in coastal estuaries or the ocean. Their populations were heavily overfished, but have returned to sustainable population levels due to the fishing moratorium and science-based management.<sup>5</sup> Alosines include species such as the American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), blueback herring (*Alosa aestivalis*), and alewife (*Alosa pseudoharengus*), are also anadromous. American shad, hickory shad, and blueback herring are experiencing coastwide reductions in populations from historical levels.<sup>5</sup> Blue and flathead catfish are invasive species in the Chesapeake Bay, that were introduced as a recreational fishery in the 1970s and 1980s. They prefer fresh water, but now inhabit every major tributary of the Bay. They are opportunistic and generalist predators, that consume at many levels of the food chain, and prey on crustaceans, worms, and other fish (menhaden, shad, river herring, and blue crabs).<sup>5</sup>

#### □ Protected Areas

Approximately 21% of the land in the Chesapeake Bay watershed – 33,879 km<sup>2</sup> – is under protection (as of the end of 2013). The right map shows the lands that are protected, by different owner type. In 2009, the Chesapeake Bay Executive Order set a goal to protect an additional 2 million acres (about 8,100 km<sup>2</sup>) throughout the watershed by 2025, including 695,000 acres (about 2,800 km<sup>2</sup>) of high value forest land.<sup>1</sup>



Protected Lands in the Chesapeake Bay Watershed 2013<sup>1</sup>

## History and Culture

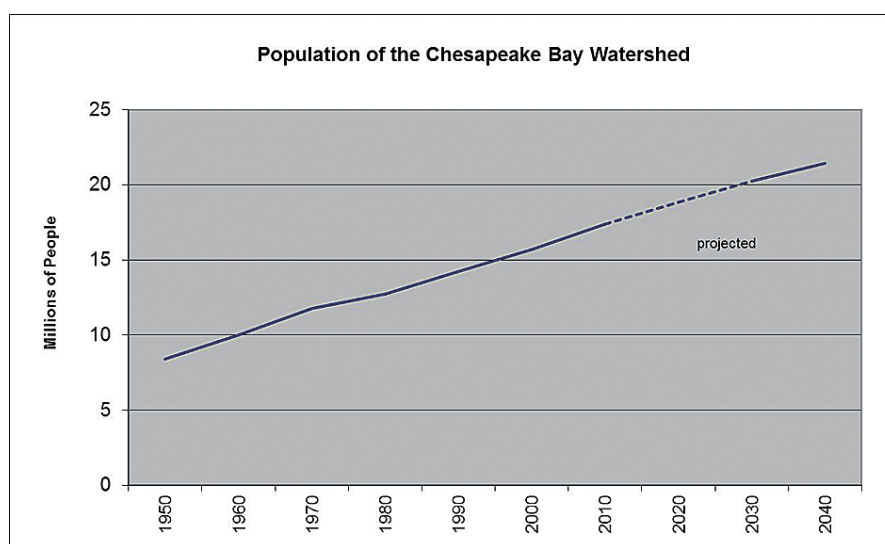
The Chesapeake Bay developed from natural occurrences during the last Ice Age. Around 10000 B.C., melting glaciers filled in the Susquehanna valley, and about 2,000 years ago, the Bay assumed its current shape. All along, Native Americans lived in the Bay region, beginning agricultural practices around 1000 B.C.<sup>1</sup> In 1607, the first permanent New World settlement was established in Virginia on the James River, and a member of the traveling group, Captain John Smith, began extensive exploration of the Bay.<sup>1</sup> War and disease caused the Native American population to dramatically decline to just 10% of the size when the Europeans first arrived. Over the next 300 years of the Bay's time line, people built homes, farmed, started businesses, and participated in a host of other activities that continue to affect the Bay today.<sup>1</sup>

It has been suggested that the name "Chesapeake" comes from a Native American word meaning "Great Shellfish Bay", to describe the large volumes of crabs, oysters, and clams that inhabited the Bay.<sup>4</sup>

## Social Environment

### <Population>

The population in the Bay catchment area has doubled since the 1950s.<sup>1</sup> An estimated 17.8 million people lived in the Bay watershed area in 2013, and about 10 million people live along its shores or close by.<sup>1,2</sup> About 150,000 new people move into the watershed each year. It is estimated that the region's population will reach 21.4 million people by 2040 at this rate.<sup>1</sup>



Population of the Chesapeake Bay Watershed<sup>1</sup>

### <Land Use>

Agricultural and developed land make up 23% and 12% of the Chesapeake Bay, respectively. Most of the remaining area (about 65%), is forested, and also includes wetlands or other use. Between major river watersheds there is a wide variety in land use ratios, with some having almost half of the land used for agriculture, and another with almost one third developed. Overall, the coverage of developed land such as road, driveways, and parking lots has increased by approximately 34% between 1990 and 2007, although the population increase was only 18%.<sup>2</sup> Although forested land increased in Pennsylvania and Virginia overall for each state in the last five years, there is a net loss of about 2,023 km<sup>2</sup> over the last fifteen years in the three major Bay states.<sup>6</sup>

### <Industry>

#### ☐ Fisheries

An extensive finfish industry, primarily based on menhaden and striped bass, rounds out the Bay's commercial seafood production. In 2013, the annual commercial landing of the Bay was 193,076 tons, with a value of 239 million US dollars.<sup>8</sup>

#### ☐ Recreation

The hospitable climate, lush vegetation and natural beauty of the Chesapeake Bay has made it an increasingly popular recreational area. Boating, crabbing, swimming, hunting and camping are major attractions. Sport fishing is another major recreational activity in the Chesapeake Bay.

## Environmental Problems

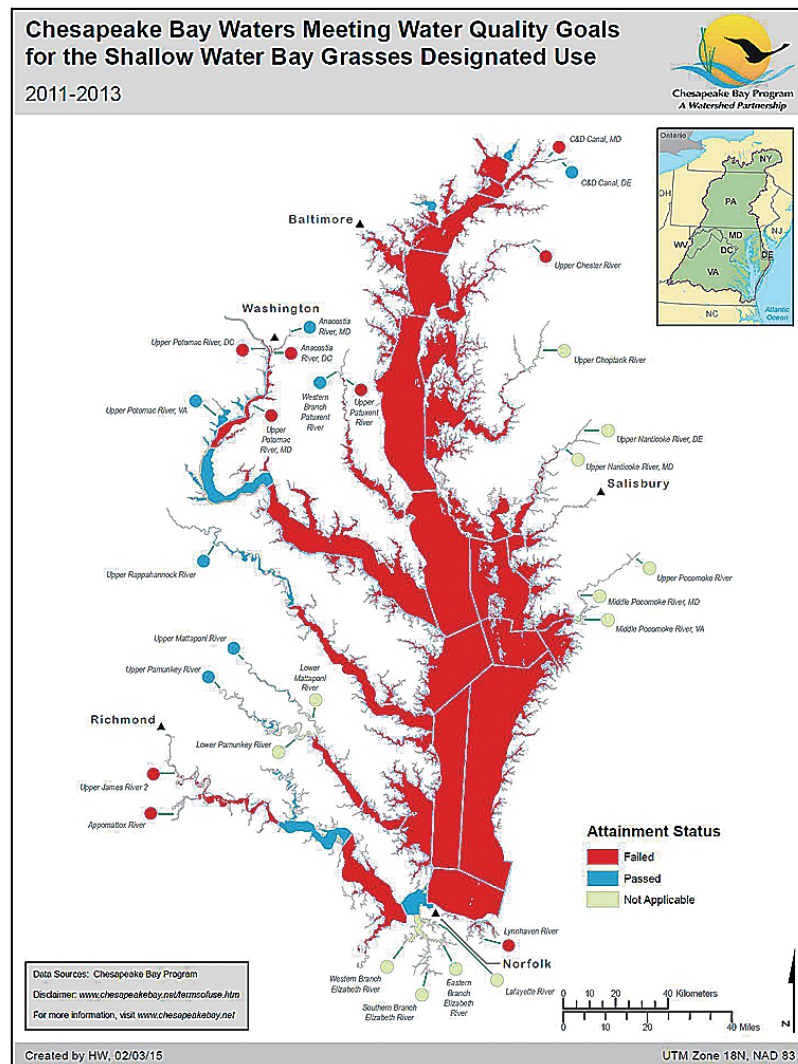
### <Current status>

According to the "Chesapeake Bay Program 2013" report, the overall health and water quality of the Bay remains in poor condition, although some areas in the headwater and watershed shows signs of recovery.<sup>9</sup> Overall, the Bay's habitats and lower food chain – which includes the acreage of bay grasses and wetlands – are much below the required amount for a healthy ecosystem. Moreover, the Bay's fish and shellfish, have low populations from pollution, diseases, overharvesting and lack of food and habitat.<sup>1</sup>



## ☐ Water Quality

Water quality standards have been set for five different aquatic habitats (migratory fish and spawning nursery habitat, open-water fish and shellfish habitat, deep-water seasonal fish and shellfish habitat, deep-channel seasonal refuge habitat, and shallow-water bay grasses habitat) in the bay. This single indicator consisting of dissolved oxygen, transparency, underwater grasses and chlorophyll *a* is set for each habitat type, and must be met for a healthy Bay ecosystem. Results from 2011-2013 assessments show that 29 % of the water quality standards were met.<sup>1</sup>



Water Quality Assessment of Chesapeake Bay (2011 to 2013)<sup>1</sup>

### 1. Dissolved Oxygen (DO)

Data from the summer months of 2011 to 2013 indicate that about one third of the total water volume (open water, deep water, and deep channel habitats) of the Bay met DO standards.<sup>1</sup>

### 2. Chlorophyll *a*

Water quality standards for chlorophyll *a* were met in 0 of the 7 tidal water segments that were assessed during 2011 to 2013.<sup>1</sup>

### 3. Transparency, Underwater Bay Grasses

Transparency, underwater grasses water quality standard is measured in shallow-water habitats of the Bay. Water quality assessments are only available on a biennial basis, and the assessed segments rotate every three years. When transparency assessments are not available the acreage of underwater grass in the segment-specific restoration acre goals is used. In the 2011-2013 assessment, only 5% of the 91 tidal segments met the standard.<sup>1</sup>

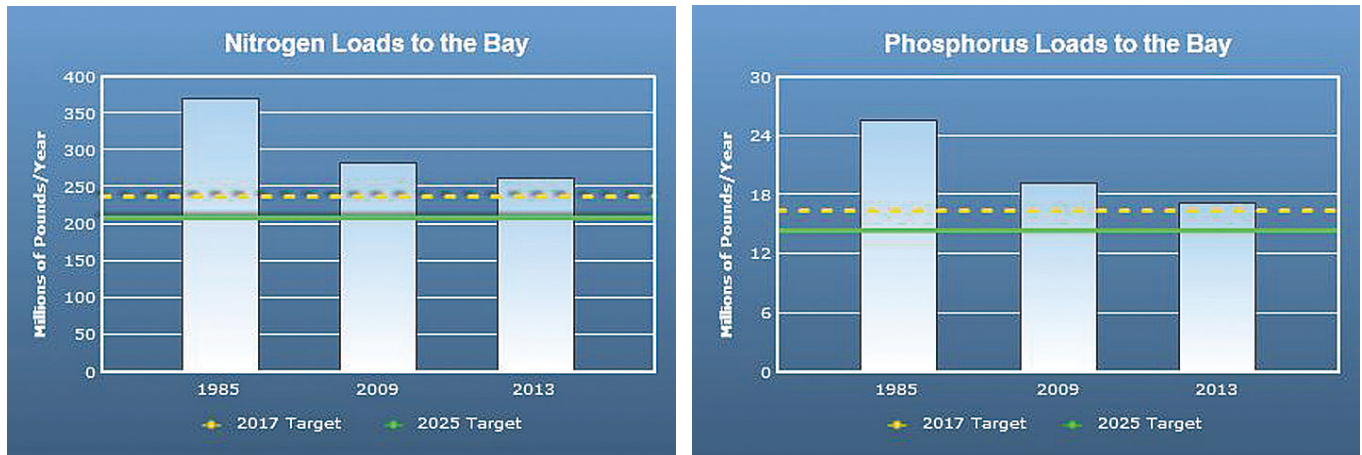
## ☐ Sedimentation

Another critical problem in the Chesapeake Bay is sedimentation into the sea floor, which makes the water turbid and difficult for aquatic organisms to inhabit. Sediment loads are an important indicator to track in order to understand water quality conditions in the Bay. Amounts of sediment are also related to the river flow, as increased precipitation, and runoff from winter and spring increases the runoff and therefore pollution into the Bay.

Sediment decreased at about 30% of the 31 monitoring sites that gathered data for 25 years, but increased at 30% of the sites, indicating degrading conditions.<sup>9</sup>

#### ☐ Pollution source

The Chesapeake Bay's worst problems are caused by the overabundance of nitrogen and phosphorus, which come from air, land and water.



Nitrogen and Phosphorus Loads to the Bay (1985 ~ 2013)<sup>1</sup>

Within the Bay watershed, nitrogen and phosphorous concentrations decreased at about 70% of the 31 locations long-term monitoring stations. Nutrient loading of total phosphorus (TP) measured at nine rivers for 2013 totaled about 15.36 million pounds, which was around 25% less than the long-term average of 20.07 million pounds. Most of this reduction was due to the implementation of phosphate detergent bans that went into effect in the 1970s and 1980s, as well as wastewater treatment plant upgrades.<sup>9</sup>

Estimated total nitrogen (TN) inflow into the Chesapeake Bay totaled about 259.37 million pounds in 2013, 15% less than the long-term average of 303.94 million pounds for 1990–2013. Long-term trends since 1985 show that TN concentrations are improving at 5 of 9 sites which include the three largest tributaries, but degrading at 2 sites.<sup>10</sup>

Toxic chemicals – such as pesticides, pharmaceuticals, and polychlorinated biphenyls (PCBs) – were found to partially or fully impair 74% of the 92 locations analyzed tidal segments of the Chesapeake Bay. Short-term trends from 2006 data show a steady increase in the number of impaired segments.<sup>1</sup>

#### <Environmental Protection Measures>

Since May 2009, the Chesapeake Bay has been managed under the Executive Order (EO) 13508 for Chesapeake Bay Protection and Restoration. Now the U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), and the National Park Service, which are all part of the U.S. Department of the Interior (DOI), have increased their efforts and leadership for the Bay's environmental protection.<sup>11</sup> A Federal Leadership Committee (FLC) was established to ensure coordination between these Federal bodies, and consult with States and stakeholders. In May 2010, the new Strategy for Chesapeake Bay Watershed Restoration and Protection was released by the FLC.

An improvement in water quality and nutrient loads is in part due to the Chesapeake Bay Total Maximum Daily Load (TMDL), agreed collaboratively by the seven jurisdictions surrounding the Bay, and issued by the U.S. Environmental Protection Agency.<sup>9</sup>

The highest priority in environmental protection measures in the Chesapeake Bay has been the restoration of the Bay's living resources – its finfish, shellfish, SAV and other aquatic life. The improvements needed include better fisheries management, habitat restoration, recovery of SAV, nutrient and toxin reductions and significant advances in estuarine science.

#### ☐ Monitoring program

The Chesapeake Bay Program and its partners have been collecting data throughout 31 locations of the non-tidal portions of the Bay watershed since 1985, regarding stream flow and water quality. Since 2004, the monitoring network was expanded, with the aim to assess changes in nutrient and sediment levels. Currently, monitoring is conducted at 123 sites throughout the watershed, gathering indicators of streamflow, nitrogen, phosphorus, and suspended sediment concentrations.<sup>9</sup> Other indicators that were assessed in the larger Chesapeake Bay tidal monitoring network includes: benthic infaunal community monitoring, shallow-water monitoring at selected segments on a rotational basis, annual aerial and ground surveys of underwater Bay grasses, decadal records of phytoplankton and zooplankton, and fisheries population monitoring programs and surveys.

### Related organizations and NGOs

- The Chesapeake Program <<http://www.chesapeakebay.net/>>
- Chesapeake Bay Foundation <<http://www.cbf.org/>>
- Maryland Department of Natural Resources. <<http://www.dnr.maryland.gov/bay/>>
- Virginia Department of Environmental Quality <<http://deq.state.va.us/Programs/Water/ChesapeakeBay.aspx>>
- National Oceanic and Atmospheric Administration, Chesapeake Bay Office. <<http://chesapeakebay.noaa.gov/>>
- United States Geological Survey, USGS Chesapeake Bay Features. <<http://chesapeake.usgs.gov/>>

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