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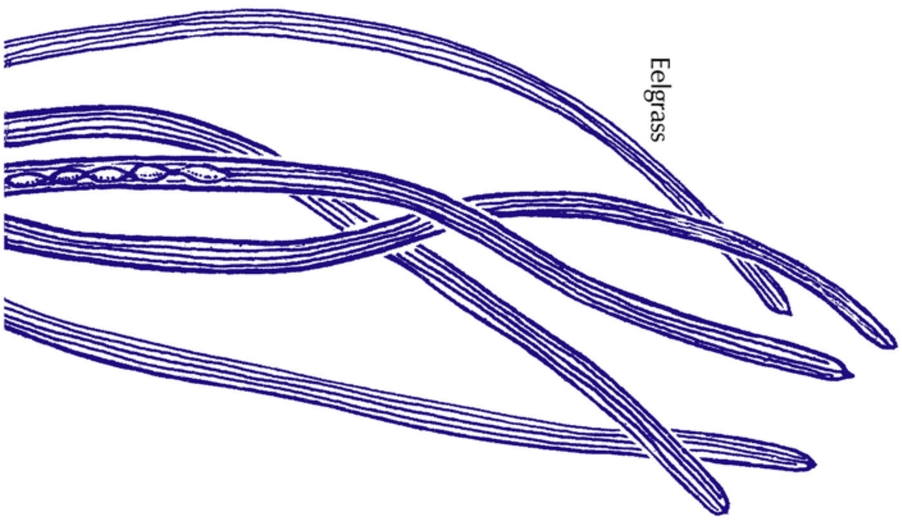
July 2004

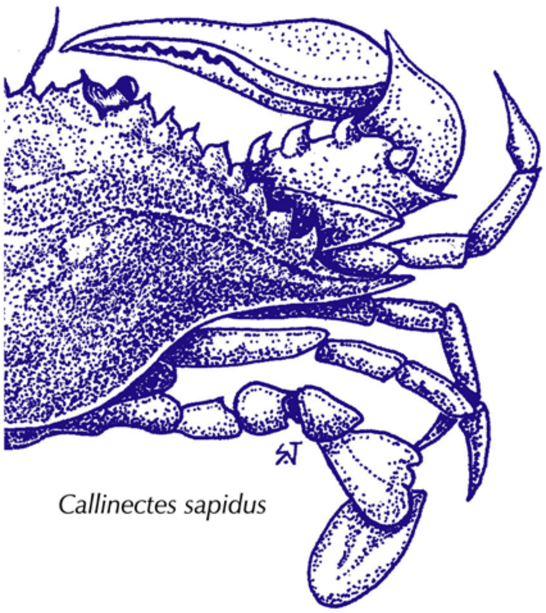


Eelgrass

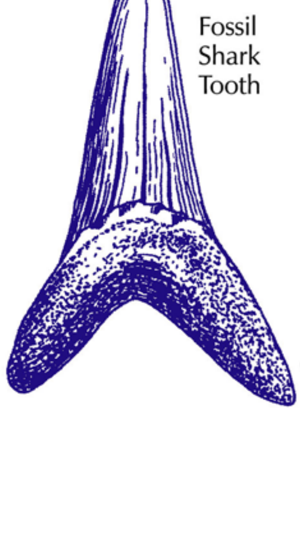
# Chesapeake Bay INTRODUCTION to an ECOSYSTEM

*Turritella plebia*

Fossil Turret Snail Shell



*Callinectes sapidus*



Fossil Shark Tooth

*Oxyrhina desori*

Chesapeake Bay Program
*A Watershed Partnership*

Note: This edition of Chesapeake Bay: Introduction to an Ecosystem is an update of the 1994 edition and includes information through January 2004.


## 1994 Version

***Editor***

Kathryn Reshetiloff

***Illustrations and Layout***

Sandra Janniche

***Reviewers***

Richard Batiuk
Peter Bergstrom
Carin Bisland
Walter Boynton
Sherri Cooper
Eugene Cronin
Richard Everett
Douglas Forsell
Eileen Setzler-Hamilton
Michael Hirshfield
Carl Hershner
Frederick Howard
Steven Jordan
Robert Lippson
Lori Mackey
Tamara McCandless
Kent Mountford
Kate Naughten
Robert Orth
Nita Sylvester
Christopher Victoria

***2004 Update***

Laura Pyzik
Jennifer Caddick
Peter Marx

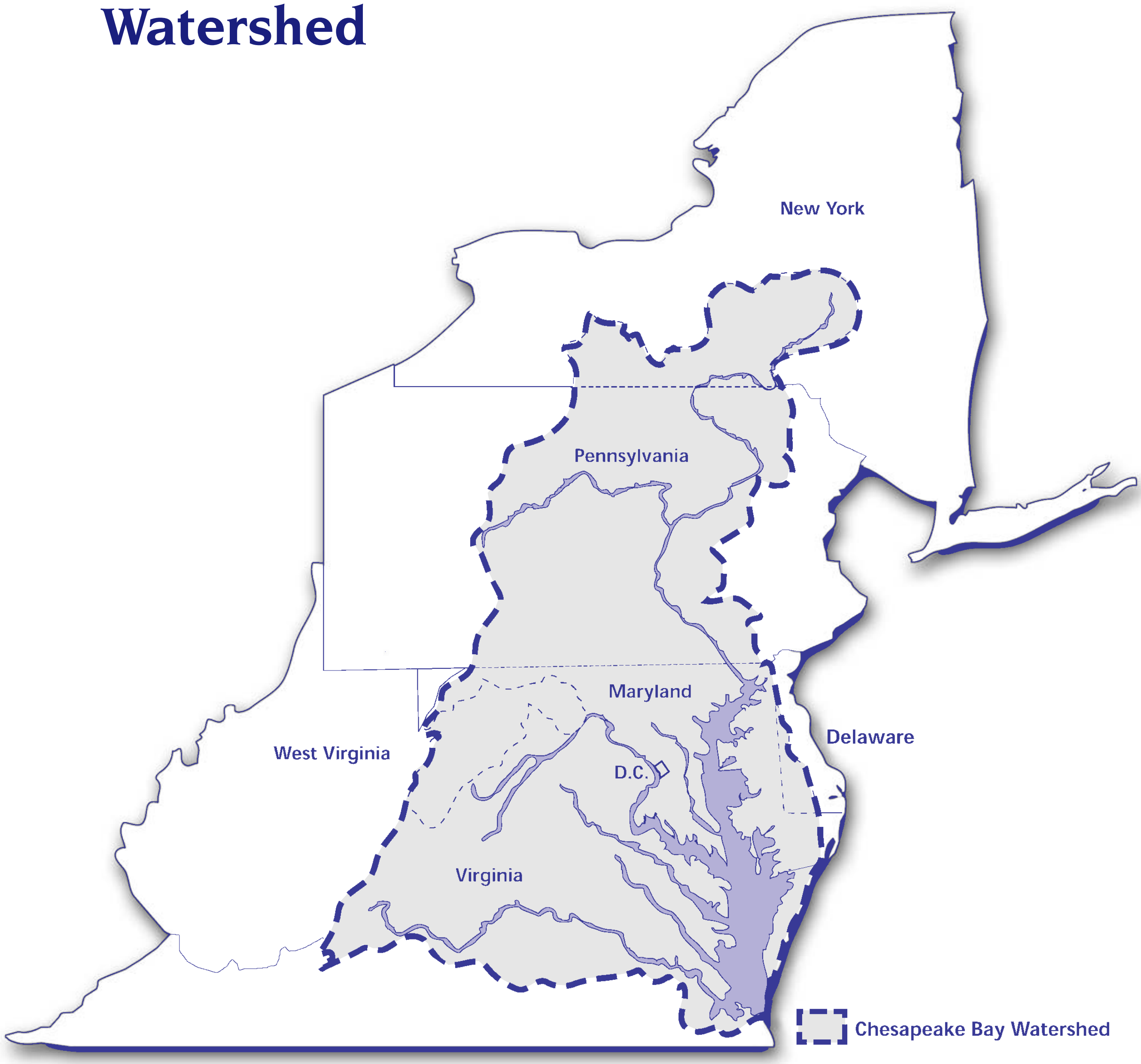
**Chesapeake Bay Program**
*A Watershed Partnership*

Recycled/Recyclable—Printed with Vegetable Oil Based Inks on Recycled Paper (30% Postconsumer)

Printed by the U.S. Environmental Protection Agency for the Chesapeake Bay Program

# Contents

# The Chesapeake Bay Watershed



# The Chesapeake Bay Ecosystem

The physical processes that drive the Chesapeake Bay ecosystem sustain the many habitats and organisms found there. Complex relationships exist among the living resources of the Bay watershed. Even the smallest of creatures plays a vital role in the overall health and production of the Bay. Forests and wetlands around the Bay and the entire watershed filter sediments and pollutants while supporting birds, mammals and fish. Small fish and crabs find shelter and food among lush beds of underwater Bay grasses. Unnoticed by the naked eye, phytoplankton and microzooplankton drift with the currents, becoming food for copepods and small fish. Clams and oysters pump Bay water through their gills, filtering out both plankton and sediment. During the fall and winter, waterfowl by the thousands descend upon the Bay, feeding in wetlands and shallow waters. Bald eagles and osprey, perched high above the water, feed perch, menhaden and other small fish to their young. The spectrum of aquatic environments, from freshwater to seawater, creates a unique ecosystem abundant with life.

The relentless encroachment of people threatens the ecological balance of the Bay. Approximately 16 million people live, work and play in the watershed. Each individual directly affects the Bay by adding waste, consuming resources and changing the character of the land, water and air that surround it. However, through the choices we make every day, we can lessen our impact on the Bay's health. We must nurture what scientist Aldo Leopold once called our "wild rootage", a recognition of the fundamental connection and dependency between society and the environment. As advocates for the Bay and its many living resources, we can preserve the Chesapeake for years to come.

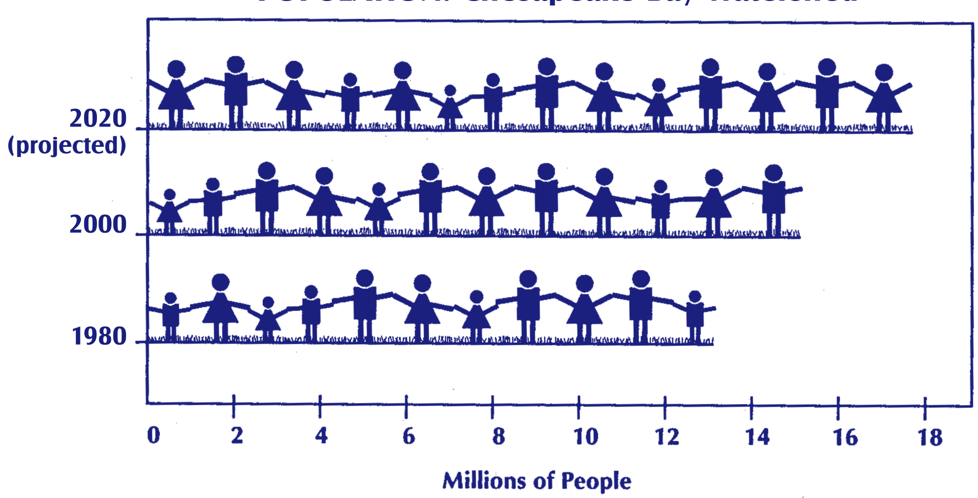
## The Watershed

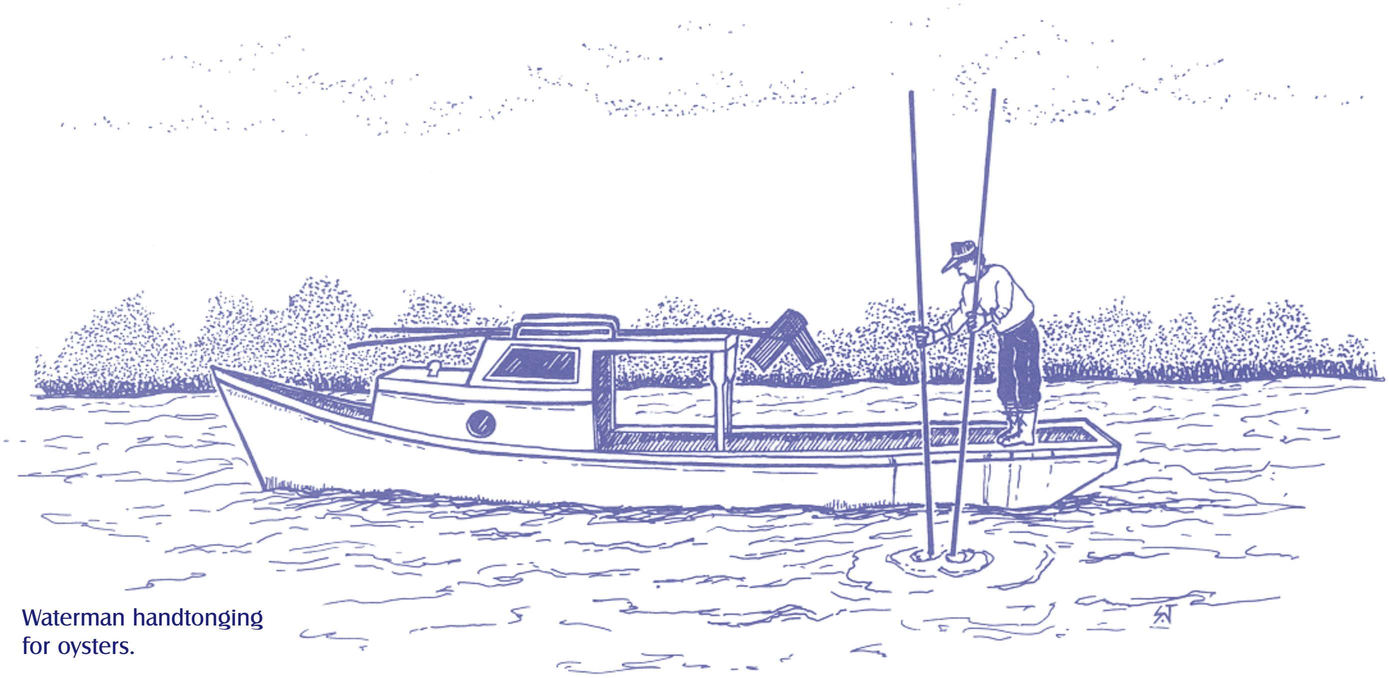
The Chesapeake Bay receives about half its water volume from the Atlantic Ocean. The rest drains into the Bay from an enormous 64,000 square-mile drainage basin or watershed. The watershed includes parts of New York, Pennsylvania, West Virginia, Delaware, Maryland and Virginia and the entire District of Columbia. Freshwater from springs, streams, small creeks and rivers flows downhill, mixing with ocean water to form the estuarine system. Soil, air, water, plants and animals, including humans, form a complex web of interdependencies that make up the ecosystem. The people living in the Chesapeake watershed play an important role in this ecosystem. The activities and problems occurring throughout the entire watershed significantly impact the functions and relationships of the Bay. We must choose whether our role will be destructive or productive.

**BAY FACT**

***Everyone in the watershed lives just a few minutes from one or more of the 100,000 streams and rivers draining into the Chesapeake Bay.***

**POPULATION: Chesapeake Bay Watershed**




Waterman handtonging for oysters.

## The Chesapeake Bay—An Important Resource

**BAY FACT**

***Prior to the late 1800s, oysters were so abundant that some oyster reefs posed navigational hazards to boats.***

Through the years, residents and visitors alike have found the Chesapeake Bay imposing, yet hospitable. The Algonquin Indians called it "Chesepiooc," meaning great shellfish bay. Spanish explorers described the Bay as ". . . the best and largest port in the world." Captain John Smith, an English explorer, extolled, "The country is not mountainous nor yet low but such pleasant plain hills and fertile valleys . . . rivers and brooks, all running most pleasantly into a fair Bay." All were impressed with its size, navigability and abundance of wildlife and food.

Today, the Bay is still one of this country's most valuable natural treasures. Even after centuries of intensive use, the Bay remains a highly productive natural resource. It supplies millions of pounds of seafood, functions as a major hub for shipping and commerce, provides natural habitat for wildlife and offers a variety of recreational opportunities for residents and visitors.

Oysters and blue crabs are famous Bay delicacies. From the 1950s to the 1970s, the average annual oyster catch was about 25 million pounds per year. Since the early 1980s, however, the catch has declined dramatically due to over-harvesting, disease and the loss or degradation of habitat. As for Bay blue crab harvesting, historically the Chesapeake has been the largest producer of blue crabs in the country, contributing more than a third of the nation's catch. In 2002, however, the Bay's blue crab harvest was only 50 million pounds, well below the long-term average of 73 million pounds. The states of Maryland and Virginia have pledged to jointly manage the Bay's blue crab harvests by reducing harvest levels by 15 percent. Harvesting of soft-shelled clams and an extensive finfish industry, primarily based on menhaden and striped bass, round out the Chesapeake's commercial seafood production. In 2001, the dockside value of commercial shellfish and finfish harvests was close to $175 million.

The hospitable climate, lush vegetation and natural beauty of the Chesapeake have made it an increasingly popular recreational area. Boating, crabbing, swimming, hunting and camping are major attractions. Both power and sail boating have grown dramatically. In Maryland and Virginia, more than 447,000 pleasure boats and other personal craft were registered in 2002.

Sportfishing is another major recreational activity in the Chesapeake region. It is estimated that more than one million anglers travel to the Bay each year to fish off the shores of Maryland and Virginia.

The Chesapeake also is a key commercial waterway, with two major Atlantic ports located here, Hampton Roads and Baltimore. The Hampton Roads Complex, which includes Portsmouth, Norfolk, Hampton and Newport News, dominates the mouth of the Bay, and ranks third in the nation for metric tons of exports. At the northern end of the Bay, the Port of Baltimore is ranked fifteenth in volume of exports in foreign trade. In all, these two ports handled more than 84 million metric tons of both imports and exports in 2001. Both Baltimore and Hampton Roads are near the coal-producing regions of Appalachia, making them essential to exporting coal.

Shipbuilding and other related industries also depend on the Bay. Industries and power companies use large volumes of water from the Bay for industrial processes and cooling.

Perhaps the Chesapeake's most valuable function, yet most difficult to put a price tag on, is its role as habitat for living resources. The Bay and its surrounding watershed provide homes for a multitude of plants and animals.

Waterfowl and other birds migrating along the Atlantic Flyway stop here, finding food and shelter in coves and marshes. The Chesapeake is the winter home for tundra swans, Canada geese and a variety of ducks, including canvasbacks, pintails, scoters, eiders and ruddy ducks. On average, nearly one million waterfowl winter each year on the Bay. It is also a major nesting area for the threatened bald eagle. The Bay region also is home to the world's largest population of another raptor, the osprey, with more than 2,000 nesting pairs.

The Chesapeake's tidal freshwater tributaries provide spawning and nursery sites for several important species of fish, such as white and yellow perch, striped bass, herring and shad. During the warmer months, numerous marine species, including bluefish, weakfish, croaker, menhaden, flounder and spot, enter the Bay to feed on its rich food supply.

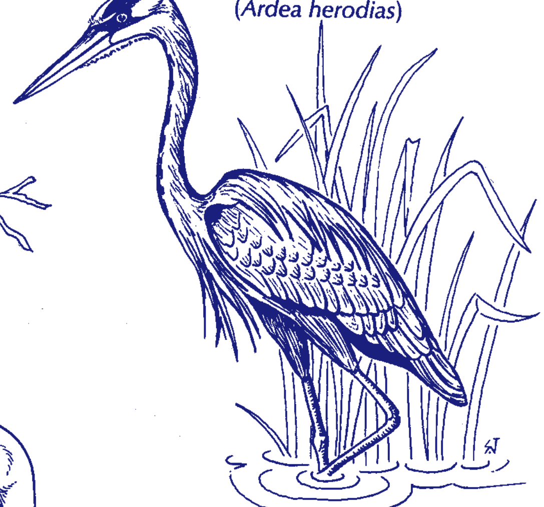
Canada goose
(*Branta canadensis*)

**BAY FACT**

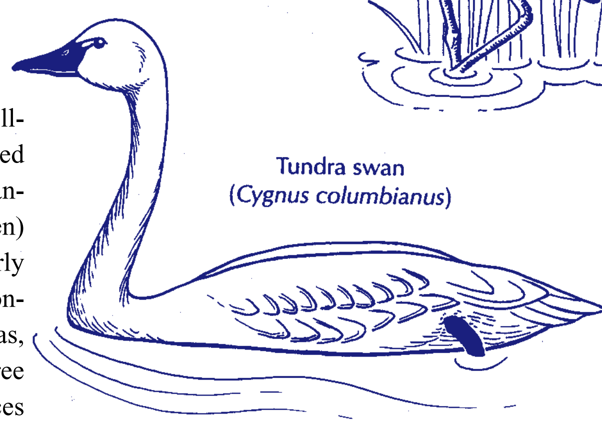
***The Chesapeake is fairly shallow. A person six feet tall could wade over 700,000 acres of the Bay without becoming completely submerged.***

Canvasback
(*Aythya valisineria*)

Osprey
(*Pandion haliaetus*)



Great blue heron
(*Ardea herodias*)



Tundra swan
(*Cygnus columbianus*)

## A Threatened Resource

The Chesapeake Bay, the largest estuary in the United States, is part of an extremely productive and complex ecosystem. This ecosystem consists of the Bay, its tributaries and the living resources it supports. Humans also are a part of this ecosystem. We are beginning to understand how our activities affect the Bay's ecology. Growing commercial, industrial, recreational and urban activities continue to threaten the Bay and its living resources.

Overharvesting and loss of habitat threaten fish and shellfish species. These two factors, plus disease, have decimated the oyster population. Excess sediment and nutrients endanger the Bay's water quality. Hypoxia (low dissolved oxygen) and anoxia (absence of dissolved oxygen) are particularly harmful to bottom-dwelling (benthic) species. Chemical contaminants, particularly high in industrialized urban areas, accumulate in the tissues of birds, fish and shellfish. Three areas, known as Regions of Concern, where living resources likely are being affected by chemical contaminants are the Baltimore Harbor/Patapsco River in Maryland, the Anacostia

River in the District of Columbia and the Elizabeth River in Virginia.

To find the causes of and potential remedies for these problems, it is necessary to see the Bay from an ecological perspective. All too often we think of ourselves as external to our environment and ignore the many relationships that link people, other living creatures and the surrounding habitat. If we ignore these connections when seeking solutions to problems, more and greater problems may result.

For example, agricultural activities and residential development increase the amount of sediment and nutrient-rich fertilizers entering the Bay through runoff. Water clarity is reduced and rivers are silted in. Excess nutrients cause algal blooms that block sunlight from reaching critical underwater bay grasses, known as submerged aquatic vegetation, or SAV. As bay grass acreage declines, so does the food, shelter and nursery grounds for many aquatic species. Solutions to these environmental problems can only be effective if complex relationships among all components of the ecosystem also are considered.

When environmental problems are approached from an ecosystem perspective, both living and non-living components are considered when recommending solutions. A truly effective solution not only corrects the problem, but avoids damaging other relationships within the ecosystem. This approach makes problem-solving a great deal more challenging, but leads to more effective environmental management.

**BAY FACT**

***More than a third of the nation's catch of blue crabs comes from the Bay.***

# Geology of the Chesapeake

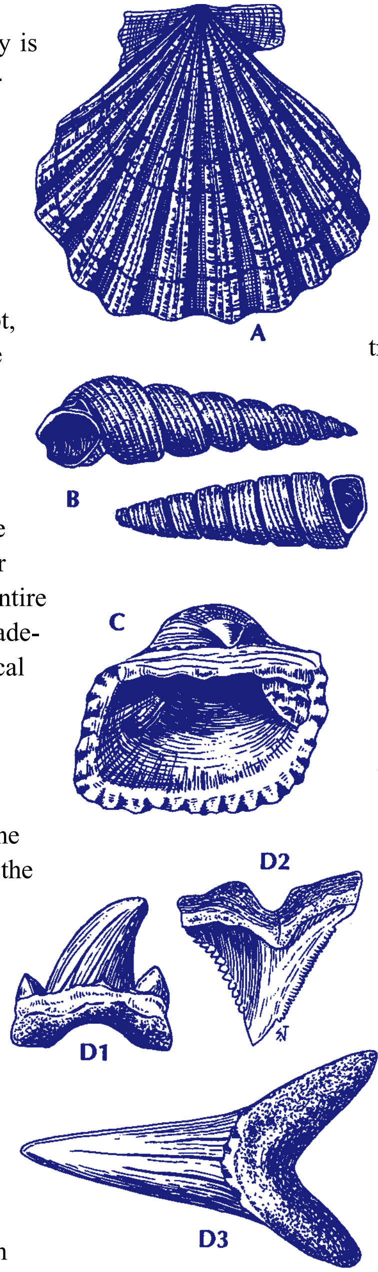
The Chesapeake Bay as we know it today is the result of thousands of years of continuous change. The Chesapeake, less than 10,000 years old, continues to change. Nature, like a dissatisfied artist, is constantly reworking the details. Some modifications enhance the Bay, while others harm it. All affect the ecosystem and its interdependent parts. Some changes are abrupt, while others take place over such a long time that we can only recognize them by looking back into geologic history.

Humans are becoming more involved in the reshaping process, often inadvertently initiating chains of events that reverberate through the Bay's ecosystem. Because our actions can have devastating effects on the entire system, it is essential that we develop an adequate understanding of the Bay's geological make-up and fundamental characteristics.

## Geologic History

During the latter part of the Pleistocene epoch, which began one million years ago, the region that is now the Chesapeake was alternately exposed and submerged as massive glaciers advanced and retreated up and down the North American continent. Sea levels rose and fell in concert with glacial contraction and expansion. The region still experiences changes in sea levels, easily observed over the duration of a century.

The most recent retreat of the glaciers, which began about 18,000 years ago, marked the end of the Pleistocene epoch and brought about the birth of the Chesapeake Bay. The rising waters from melting glaciers covered the continental shelf and reached the mouth of the Bay about 10,000 years ago. Sea level continued to rise, eventually submerging the area now known as the Susquehanna River Valley. The Bay assumed its present dimensions about 3,000 years ago. . This complex array of drowned streambeds forms the Chesapeake basin known today.




A Broad Ribbed scallop (*Lyropecten santamaria*)
B Turret snail (*Turritella plebia*)
C Ark (*Anadora staminea*)
D Shark teeth
1 (*Otodus obliquus*)
2 (*Hemipristis serra*)
3 (*Oxyrhina desori*)

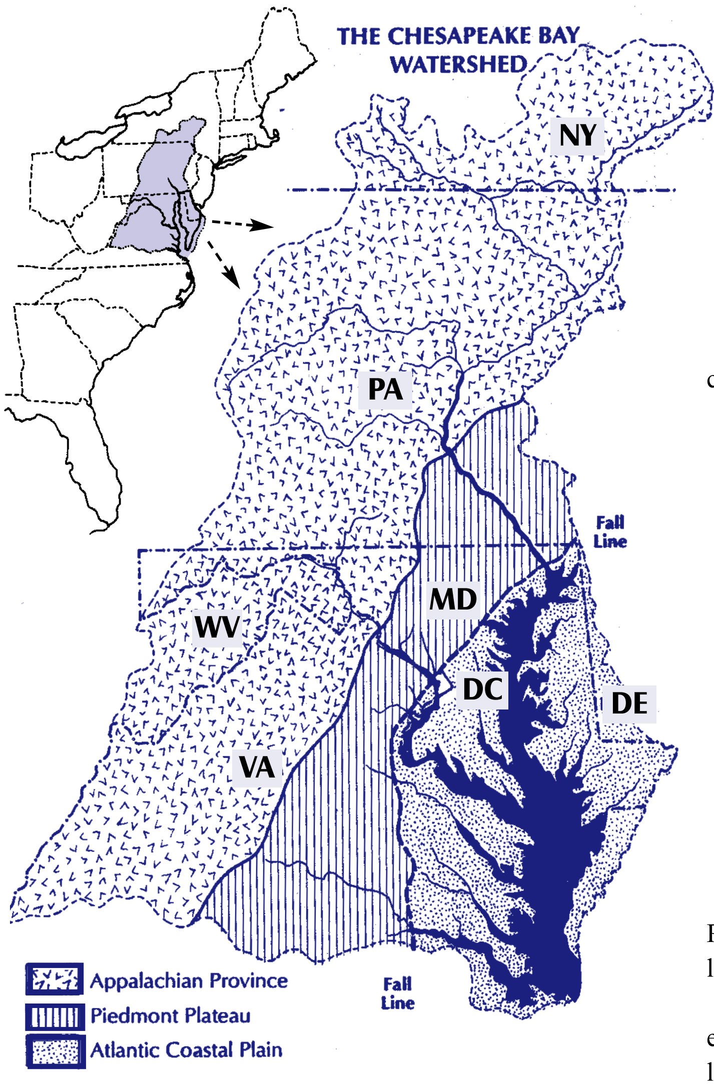
## The Chesapeake Bay

The Bay proper is approximately 200 miles long, stretching from Havre de Grace, Maryland, to Norfolk, Virginia. It varies in width from about 3.4 miles near Aberdeen, Maryland, to 35 miles at its widest point, near the mouth of the Potomac River. Including its tidal tributaries, the Bay has approximately 11,684 miles of shoreline.

Fifty major tributaries pour water into the Chesapeake every day. Eighty to 90% of the freshwater entering the Bay comes from the northern and western sides. The remaining 10 to 20% is contributed by the eastern shore. Nearly an equal volume of saltwater enters the Bay from the ocean.

On average, the Chesapeake holds more than 15 trillion gallons of water. Although the Bay's length and width are dramatic, the average depth is only about 21 feet. The Bay is shaped like a shallow tray, except for a few deep troughs believed to be remnants of the ancient Susquehanna River. The troughs form a deep channel along much of the length of the Bay. This channel allows passage of large commercial vessels. Because it is so shallow, the Chesapeake is far more sensitive to temperature fluctuations and wind than the open ocean.

To adequately define the Chesapeake ecosystem, we must go far beyond the shores of the Bay itself. Although the Bay lies totally within the Atlantic Coastal Plain, the watershed includes parts of the Piedmont Province and the Appalachian Province. The tributaries provide a mixture of waters with a broad geochemical range to the Bay. These three different geological provinces influence the Bay. Each contributes its mixture of minerals, nutrients and sediments.




The Atlantic Coastal Plain is a flat, low land area with a maximum elevation of about 300 feet above sea level. It is supported by a bed of crystalline rock, covered with southeasterly-dipping wedge-shaped layers of relatively unconsolidated sand, clay and gravel. Water passing through this loosely compacted mixture dissolves many of the minerals. The most soluble elements are iron, calcium and magnesium.

**BAY FACT**

***More than 600 species are fossilized in the sediments of Calvert Cliffs in Maryland.***

The Atlantic Coastal Plain extends from the edge of the continental shelf, to the east, to a fall line that ranges from 15 to 90 miles west of the Bay. This fall line forms the boundary between the Piedmont Plateau and the Coastal Plain. Waterfalls and rapids clearly mark this line, which is close to Interstate 95. Here, the elevation rises to 1,100 feet. Cities such as Fredericksburg and Richmond in Virginia, Baltimore in Maryland, and the District of Columbia developed along the fall line taking advantage of the potential water power generated by the falls. Since colonial ships could not sail past the fall line, cargo would be transferred to canals or overland shipping. Cities along the fall line became important areas for commerce.

The Piedmont Plateau ranges from the fall line in the east to the Appalachian Mountains in the west. This area is divided into two geologically distinct regions by Parrs Ridge, which traverses Carroll, Howard and Montgomery counties in Maryland and adjacent counties in Pennsylvania. Several types of dense crystalline rock, including slates, schists, marble and granite, compose the eastern side. This results in a very diverse topography. Rocks of the Piedmont tend to be impermeable, and water from the eastern side is low in the calcium and magnesium salts. This makes the water soft and easy to lather.

The western side of the Piedmont consists of sandstones, shales and siltstones, underlain by limestone. This limestone bedrock contributes calcium and magnesium to its water, making it hard. Waters from the western side of Parrs Ridge flow into the Potomac River, one of the Bay's largest tributaries.

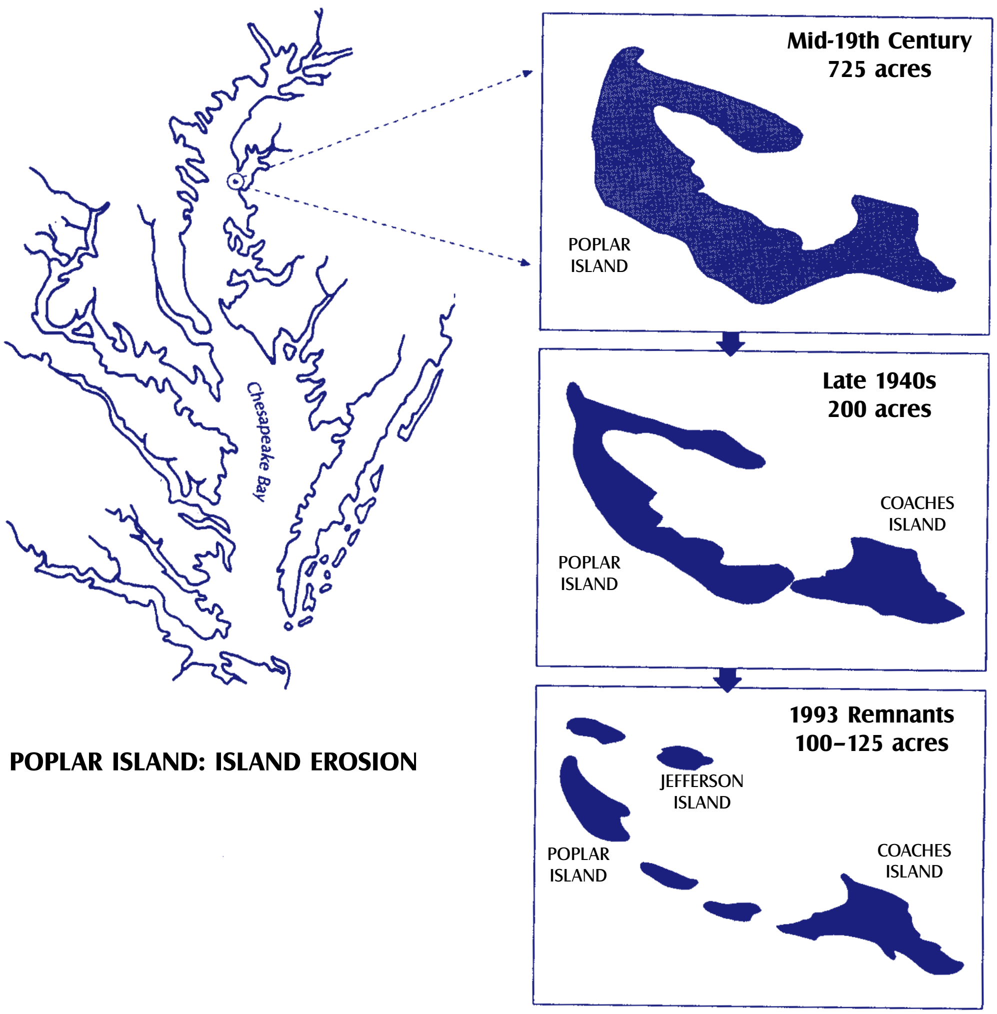
The Appalachian Province lies in the western and northern parts of the watershed. Sandstone, siltstone, shale and limestone form the bedrock. These areas, characterized by mountains and valleys, are rich in coal and natural gas deposits. Water from this province flows to the Bay mainly via the Susquehanna River.

The waters that flow into the Bay have different chemical identities, depending on the geology of the place where the waters originate. In turn, the nature of the Bay itself depends on the characteristics and relative volumes of these contributing waters.

## Erosion and Sedimentation

Since its formation, the Bay's shore has undergone constant modification by erosion, transport and deposition of sediments. In this process, areas of strong relief, like peninsulas and headlands, are eroded and smoothed by currents and tides, and the materials are deposited in other parts of the Bay. Sediments may be deposited in channels. Sediments, carried by the river currents, also are left at the margins of the Bay and major tributaries, resulting in broad, flat deposits of mud and silt. Colonization of these areas by hydrophytic (water-loving) vegetation may stabilize the sediments and wetlands can develop. Recently, however, wetlands along shorelines have been retreating inland as sea level has risen. The speed at which these actions progress depends on numerous factors, including weather, currents, composition of the affected land, tides, wind and human activities.

Many of the islands that existed in the Bay during colonial times are now submerged. Poplar Island, in Talbot County, Maryland, illustrates the erosive forces continuing today. In the early 1600s, the island encompassed several hundred acres. Over the centuries, rising sea level eroded the perimeter of Poplar Island. Though still populated by the 1940s, only 200 acres remained and the island had been cut in two. Today, a chain of small islands is all that remains of the original Poplar Island. Efforts are under way to stabilize the remnant acres. In addition, the island's original landmass will be rebuilt by creating marshes that will protect the island from further erosion and provide a haven for birds and other wildlife. In contrast, sedimentation also has altered the landscape. By the mid 1700s, some navigable rivers were filled in by sediment as more land was cleared for agriculture. Joppatown, Maryland, once a seaport, is now more than two miles from water. The forces of erosion and sedimentation continue to reshape the details of the Bay.




**POPLAR ISLAND: ISLAND EROSION**

# Water & Sediments

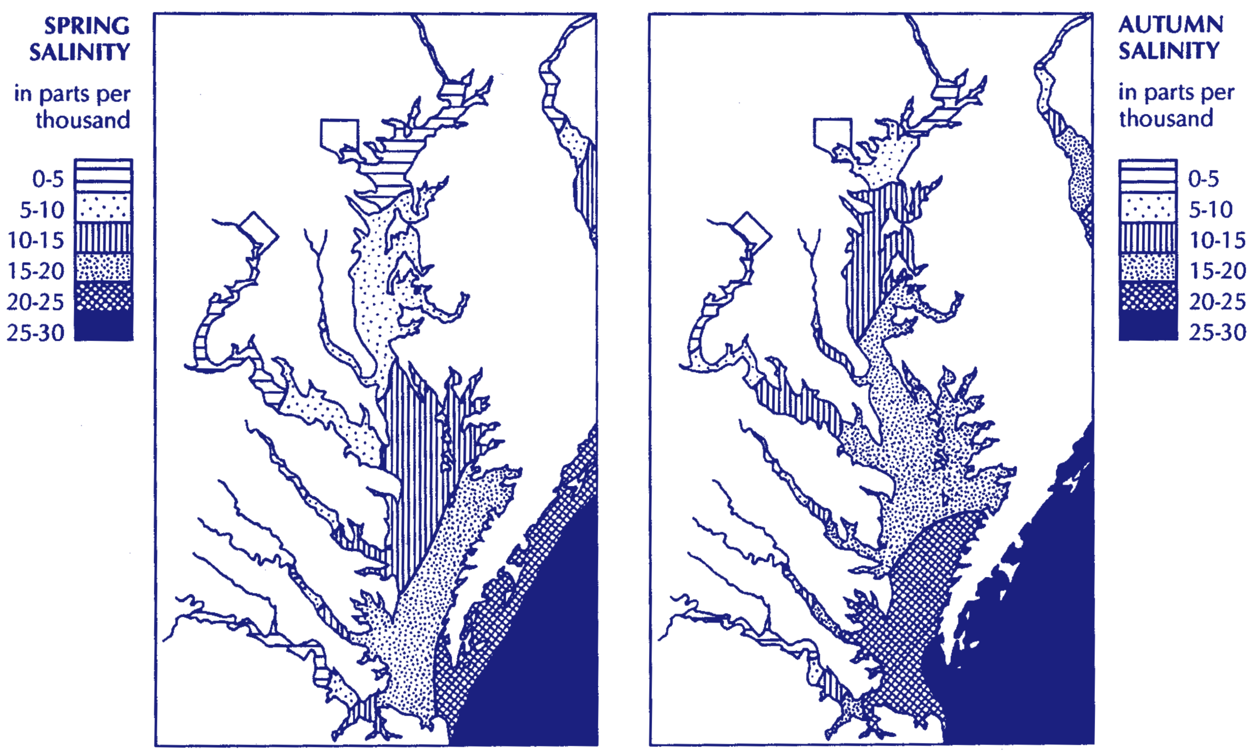
Water . . . approximately 70% of the Earth's surface is covered by it. It makes up about 80% of our total body weight. Without it, we cannot live. Perhaps, because its presence is so pervasive in our lives, we tend to think of water as uniform rather than a substance with extremely diverse characteristics and properties.

In the natural environment, water is never pure. It tends to hold other substances in solution and easily enters into various chemical reactions. As the universal solvent, water is an important environmental medium. Water normally contains dissolved gases, such as oxygen, and a variety of organic (containing carbon) and inorganic materials. The concentration and distribution of these substances can vary within a single body of water. Add differences in temperature and circulation, which can enhance or retard certain chemical reactions, and the variety of possible water environments vastly increases.

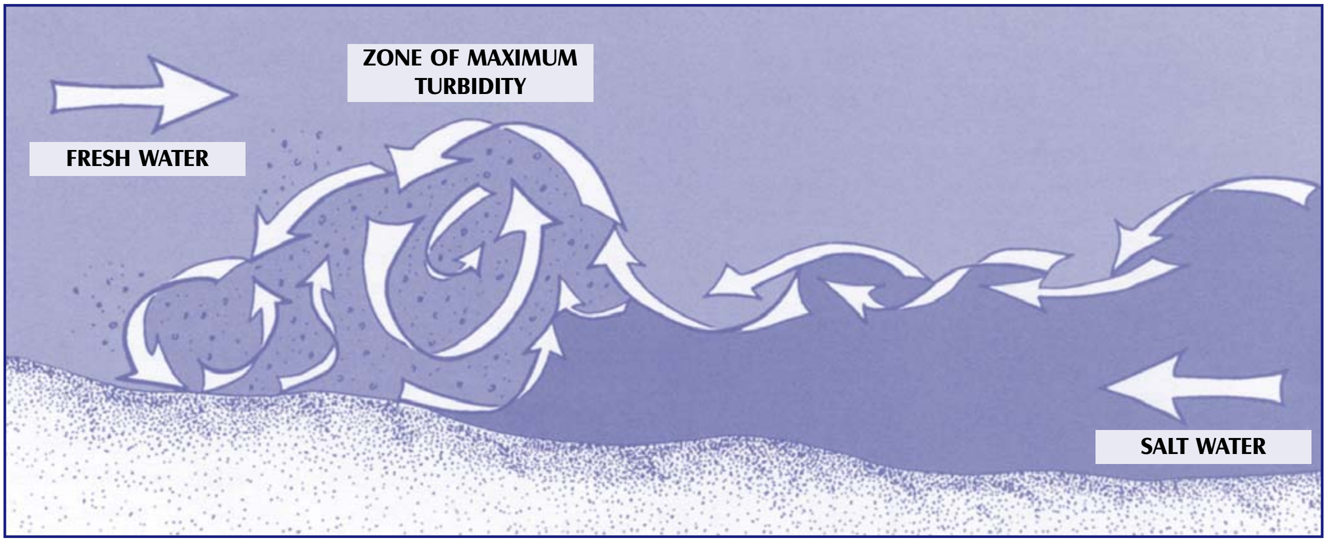
Of all bodies of water, estuarine systems offer the greatest physical variability in water composition. An estuary, according to the late oceanographer Donald W. Pritchard, is a ". . . semi-enclosed body of water which has free connection with the open sea and within which seawater is measurably diluted by freshwater from land drainage." Within an estuary, freshwater mixes with saltwater, with each contributing its own chemical and physical characteristics. This creates a range of environments that support a wide variety of plants and animals.

## Water: Salinity, Temperature and Circulation

The distribution and stability of an estuarine ecosystem, such as the Chesapeake Bay, depend on three important physical characteristics of the water: salinity, temperature and circulation. Each affects and is affected by the others.




Isohalines mark the salt content of surface water. The salinity gradient varies during the year due to freshwater input: fresher during spring rains, saltier during the drier months of autumn.




Salinity is a key factor influencing the physical make-up of the Bay. Salinity is the number of grams of dissolved salts present in 1,000 grams of water. Salinity is usually expressed in parts per thousand (ppt). Freshwater contains few salts (less than 0.5 ppt) and is less dense than full ocean strength seawater, which averages 25 to 30 ppt. This difference in density causes salinity to increase with depth, and freshwater to remain at the surface. Water with a salinity of greater than 0.5 ppt but less than 25 ppt is called brackish, meaning a combination of saltwater and freshwater. Most of the water in the Bay falls into this category.

Seawater from the Atlantic Ocean enters the mouth of the Bay. Salinity is highest at that point and gradually decreases as one moves north. Salinity levels within the Chesapeake vary widely, both seasonally and from year to year, depending on the volume of freshwater flowing into the Bay. On a map, isohalines, or salinity contours, mark the salt content of surface waters. Because the greatest volume of freshwater enters the Bay from northern and western tributaries, isohalines tend to show a southwest to northeast tilt. The rotation of the Earth also drives this salinity gradient. Known as the Coriolis Force, it deflects flowing water to the right in the Northern Hemisphere so that saltier water moving up the Bay is deflected toward the Eastern Shore. Therefore, the water near the Eastern Shore of the Bay is saltier than water near the Western Shore.

Temperature dramatically changes the rate of chemical and biological reactions within the water. Because the Bay is so shallow, its capacity to store heat over time is relatively small. As a result, water temperature fluctuates throughout the year, ranging from 34 to 84 degrees Fahrenheit. These changes in water temperature influence when plants and animals feed, reproduce, move locally or migrate. The temperature profile of the Bay is fairly predictable. During spring and summer, surface and shallow waters are warmer than deeper waters, creating two distinct temperature layers. The turbulence of the water can help to break down this layering.

**BAY QUOTE**

***". . . the tide is also governed by the wind. South-east makes the highest flood and northwest the lowest ebb."***

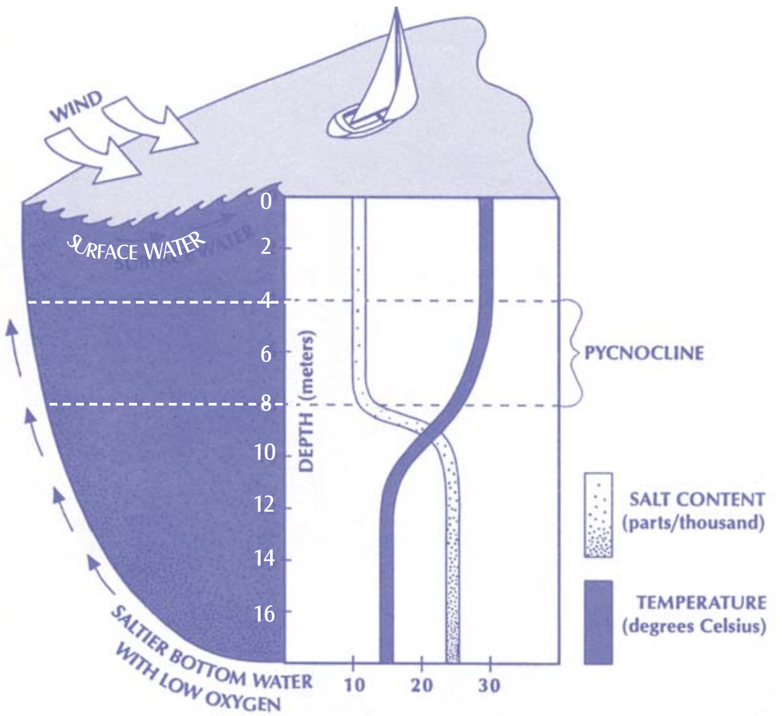
Rev. Hugh Jones, 1697

Just as circulation moves much-needed blood throughout the human body, circulation of water transports plankton, fish eggs, shellfish larvae, sediments, dissolved oxygen, minerals and nutrients throughout the Bay. Circulation is driven primarily by the movements of freshwater from the north and saltwater from the south. Circulation causes nutrients and sediments to be mixed and resuspended. This mixing creates a zone of maximum turbidity that, due to the amount of available nutrients, is often used as a nursery area for fish and other organisms.

Weather can disrupt or reinforce this two-layered circulation pattern. Wind plays a role in the mixing of the Bay's waters. Wind also can raise or lower the level of surface waters and occasionally reverse the direction of flow. Strong northwest winds, associated with high-pressure areas, push water away from the Atlantic Coast, creating exceptionally low tides. Strong northeast winds, associated with low-pressure areas, produce exceptionally high tides.

Together, salinity, temperature and circulation dictate the physical characteristics of water. The warmer, lighter

The change in temperature and salinity divides the Bay into saltier bottom water and lighter, fresher surface water. A blurry mixing layer, known as the pycnocline, divides the two. Strong winds can pile surface water against one shore of the Bay. To reestablish equilibrium, the bottom layer flows up into shallower water.




freshwater flows seaward over a layer of saltier and denser water flowing upstream. The opposing movement of these two flows forms saltwater fronts, or gradients, that move up and down the Bay in response to the input of freshwater. A layer separating water of different densities, known as a pycnocline, is formed. The pycnocline is characterized by intensive mixing of these two layers. This stratification varies within any season depending on rainfall. Stratification is usually highest in the spring as the amount of freshwater in the Bay increases due to melting snow and frequent rain. Stratification is maintained throughout summer due to the warming of surface waters.

In autumn, fresher surface waters cool faster than deeper waters and sink. Vertical mixing of the two water layers occurs rapidly, usually overnight. This mixing moves nutrients up from the bottom, making them available to phytoplankton and other organisms inhabiting upper water levels. This turnover also distributes much-needed dissolved oxygen to deeper waters. During the winter, water temperature and salinity are relatively constant from surface to bottom.

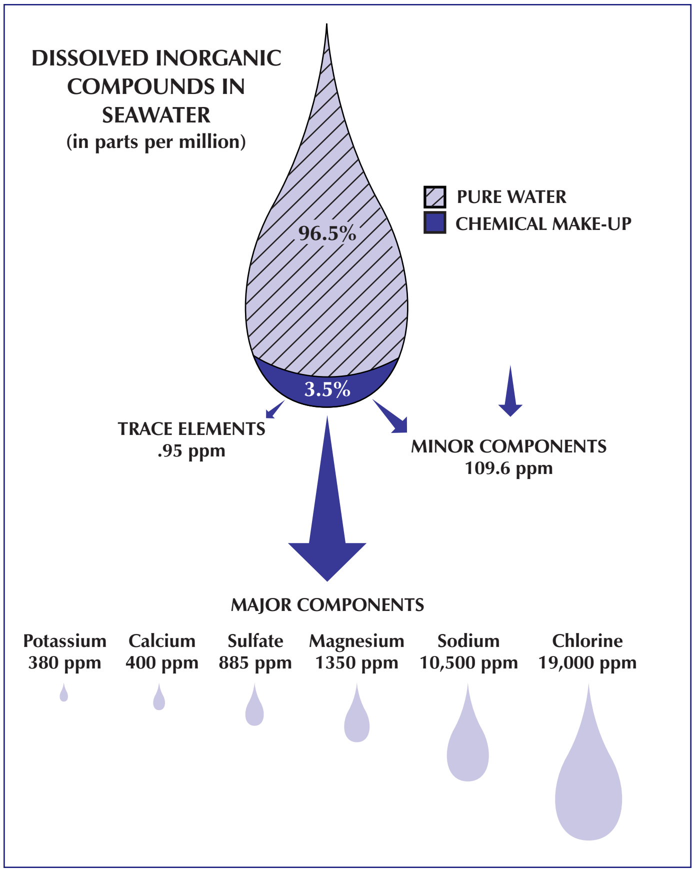
## Suspended Sediments: Composition and Effects

The waters of the Chesapeake and its tributaries transport huge quantities of sediments. Although sediments are a natural part of the Bay ecosystem, accumulation of excessive amounts of sediments is undesirable because they can fill in ports and waterways. This sedimentation process already has caused several colonial seaports, like Port Tobacco and Bladensburg, Maryland, to become landlocked. As they settle to the bottom of the Bay, sediments can smother bottom-dwelling plants and animals, such as oysters and clams. Sediments suspended in the water column cause the water to become cloudy, or turbid, decreasing the light available for underwater bay grasses.

In the upper Bay and tributaries, sediments consist of fine-grained silts and clays that are light and can be carried long distances by the fresh, upper layer of water. As they move into the Bay, the particles slowly descend into the denser saline layer. Here, the particles may reverse direction and flow back up toward tidal tributaries with the lower layer of water. As the upstream flow decreases, the sediments settle to the bottom.

Sediments in the middle Bay are mostly made of silts and clays and mainly are derived from shoreline erosion. In the lower Bay, by contrast, the sediments are sandier and heavier and result from shore erosion and inputs from the ocean. Sediments drop to the bottom fairly rapidly, remain near their original source and are less likely to be resuspended than finer silts.

Sediments also can carry high concentrations of certain toxic materials. Individual sediment particles have a large surface area, and many molecules easily attach to them. As a result, sediments can act as chemical sinks by absorbing metals, nutrients, oil, pesticides and other potentially toxic materials. Thus, areas of high sediment deposition sometimes have high concentrations of nutrients, persistent (long-lasting) chemicals and contaminants, which may later be released.




## Chemical Make-up: Composition and Dissolved Gases

Like temperature and salinity, the chemical composition of the water also helps determine the distribution and abundance of plant and animal life within the Bay. The waters of the Chesapeake contain organic and inorganic materials, including dissolved gases, nutrients, inorganic salts, trace elements, heavy metals and potentially toxic chemicals.

### Composition of Water

The composition of seawater is relatively constant from place to place. Freshwater, however, varies depending on the soil and rocks with which the water has come in contact. Both fresh and saltwater contain many natural dissolved materials from several sources. Microorganisms, such as bacteria, decompose dead organisms and release compounds into the water. Live organisms also release compounds directly into the water. In addition, dissolved material enters the Bay via its tributaries and the ocean.

Seawater also contains hundreds of trace elements that are important in many biological reactions. For example, living organisms require minute quantities of cobalt to make vitamin B-12. Metals such as mercury, lead, chromium and cadmium also naturally occur in low concentrations. As you move down the Bay the composition of the water follows the salinity gradients. Major constituents include chlorides, sodium, magnesium, calcium and potassium.

Dissolved salts are important to the life cycles of many organisms. Some fish spawn in fresh or slightly brackish water and must move to more saline waters as they mature. These species have internal mechanisms that enable them to cope with the changes in salinity.

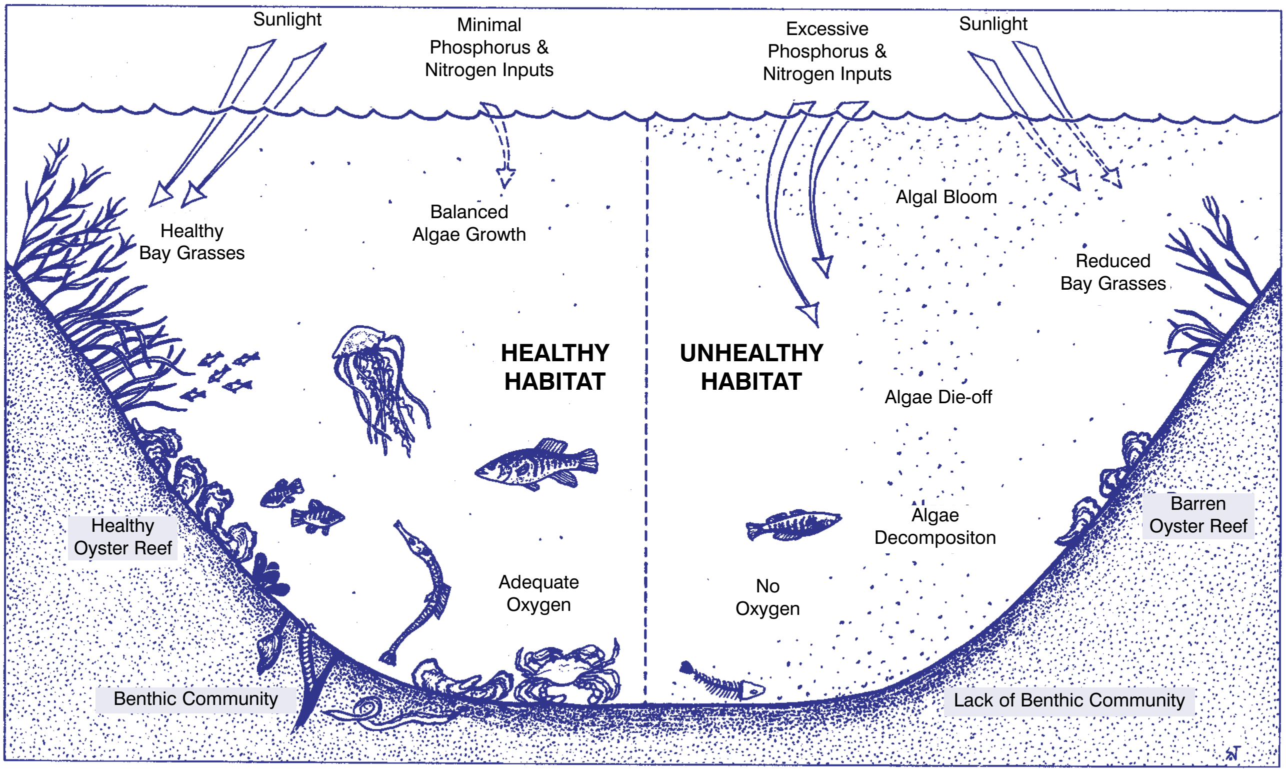
### Dissolved Gases

Dissolved oxygen is essential for most animals inhabiting the Bay. The amount of available oxygen is affected by salinity and temperature. Cold water can hold more dissolved oxygen than warmer water, and freshwater holds more than saline water. Thus, concentrations of dissolved oxygen vary, in part, with both location and time. Oxygen is transferred from the atmosphere into surface waters by diffusion and the aerating action of the wind. It also is added as a byproduct of photosynthesis. Floating and rooted aquatic plants and phytoplankton release oxygen when photosynthesizing. Since photosynthesis requires light, production of oxygen by aquatic plants is limited to shallow water areas, usually less than six feet deep. Surface water is nearly saturated with oxygen most of the year, while deep bottom waters range from saturated to anoxic (no oxygen present).

**BAY FACT**

***Due to a lack of oxygen in the water, hundreds of blue crabs may run out onto land. This rare phenomenon is known as a "crab jubilee."***

During the winter, respiration levels of organisms are relatively low. Vertical mixing is good, and there is little salinity or temperature stratification. As a result, dissolved oxygen is plentiful throughout the water column. During the spring and summer, increased levels of animal and microbial respiration and greater stratification may reduce vertical mixing, resulting in low levels of dissolved oxygen in deep water. In fact, deep parts of some tributaries like the Patuxent, Potomac and Rappahannock rivers and deep waters of the Bay's mainstem can become anoxic in summer. In the autumn when surface waters cool, vertical mixing occurs and deep waters are re-oxygenated.




Carbon dioxide, another dissolved gas, is important to the well-being of the Bay's aquatic environment. It provides the carbon that plants use to produce new tissue during photosynthesis and is a byproduct of respiration. Carbon dioxide is more soluble in water than oxygen. Its availability also is affected by temperature and salinity in much the same fashion as oxygen.

## Nitrogen and Phosphorus

Nitrogen is essential to the production of plant and animal tissue. It is used primarily by plants and animals to synthesize protein. Nitrogen enters the ecosystem in several chemical forms. It also occurs in other dissolved or particulate forms, such as in the tissues of living and dead organisms.

Some bacteria and blue-green algae can extract nitrogen gas from the atmosphere and transform it into organic nitrogen compounds. This process, called nitrogen fixation, cycles nitrogen between organic and inorganic components. Other bacteria release nitrogen gas back into the atmosphere as part of their normal metabolism in a process called denitrification. Denitrification removes about 25% of the nitrogen entering the Bay each year.

Phosphorus is another key nutrient in the Bay's ecosystem. In the water, phosphorus occurs in dissolved organic and inorganic forms, often attached to particles of sediment. This nutrient is essential to cellular growth and reproduction. Phytoplankton and bacteria assimilate and use phosphorus in their growth cycles. Phosphates (the organic form) are preferred, but organisms will use other forms of phosphorus when phosphates are unavailable.

In the presence of oxygen, high concentrations of phosphates in the water will combine with suspended particles. These particles eventually settle to the Bay bottom and are temporarily removed from the cycling process. Phosphates often become long-term constituents of the bottom sediments. Phosphorus compounds in the Bay generally occur in greater concentrations in less saline areas, such as the upper part of the Bay and tributaries. Overall, phosphorus concentrations vary more in the summer than winter.

Nutrients, like nitrogen and phosphorus, occur naturally in water, soil and air. Just as the nitrogen and phosphorus in fertilizer aids the growth of agricultural crops, both nutrients are vital to the growth of plants within the Bay. Excess nutrients, however, are pollutants. Sewage treatment plants, industries, vehicle exhaust, acid rain, and runoff from agricultural, residential and urban areas are additional sources of nutrients entering the Bay. Nutrient pollution is the number one problem in the Bay system.

Excess amounts of nitrogen and phosphorus cause the rapid growth of phytoplankton, creating dense populations or algal blooms. These blooms become so dense that they reduce the amount of sunlight available to underwater bay grasses. Without sufficient light, plants cannot photosynthesize and produce the food they need to survive. Algae also may grow directly on the surface of bay grasses, blocking light. Another hazard of nutrient-enriched algal blooms comes after the algae die. As the blooms decay, oxygen is used up in decomposition. This can lead to dangerously low oxygen levels that can harm and even kill aquatic organisms.

Besides nutrients, people add other substances to the Bay's water, creating serious pollution problems. Heavy metals, insecticides, herbicides and a variety of synthetic products and byproducts can be toxic to living resources. These contaminants reach the Bay through municipal and industrial wastewater, runoff from agricultural, residential and urban areas and atmospheric deposition.

**BAY FACT**

***During the 1600s, wolves, cougars, elk and buffalo still inhabited the Bay watershed.***

This situation is improving. In many cases, industrial wastewater is treated to remove contaminants. The use of especially damaging synthetic substances, like DDT and Kepone, has been banned.

Since 1987, regional Bay restoration leaders have worked together to reduce the amount of nutrients flowing into the Bay and its rivers. In 2003, the six Bay watershed states, the District of Columbia and the U.S. Environmental Protection Agency agreed to steep cuts in the amount of nutrients flowing into the Bay and its rivers.

The new nutrient reduction goals, or allocations, call for Bay watershed states to reduce the amount of nitrogen flowing into the Bay from the 274 million pounds in 2001 to no more than 175 million pounds per year by 2010, and phosphorus from 19.1 million pounds to no more than 12.8 million pounds per year by 2010. When coordinated nutrient reduction efforts began in 1985, 338 million pounds of nitrogen and 27.1 million pounds of phosphorus entered the Bay annually. When achieved, the new allocations will provide the water quality necessary for the Bay's plants and animals to thrive.

# Habitats

The Bay provides food, water, cover and nesting or nursery areas, collectively known as habitat, to more than 3,000 migratory and resident wildlife species. All plants and animals have specific habitat requirements that must be satisfied in order to live and thrive. Food, temperature, water, salinity, nutrients, substrate, light, oxygen and shelter requirements vary with each species. These physical and chemical variables largely determine which species can be supported by a particular habitat.

As a highly productive estuary, the Chesapeake Bay provides an array of habitats. Habitat types range from hardwood forests of the Appalachian mountains to saltwater marshes in the Bay. These habitats are influenced by climate, soils, water, plant and animal interactions and human activities. Four major habitat areas are critical to the survival of the living resources of the Bay.

## Islands and Inlands

Lands near water sources support a multitude of species, from insects, amphibians and reptiles to birds and mammals. Streambanks, floodplains and wetlands form the transition from water to land. These areas act as buffers by removing sediments, nutrients, organic matter and pollutants from runoff before these substances can enter the water. Forests and forested wetlands are particularly important to waterfowl, other migratory birds and colonial waterbirds.

Forested uplands and wetlands are nesting and resting habitat for neotropical migratory birds. These birds breed in the United States but winter in Central and South America. Some neotropical birds breed in the forests found in the Bay watershed. The Bay lies within the Atlantic Flyway, a major migration route for neotropical migrants and migrating waterfowl, and is a significant resting area for birds.

Surrounded by water and cut off from most large predators, Bay islands are a haven for colonial waterbirds (terns and herons), waterfowl (ducks) and raptors (osprey and bald eagles). Islands also can protect underwater bay grasses and shallow water areas from erosion and sedimentation. However, islands themselves are eroding at alarming rates, mostly due to sea level rise and the erosive force of wind and waves.

## Freshwater Tributaries

Within the Chesapeake Bay watershed, five major rivers—the Susquehanna, Potomac, Rappahannock, York and James—provide almost 90% of the freshwater to the Bay. These rivers and other smaller rivers, along with the hundreds of thousands of creeks and streams that feed them, provide habitat necessary for the production of many fish species. Anadromous fish spend their adult lives in the ocean but must spawn in freshwater. Anadromous fish species in the Bay include striped bass (rockfish), blueback herring, alewife, American and hickory shad, shortnose sturgeon and Atlantic sturgeon. Semi-anadromous fish, such as white and yellow perch, inhabit tidal tributaries but also require freshwater to spawn.

While all of these species have different habitat requirements, all must have access to freshwater spawning grounds. However, due to dams and other obstacles, many historical spawning grounds are no longer available to fish. Fish not only need access to spawning grounds but require good stream and water quality conditions for the development and

survival of eggs and juvenile fish. Nutrients, chemical contaminants, excessive sediment and low dissolved oxygen degrade spawning and nursery habitat.

## Shallow Water

Shallow water provides habitats for many life stages of invertebrates, fish and waterfowl. Shrimp, killifish and juveniles of larger fish species use bay grass beds, tidal marshes and shallow shoreline margins as nursery areas and for refuge. Predators, including blue crabs, spot, striped bass, waterfowl, colonial waterbirds and raptors, forage for food there. Along shorelines, fallen trees and limbs also give cover to small aquatic animals. Even unvegetated areas, exposed at low tide, are productive feeding areas. Microscopic plants cycle nutrients and are fed upon by crabs and fish.

**BAY QUOTE**

***"In sommer no place affordeth more plentie of sturgeon, nor in winter more abundance of foule. . ."***

John Smith, 1607–08

## Open Water

Striped bass, bluefish, weakfish, American shad, blueback herring, alewife, bay anchovy and Atlantic menhaden live in the open, or pelagic, waters of the Bay. Although unseen by the naked eye, microscopic plants and animal life (plankton) float in the open waters. These tiny organisms form the food base for many other animals. Hundreds of thousands of wintering ducks, particularly sea ducks like scoters, oldsquaw and mergansers, depend on open water for the shellfish, invertebrates and fish they eat during the winter months. Open water also supports oysters and other bottom-dwellers. Oysters and other filter feeders help maintain water quality by filtering suspended organic particles out of the water. The oyster reef itself is a solid structure that provides habitat for other shellfish, finfish and crabs.

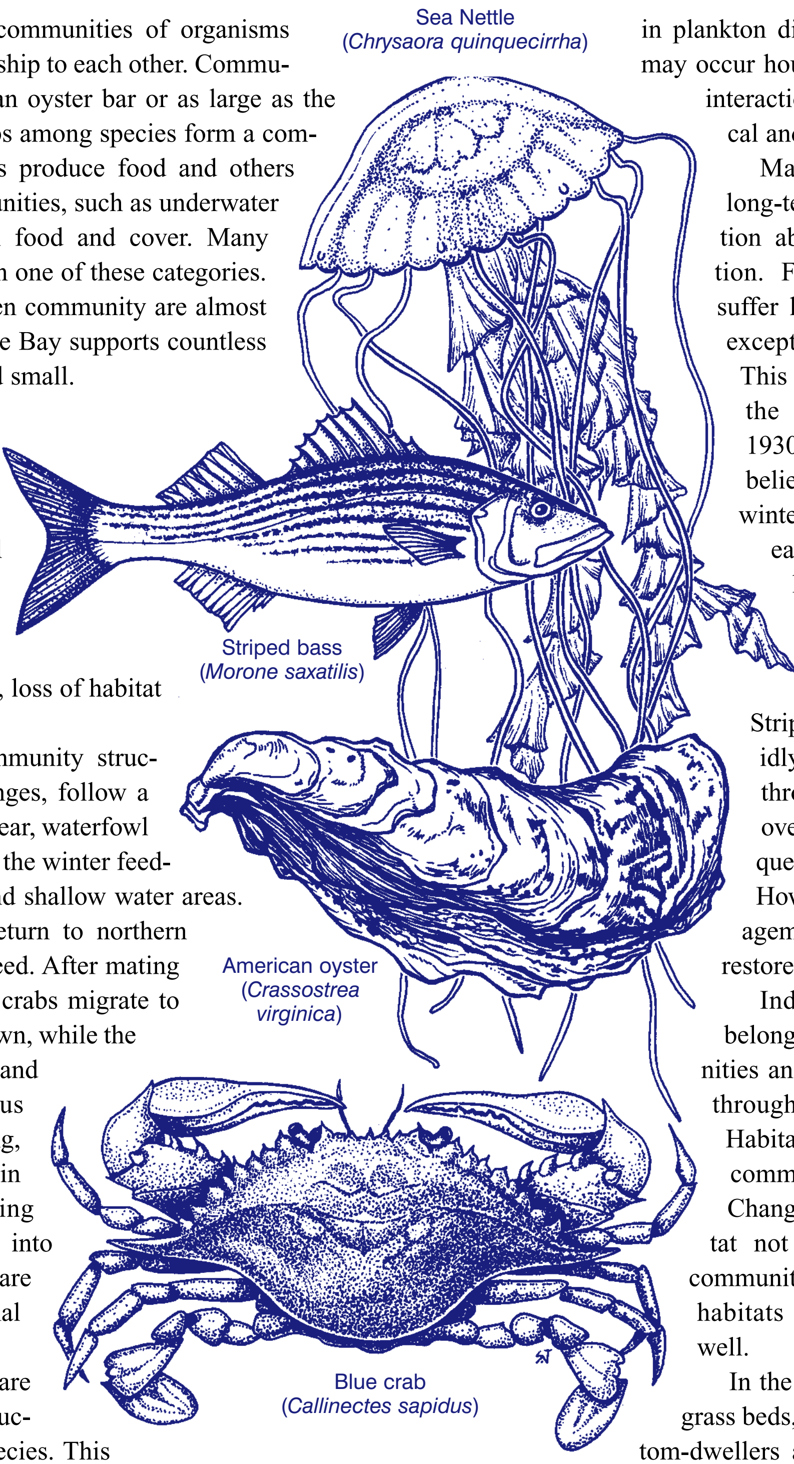
# Living Resources & Biological Communities

Within every habitat, communities of organisms exist in close relationship to each other. Communities may be as small as an oyster bar or as large as the entire Bay. The relationships among species form a complex web. Some organisms produce food and others serve as prey. Some communities, such as underwater Bay grasses, provide both food and cover. Many organisms fit into more than one of these categories. The functions within a given community are almost endless, and the Chesapeake Bay supports countless communities both large and small.

Change is characteristic of ecological systems, including the Bay. Germination of plant seeds, birth of animals, growth, local movement and migration affect the species composition of each community, as do changes in water quality, loss of habitat or overharvesting.

Some variations in community structure, such as seasonal changes, follow a predictable pattern. Every year, waterfowl migrate to the Bay to spend the winter feeding in uplands, wetlands and shallow water areas. Then, each spring, they return to northern parts of the continent to breed. After mating each summer, female blue crabs migrate to the mouth of the Bay to spawn, while the males remain in the upper and middle Bay. Anadromous fish, like shad and herring, spend most of their lives in the ocean, but each spring enter the Bay and migrate into freshwater to spawn. These are just a few of the seasonal variations that occur.

Some Bay communities are prone to rapid population fluctuations of one or more species. This is particularly true of plankton. Rapid changes in plankton diversity and abundance may occur hourly or daily due to the interaction of biological, physical and chemical factors.




Many species exhibit long-term patterns in population abundance and distribution. For example, croakers suffer high mortalities during exceptionally cold weather. This fish was abundant in the Bay during the late 1930s and early 1940s. It is believed that relatively mild winters in the late 1930s and early 1940s promoted the high numbers of croakers. Human-induced pressures can affect long-term patterns. Striped bass declined rapidly in the late 1970s and through the 1980s due to overharvesting and subsequent reproductive failure. However, successful management measures led to a restored stock in 1995.

Individual species may belong to a variety of communities and use different habitats throughout their life cycles. Habitats are connected and communities often overlap. Changes in a particular habitat not only may affect the communities it supports but other habitats and communities as well.

In the Chesapeake, wetlands, grass beds, plankton, fish and bottom-dwellers are biological communities supported by the Bay's diverse habitats. Wetlands are transitional areas between water and land. Bay grass beds range from mean low tide to a depth of about six feet or where light becomes limiting to plant growth, although some freshwater species thrive in water up to nine feet deep. Open water supports the plankton community, composed mostly of minute creatures that float and drift with the movement of the water, and the nekton community, the fish and other swimmers that move freely throughout the Bay and its tributaries. The bottom sediments support benthic organisms.

## Wetlands

Wetlands are environments subjected to periodic flooding or prolonged saturation, producing specific plant communities and soil types. The presence of water affects the type of soil that develops and the types of plants and animals that live there. Wetlands are characterized by hydrophytic vegetation (water-loving plants adapted to wet soils) and hydric soils (saturated or periodically flooded soils). There are two broad categories of wetlands in the Bay watershed. Wetlands within the reach of tides are considered tidal. Salinity in tidal wetlands ranges from fresh to saltwater. Nontidal or palustrine wetlands are freshwater areas unaffected by the tides. Wetlands receive water by rain, groundwater seepage, adjacent streams and, in the case of tidal wetlands, tides. Salinity, substrate and frequency of flooding determine the specific plant and animal life a wetland can support.

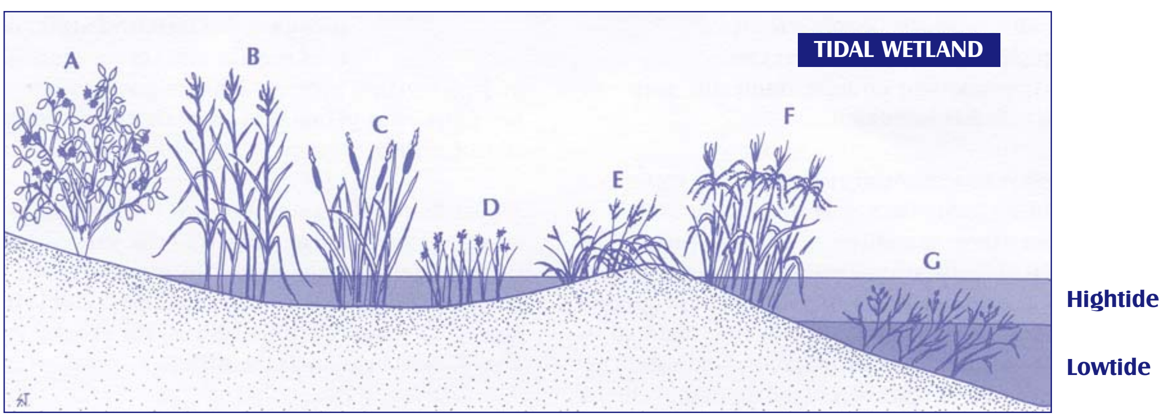
**BAY FACT**

***Wetlands are among the most productive ecosystems in the world, producing more food (in the form of detritus) than many agricultural fields.***

Tidal wetlands are dominated by nonwoody or herbaceous vegetation and are subjected to tidal flooding. These wetlands have a low marsh zone (flooded by every high tide) and a high marsh zone (flooded by extremely high tides). Plants such as smooth cordgrass are found in the low marsh zone of brackish and saltwater marshes. The high marsh zone may be dominated by saltmeadow cordgrass, black needlerush, saltgrass or marsh elder. Freshwater marshes also have low and high zones. Along the water's edge, you may find wild rice, arrow arum, pickerel weed and pond lily. In the high zone, cattail and big cordgrass may be prevalent.

Nontidal wetlands frequently contain bulrush, broad-leaved cattail, jewel weed, spike rushes and sedges. Forested wetlands, often referred to as swamps, may have permanent standing water or may be seasonally flooded. Trees commonly found in forested wetlands include red maple, black gum, river birch, black willow, Atlantic white cedar and bald cypress. Willows, alders and button bushes are types of shrubs present in forested wetlands.

Approximately 1.5 million acres of wetlands remain in the Bay watershed, less than




**A** Button bush *(Cephalanthus occidentalis)*

**B** Big cordgrass *(Spartina cynosuroides)*

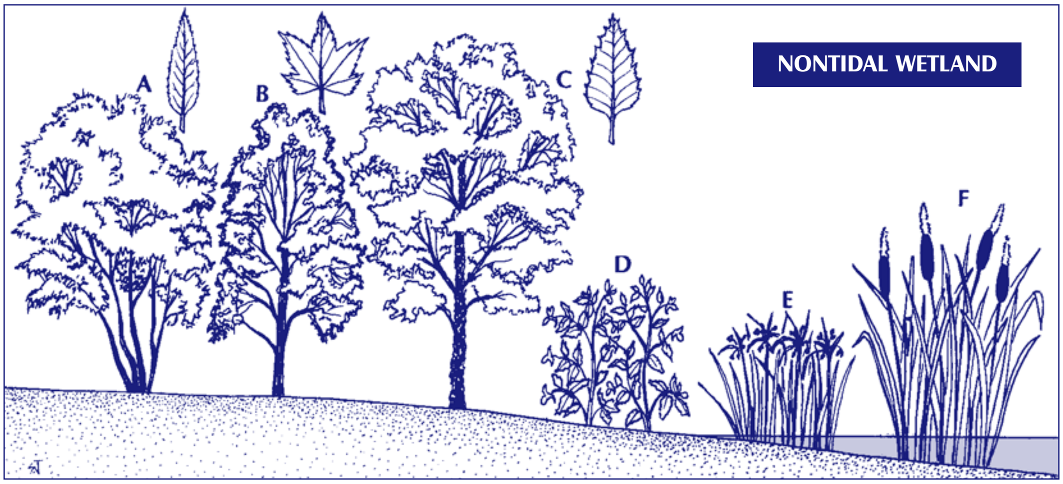
**C** Narrow-leaved cattail *(Typha angustifolia)*

**D** Black needlerush *(Juncus roemerianus)*

**E** Saltmeadow cordgrass *(Sparina patens)*

**F** Wild rice *(Zizania aquatica)*

**G** Widgeon grass *(Ruppia maritima)*




**A** Black willow *(Salix nigra)*
**B** Red maple *(Acer rubrum)*
**C** River birch *(Betula nigra)*
**D** Jewelweed *(Impatiens capensis)*
**E** River bulrush *(Scirpus fluviatilis)*
**F** Broad-leaved cattail *(Typha latifolia)*

half of the wetlands that were here during colonial times. Of the remaining wetlands, 13% are tidal and 87% are nontidal.

Often viewed as wastelands, wetlands were drained or filled for farms, residential developments, commercial buildings, highways and roads. Over the past several decades, our understanding and appreciation of wetlands has increased.

Plant diversity, biochemical reactions and hydrology of these habitats make them extremely productive. Wetlands support large quantities of plant biomass. The huge amount of visible plant material in wetlands makes up only the above-ground biomass. The below-ground biomass, composed of root and rhizome material, is often more than double the above-ground biomass. This creates a tremendous reservoir of nutrients and chemicals bound up in plant tissue and sediments.

Many of the Bay's living resources depend on these wetland habitats for their survival. Tidal wetlands are the wintering homes for great flocks of migratory waterfowl. Other wildlife, including muskrats, beavers, otters, songbirds and wading birds, rely on wetlands for food and cover. Fish and shellfish, many of which are commercially valuable, use wetlands as spawning or nursery areas. Thousands of aquatic animals, including reptiles, amphibians, worms, insects, snails, mussels and tiny crustaceans, thrive in wetlands and are food for other organisms.

**BAY FACT**

*Two-thirds of the nation's commercial fish and shellfish depend on wetlands as nursery or spawning grounds.*

The abundance of food and shelter provided by wetland vegetation is essential to other members of this community. A host of invertebrates feed on decomposing plants and animals. This nutrient-rich detritus is also available to juvenile stages of fish and crabs. A dense layer of microscopic plants and animals, including bacteria and algae, coats the land surface and serves as food. Stems of larger plants provide another good source of food. Decomposing plants and animals are the major food source for other wetland inhabitants.

Wetlands are also important for controlling flood and storm waters. Fast-moving water is slowed by vegetation and temporarily stored in wetlands. The gradual release of water reduces erosion and possible property damage. Coastal wetlands absorb the erosive energy of waves, further reducing erosion.

Poised between land and water, wetlands act as buffers, regulating the flow of sediments and nutrients into rivers and the Bay. As water runs off the land and passes through wetlands, it is filtered. Suspended solids, including sediment pollutants, settle and are trapped by vegetation. Nutrients, carried to wetlands by tides, precipitation, runoff and groundwater, are trapped and used by wetland vegetation. As plant material decomposes, nutrients are released back into the Bay and its tributaries, facilitated by floodwaters or tides.

Economically, wetlands provide opportunities for fishing, crabbing and hunting. Other popular activities include hiking, birdwatching, photography and wildlife study. People are lured by the beauty of wetlands to enjoy the sights and sounds that these areas can offer.

## Underwater Bay Grasses

In the shallow waters of the Bay, underwater grasses sway in the aquatic breeze of the current. Known as submerged aquatic vegetation or SAV, these amazing plant communities provide food and shelter for waterfowl, fish, shellfish and invertebrates. Like other green plants, bay grasses produce oxygen, a precious and sometimes lacking commodity in the Bay. These underwater plants also trap sediment that can cloud the water and bury bottom-dwelling organisms like oysters. As waves roll into grass beds, the movement is slowed and energy is dispelled, protecting shorelines from erosion. During the growing season, Bay grasses take up and retain nitrogen and phosphorus, removing excess nutrients that could fuel unwanted growth of algae in the surrounding waters.

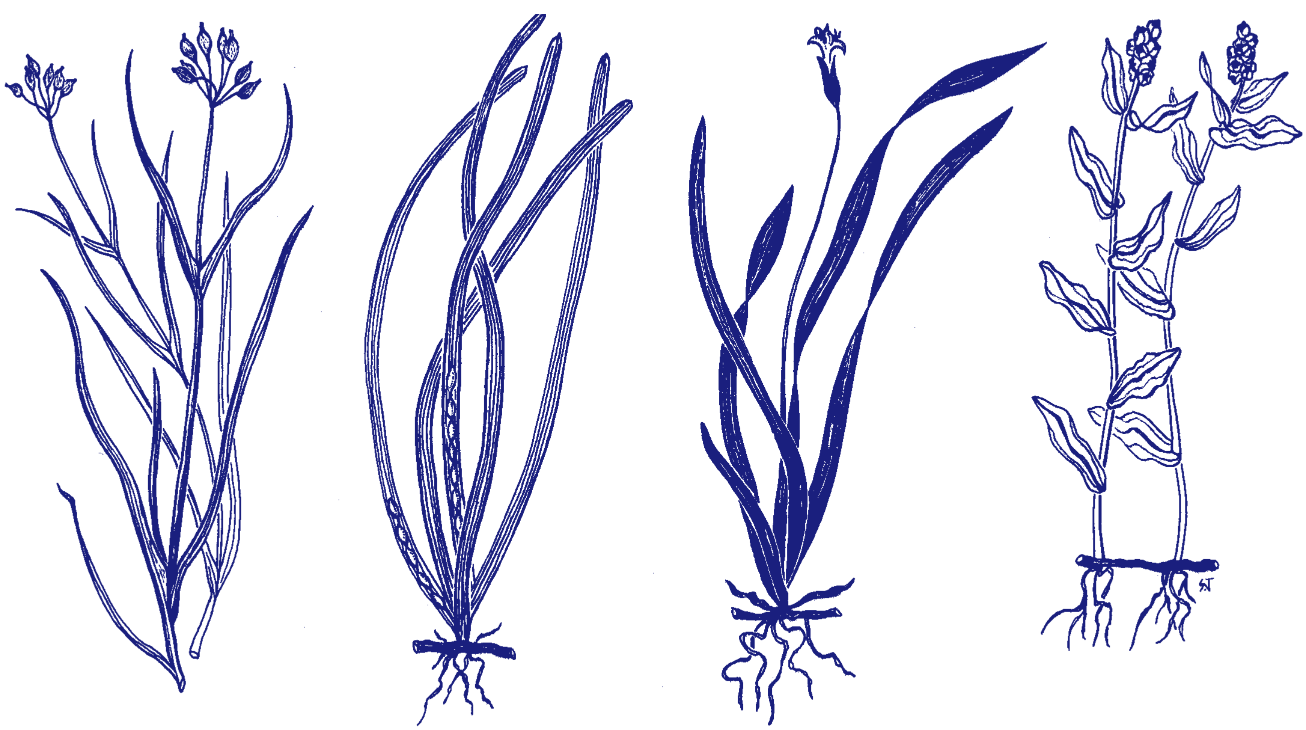
Like a forest, field or wetland, a grass bed serves as habitat for many aquatic animals. Microscopic zooplankton feed on decaying Bay grasses and, in turn, are food for larger Bay organisms. Minnows dart between the plants and graze on tiny organisms that grow on the stems and leaves. Small fish seek refuge from larger and hungrier mouths. Shedding blue crabs conceal themselves in the vegetation until their new shells have hardened. Thus, grasses are a key contributor to the energy cycling in the Bay. Bay grasses are a valuable source of food, especially for waterfowl. In the fall and winter, migrating waterfowl search the sediment for nutritious seeds, roots and tubers. Resident waterfowl may feed on grasses year-round.

Fourteen species of grasses are commonly found in the Bay or nearby rivers. Salinity, water depth and bottom sediment determine where each species can grow. Survival of Bay grasses is affected most by the amount of light that reaches the plants. Poor water quality resulting in less light penetration is the primary cause for declining grasses.

Factors that affect water clarity, therefore, also affect the growth of bay grasses. Suspended sediment and other solids cloud the water, blocking precious sunlight from the grasses. Excessive amounts of suspended sediment may cover the plants completely. Sources of suspended sediments include runoff from farmland, building sites and highway construction. Shoreline erosion also adds sediment to the Bay. Land development, boat traffic and loss of shoreline vegetation can accelerate natural erosion.

Nutrients, although vital to all ecosystems, can create problems when present in excessive amounts. Major sources of nutrients include sewage treatment plants, acid rain, agricultural fields and fertilized lawns. High levels of nutrients stimulate rapid growth of algae, known as blooms. Algal blooms cloud the water and reduce the amount of sunlight reaching Bay grasses. Certain types of algae grow directly on the plants, further reducing available sunlight.

## Common Underwater Bay Grasses



**Widgeon grass (*Ruppia maritima*)**

**Eelgrass (*Zostera marina*)**

**Wild celery (*Vallisneria americana*)**

**Redhead grass (*Potamogeton perfoliatus*)**

Historically, more than 200,000 acres of grasses grew along the shoreline of the Bay. By 1984, a survey of bay grasses documented only 37,000 acres in the Bay and its tidal tributaries. Declining water quality, disturbance of grass beds and alteration of shallow water habitat all contributed to the Bay-wide decline. The absence of grasses translates into a loss of food and habitat for many Chesapeake Bay species. However, bay grasses have rebounded steadily since the low point in 1984. In 2003, scientists estimated that about 64,709 acres of underwater grasses were living in the Bay.

Water quality is the key to restoring grasses. Scientists have identified the water quality conditions and requirements necessary for the survival of five grass species: wild celery found in freshwater, sago pondweed, redhead grass and widgeon grass found in more estuarine water and eelgrass found in the lower Bay in saltier water. Each species is an important source of food for waterfowl. Bay grasses are making a comeback, however. Water quality is beginning to improve due to the ban of phosphates in detergents, reduction of fertilizer use by farmers and homeowners, protection of shallow water habitat and the reduction of nutrients in sewage effluent.

## Plankton

Mainly unseen by the naked eye, a community made up of predominantly microscopic organisms also fuels the Bay ecosystem. These tiny plants and animals, called plankton, drift at the mercy of the currents and tides. Some of the tiny creatures move up and down in the water column to take advantage of light. Others will drop below the pycnocline, a zone between waters with different densities, to avoid being washed out to the ocean.

Phytoplankton are tiny single-celled plants. Like higher plants, phytoplankton require light to live and reproduce. Therefore, the largest concentrations occur near the surface. Salinity affects phytoplankton distribution with the largest number of species preferring the saltier waters near the mouth of the Bay. The amount of nutrients in the water is a major determinant to the abundance of these plants. The largest concentrations of phytoplankton in the Bay occur during the spring when nutrients are replenished by freshwater runoff from the watershed. These high concentrations produce the characteristic brown-green color of estuarine and near-shore waters. Although there are many species of phytoplankton, the major types in the Bay are diatoms and dinoflagellates. When dinoflagellates dominate the water, a red-tinted bloom, called a mahogany tide, may be produced. Mahogany tides typically occur on warm, calm days, often following rain. Diatoms, which are present throughout much of the year, may account for 50% of total algal production.

**BAY FACT**

***One drop of Bay water may contain thousands of phytoplankton.***

Changes in chemical conditions, such as the addition of nutrients, can cause rapid increases in the amount of algae. These algal blooms can have serious consequences. They block light from reaching SAV beds. Even after they die, they can cause problems. Deposition and subsequent decomposition of large masses of plankton in the mainstem of the Bay can deplete dissolved oxygen, suffocating other estuarine animals.

Phytoplankton are the major food source for microscopic animals called zooplankton. Dominating the zooplankton are the copepods (tiny crustaceans about one millimeter long) and fish larvae. Zooplankton are distributed according to salinity levels. Distribution patterns also are related to those of their main food source—the phytoplankton. Zooplankton also feed on other particulate plant matter and bacteria.

Tiny larvae of invertebrates and fish also are considered zooplankton. Although this planktonic stage is only temporary, the larvae are a significant part of the community. These larvae are consumed by larger animals, and may, as they grow, consume copepods.

Another group of zooplankton found in the Bay are the protozoa. These single-celled animals feed on detritus and bacteria. They, in turn, become food for larvae, copepods and larger protozoa.

Bacteria play an important function in the Bay. They are essentially the decomposers. Their primary function is to break down dead matter, particularly plants. Through this process, nutrients in dead plant and animal matter again become available for growing plants. Bacteria are eaten by zooplankton and other filter-feeding animals in the Bay.

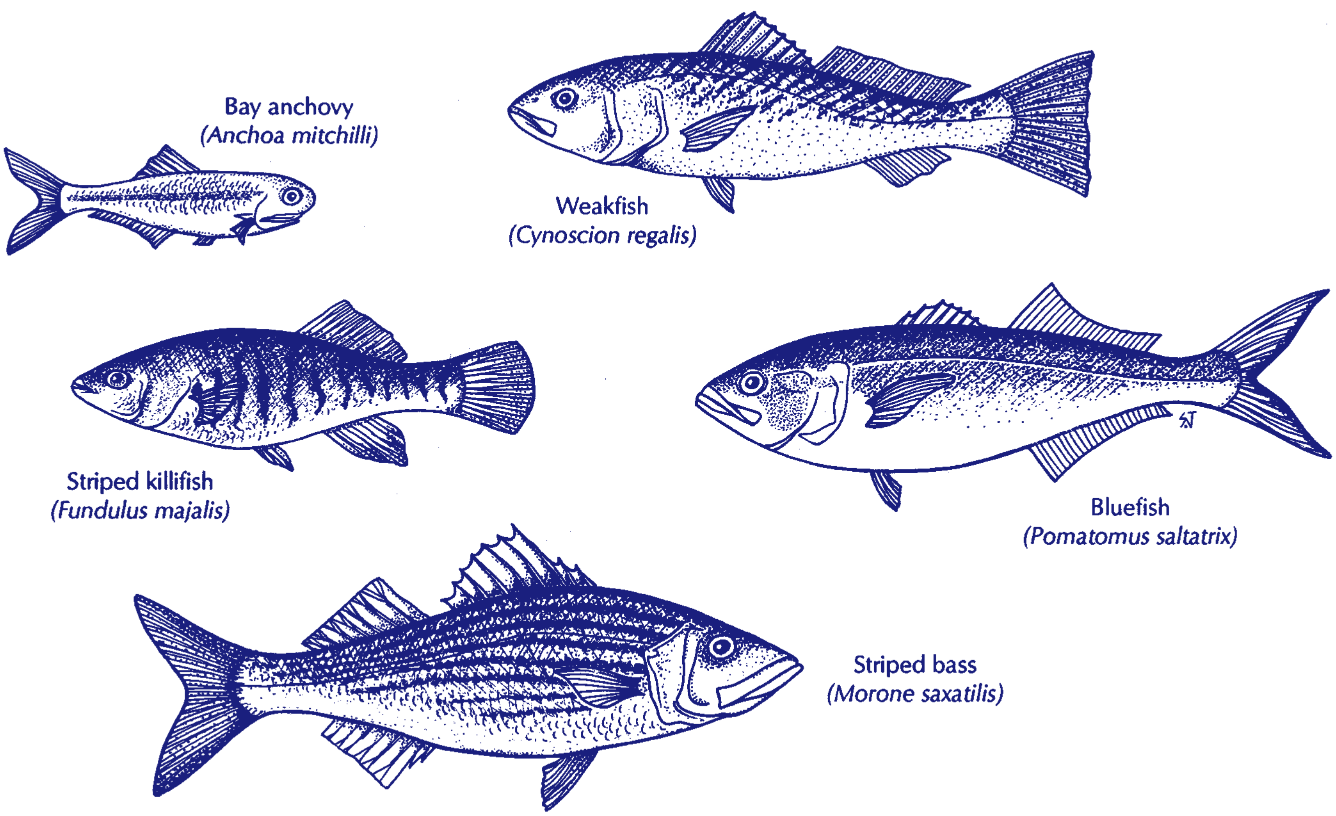
Bacteria can be residents of the Bay or can be introduced through various pathways, including human sewage and runoff from the land. Coliform bacteria are normal resident bacteria found in the intestines of mammals. The presence of coliform in a body of water indicates that human or other animal wastes are present. Coliform bacteria are an indicator that disease-producing pathogens may be present in the water.

Clearly visible to the unaided eye, jellyfishes and comb jellies are the largest zooplankton. Some of these gelatinous creatures swim, though they are still at the mercy of the water currents. Jellyfishes have tentacles with stinging cells used to stun prey. The most famous jellyfish in the Chesapeake is the sea nettle. Sea nettles feed voraciously on other zooplankton, including fish larvae, comb jellies and even small fish. Because of the large volume of water in their bodies, few animals except sea turtles prey on sea nettles. Comb jellies, lacking the stinging cells of nettles, capture prey with adhesive cells. They, too, consume vast quantities of small copepods and zooplankton, especially oyster larvae.

## The Swimmers

Swimmers comprise the nekton community. These organisms can control and direct their movements. This group includes fish, some crustaceans and other invertebrates. Approximately 350 species of fish can be found in the Chesapeake Bay. They can be divided into permanent residents and migratory fish. The residents tend to be smaller in size and do not travel the long distances that migratory species do.

Smaller resident species, such as killifish, normally occur in shallow water where they feed on a variety of invertebrates. The bay anchovy, the most abundant fish in the Bay, is a key player in the Chesapeake food web. Bay anchovies feed primarily upon zooplankton. Adult anchovies also may consume larval fish, crab larvae and some benthic species. In turn, the bay anchovy is a major food source for predatory



fish like striped bass, bluefish and weakfish, as well as some birds and mammals.

Migratory fish fall into two categories: anadromous, which spawn in the Bay or its tributaries, and catadromous fish, which spawn in the ocean. Anadromous fish migrate varying distances to spawn in freshwater. Some can even be considered Bay residents. For instance, during the spawning season, yellow and white perch travel short distances from the brackish water of the middle Bay to freshwater areas of the upper Bay or tributaries. Striped bass also spawn in the tidal freshwater areas of the Bay and major tributaries. Some remain in the Chesapeake to feed while others migrate to ocean waters. Shad and herring are truly anadromous, traveling from the ocean to freshwater to spawn and returning to the ocean to feed. Eels are the only catadromous species in the Bay. Although they live in the Bay for long periods, eels eventually migrate to the Sargasso Sea in the central North Atlantic to spawn.

Other fish utilize the Bay strictly for feeding. Croaker, drum, menhaden, weakfish and spot journey into the Bay while still in their larval stage to take advantage of the rich supply of food. The abundance of menhaden supports a commercial fishing industry and provides food for predatory fish and birds. Bluefish enter the Bay only as young adults or mature fish.

Besides fish, crustaceans and invertebrates may be part of the nekton community. Larger animals like sharks, rays, sea turtles, and occasionally marine dolphins and whales enter the Bay.

The blue crab is difficult to place in any one community, because it requires a variety of aquatic habitats, from the mouth of the Bay to fresher rivers and creeks, in order to complete its life cycle. Throughout the year, crabs may burrow into the Bay bottom, shed and mate in shallow waters and beds of bay grasses or swim freely in open water. The first life stage of a blue crab, called the zoea, is microscopic and lives a planktonic free-floating existence. After several molts, the zoea reaches its second larval stage: the megalops. Another molt and a tiny crab form is apparent. Both juvenile and adult blue crabs forage on the bottom and hibernate there through the winter. In spring, the crab quickly begins migrating from the southern part of the Chesapeake to tidal rivers and northern portions of the Bay. During the rest of the year, adult blue crabs are dispersed throughout the Bay, swimming considerable distances using their powerful paddle-like back fins.

**BAY FACT**

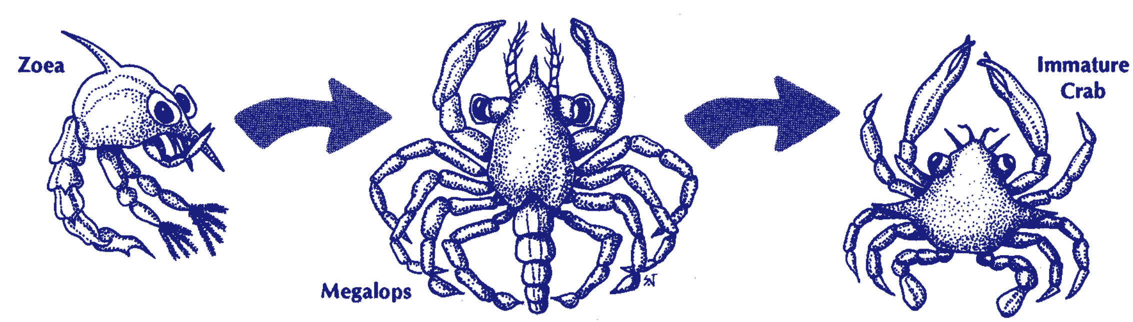
***Oysters are alternate hermaphrodites, meaning they can sense gender imbalances and change their sex.***

## Life at the Bottom

The organisms that live on and in the bottom sediments of the Bay form complex communities. Known as benthos, these bottom-dwellers include animals, plants and bacteria. Benthic organisms often are differentiated by their habitat. Epifauna, like oysters, barnacles and sponges, live upon a surface. Worms and clams, considered infauna, form their own community structure beneath the bottom sediments, connected to the water by tubes and tunnels. The roots and lower portions of bay grasses supply the physical support for a variety of epiphytic organisms. An oyster bar, and the many species it supports, is another example of a benthic community. Benthic communities that exist on or in bare, unvegetated substrate are made up of mollusks, worms and crustaceans.

As with all aquatic life in the Bay, salinity affects the distribution of bottom-dwellers, but sediment type also plays a role. Neither coarse sand nor soft mud support rich benthic

LIFE STAGES OF A BLUE CRAB



## BENTHIC COMMUNITY

**A** A Hard clam (*Mercenaria mercenaria*)
**B** Atlantic oyster drill (*Urosalpinx cinerea*)
**C** Common clam worm (*Nereis succinea*)
**D** Red ribbon worm (*Micrura leidyi*)
**E** Soft-shelled clam (*Mya arenaria*)
**F** Glassy tubeworm (*Spiochaetopterus oculatus*)
**G** Black-fingered mud crab (*Panopeus herbstii*)
**H** Whip mudworms (*Polydora ligni*)
**I** Sea squirts (*Molgula manhattensis*)
**J** Oyster spat
**K** Ivory barnacle (*Balanus eburneus*)
**L** Skilletfish (*Gobiesox strumosus*)
**M** American oyster (*Crassostrea virginica*)


populations. The best sediment for diverse benthic communities consists of a mixture of sand, silt and clay. Some organisms require specialized substrates. Oysters need a clean hard surface, preferably another oyster shell, on which the larval spat can attach or set. Oysters form a reef community that is important habitat for other benthic species.

The benthic community affects the physical and chemical condition of the water and sediments. Some build tubes or burrows through which they pump water. Infaunal deposit feeders, such as worms, plow through the sediments in search of food. Many benthic animals bind sediments together as fecal pellets that remain at the bottom. Predators, such as adult blue crabs, scurry across bottom searching for food. These activities stir the sediments, increasing the rate of exchange of materials into the water column. This mixing also increases diffusion of oxygen into the sediments.

Filter feeders, like oysters and clams, pump large volumes of water through their bodies and extract food from it. As they filter water for food, they also remove sediments and organic matter, cleaning the water. Since many chemical contaminants often are present in sediments, benthic fauna often are exposed to and can be harmed by these pollutants.

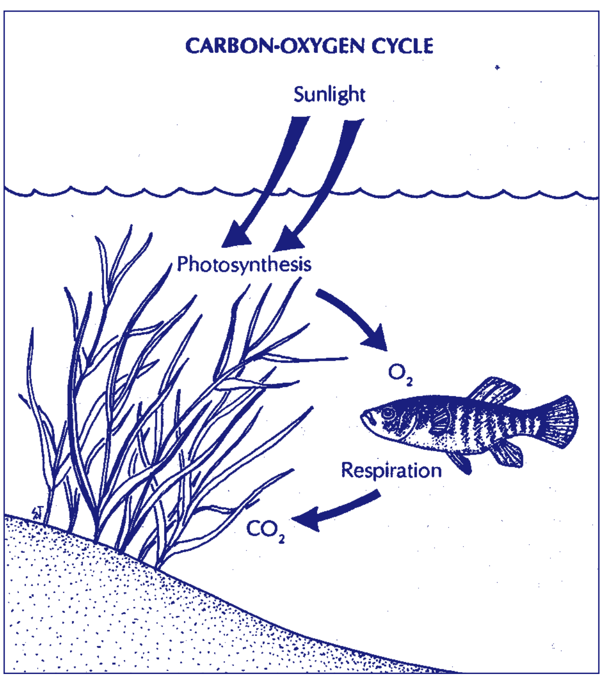
Some benthic organisms are widely distributed. Others are limited more by salinity. For example, hard clams and oysters require higher saline waters. Mid-salinity waters support soft-shelled clams. Brackish water clams also are found in lower salinities, along with freshwater mussels. Salinity also determines the distribution of certain benthic predators, parasites and diseases. MSX, a lethal parasite, and Dermo, a disease caused by another parasite, have decimated oyster populations of the mid and lower Bay, respectively. Oyster drills and starfish, which feed on oysters, are less of a problem in upper Bay waters because of their intolerance to low salinities.

# Food Production & Consumption

The most important relationship among Chesapeake Bay species is their dependence upon each other as food. We are all carbon-based creatures. Carbon is the basic element of organic compounds, such as proteins, carbohydrates, lipids and nucleic acids. These compounds are the building blocks of life that make up the bodies of living organisms. Feeding is the process by which organisms cycle energy-rich carbon through the ecosystem. Each organism supplies the fuel needed to sustain other life forms.

Plants and some bacteria can produce their own food through a process known as photosynthesis. Using energy from the sun, carbon dioxide and water are combined to form high-energy organic compounds. These organic compounds and other necessary chemicals form a plant's cellular structure, allowing it to grow. Because of this ability to use carbon dioxide and sunlight to produce their own food, plants are called autotrophs or self-feeders. They are the primary food producers. All other organisms must feed, directly or indirectly, on organic material produced by plants.

Animals cannot process carbon via photosynthesis. Instead, they acquire carbon by eating the organic matter contained in plant and animal tissue or dissolved in water. The animal breaks this organic material down into components it can use for energy and growth. Animals are heterotrophs or other-feeders.




Every biological activity, such as reproduction, growth, movement and bodily functions, requires energy. Whether organisms produce food themselves or ingest it from other sources, they all must break down organic molecules to use the carbon and energy contained within. This process is called respiration.

Aerobic respiration uses oxygen and releases carbon in the form of carbon dioxide. It compliments photosynthesis, which uses carbon dioxide and produces oxygen. Together, aerobic respiration and photosynthesis compose the carbon-oxygen cycle.

**BAY FACT**

***Each year, crabbers catch approximately two-thirds of the adult blue crab population in the Bay.***

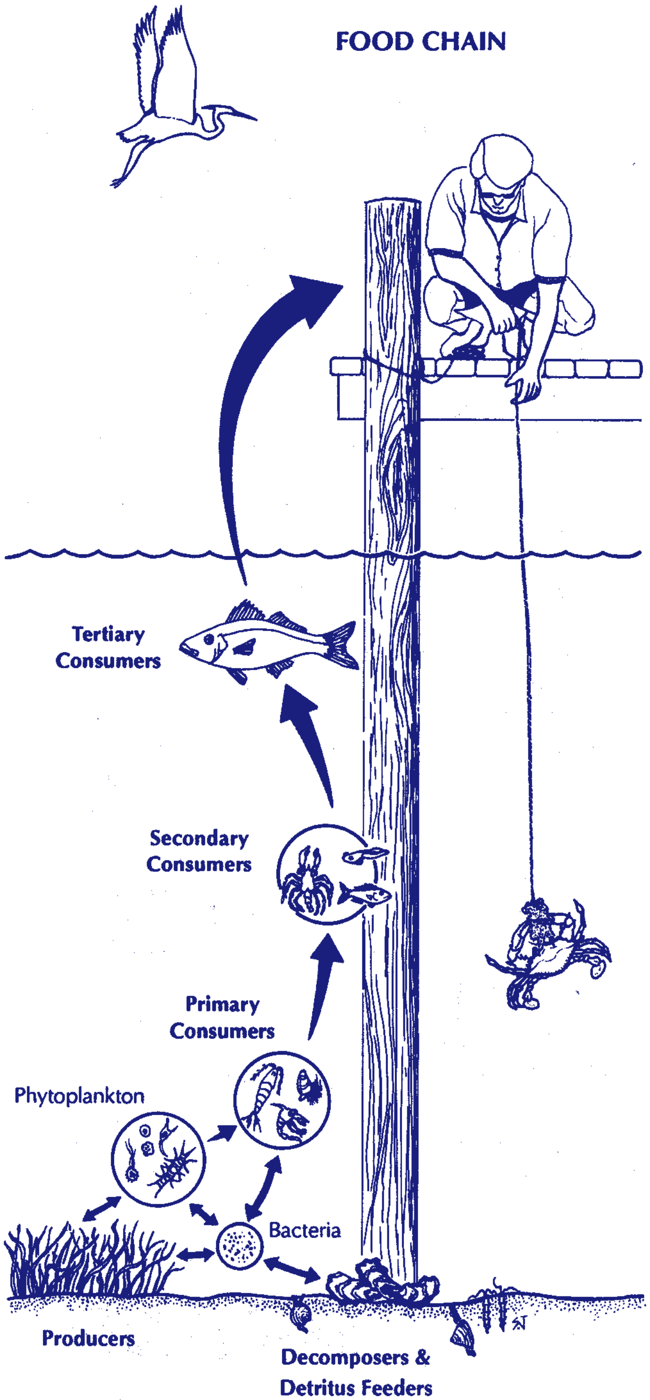
All living things respire, but autotrophs carry out photosynthesis as well. Plants usually release more oxygen than they consume, and animals use that excess oxygen for respiration. In turn, animals release carbon dioxide, which plants require for photosynthesis.

While carbon and oxygen are two of the most prevalent elements in our physical make-up, many others are needed. Nitrogen and phosphorus are two such elements. They are crucial to the operation of the Bay's life support system.

Nitrogen is a major component of all organisms, primarily as a key ingredient in protein. When an organism dies, bacteria breaks down proteins into amino acids. Bacteria then remove the carbon, converting the acids into ammonia. Plants are able to use ammonia as a source of nitrogen. In the presence of oxygen, bacteria can convert ammonia to nitrite and nitrate, also good sources of nitrogen. Under low oxygen conditions, some bacteria convert nitrate to gaseous nitrogen that is unavailable to most aquatic organisms. However, in tidal freshwater, some blue-green algae are able to use gaseous nitrogen directly.

Phosphorus is another element essential to plant growth. During decomposition and in the presence of oxygen, bacteria convert organic phosphorus to phosphate. Phosphates are readily used by plants. However, phosphate also attaches to sediment particles and settles out of water very quickly. The resulting decrease in available phosphorus can limit plant growth.

Temperature, sunlight, carbon dioxide and usable nitrogen and phosphorus control the rate of photosynthesis. Since plants are the only organisms able to produce new food from inorganic matter, the rate of photosynthesis determines the




production of organic carbon compounds and, ultimately, the availability of food in the Bay ecosystem.

To illustrate how these factors affect the productivity of the Bay, examine the Chesapeake's most abundant food producer—the phytoplankton. Like all plants, phytoplankton require sunlight, nutrients and water. In the Bay, water is never a limiting factor. However, the amount of sunlight and nutrients can limit phytoplankton growth. The amount of sunlight available to an aquatic plant depends on the sun's altitude, cloud cover, water depth and turbidity (cloudiness of water). Temperature also controls the rate of photosynthesis.

Nutrients in the form of carbon dioxide and usable nitrogen and phosphorus are rarely available in the exact proportions required by plants. Normally, one nutrient is in short supply compared to the others and is considered the limiting nutrient. If a limiting nutrient is added, a growth spurt may occur. Conversely, reducing the amount of a limiting nutrient causes plant production to decline.

Phosphorus controls the growth of some phytoplankton species in the spring, especially in the tidal freshwater and brackish areas. Nitrogen is the prime limiting factor at higher salinities, particularly during warm months. Carbon dioxide limitations may control the rate of photosynthesis during algal blooms in tidal freshwater.

The Bay's life support system depends on maintaining the delicate balance between the living and non-living components. Although the Chesapeake's potential production capacity is massive, it is also finite. Problems affecting the simplest producers dramatically affect the survival of consumers.

## The Food Web

As one organism eats another, a food chain is formed. Each step along a food chain is known as a trophic level, and every organism can be categorized by its feeding or trophic level. The most basic trophic level is made up of producers: plants and algae that make their own food. Organisms that eat plants or other animals are consumers. Decomposers digest the bodies of dead plants and animals and the waste products of both. An example of a simple food chain starts with phytoplankton converting sunlight and nutrients into living tissue. They, in turn, are eaten by copepods—members of the zooplankton community. The copepods then are consumed by bay anchovies, which are eaten by bluefish and striped bass. These fish can be harvested and eaten by people. This illustrates how organic carbon compounds originally produced by a plant pass through successively higher trophic levels.

Food production and consumption in the Bay are rarely this simple or direct. Seldom does one organism feed exclusively on another. Usually, several food chains are interwoven together to form a food web. Decomposers appear throughout the food web, breaking organic matter down into nutrients. These nutrients are again available to producers.

This complex network of feeding continuously cycles organic matter back into the ecosystem.

The transfer of energy from one organism to the next is, however, inefficient. Only about 10% of the available energy is transferred from one trophic level to the next. For example, only a portion of the total amount of phytoplankton carbon ingested by zooplankton is assimilated by the zooplankton's digestive system. Some of that is used for respiration, bodily functions and locomotion. A small fraction is used for growth and reproduction. Since these are the only functions that produce additional tissue, only this fraction of energy is available to the consumer at the next trophic level.

Economically important foods like fish and shellfish depend upon lower trophic level organisms. For every pound of commercial fish taken from the Chesapeake, almost 8,000 pounds of plankton had to be produced. An ecosystem must be enormously productive to support substantial populations of organisms at the highest trophic levels. Massive quantities of plants are required to support relatively few carnivores, such as the striped bass or bluefish. Because producers are the basis of all food, they influence the production of other organisms. However, an overabundance of producers like algae also can be detrimental, causing a loss of Bay grasses and reducing the amount of dissolved oxygen available to other organisms.

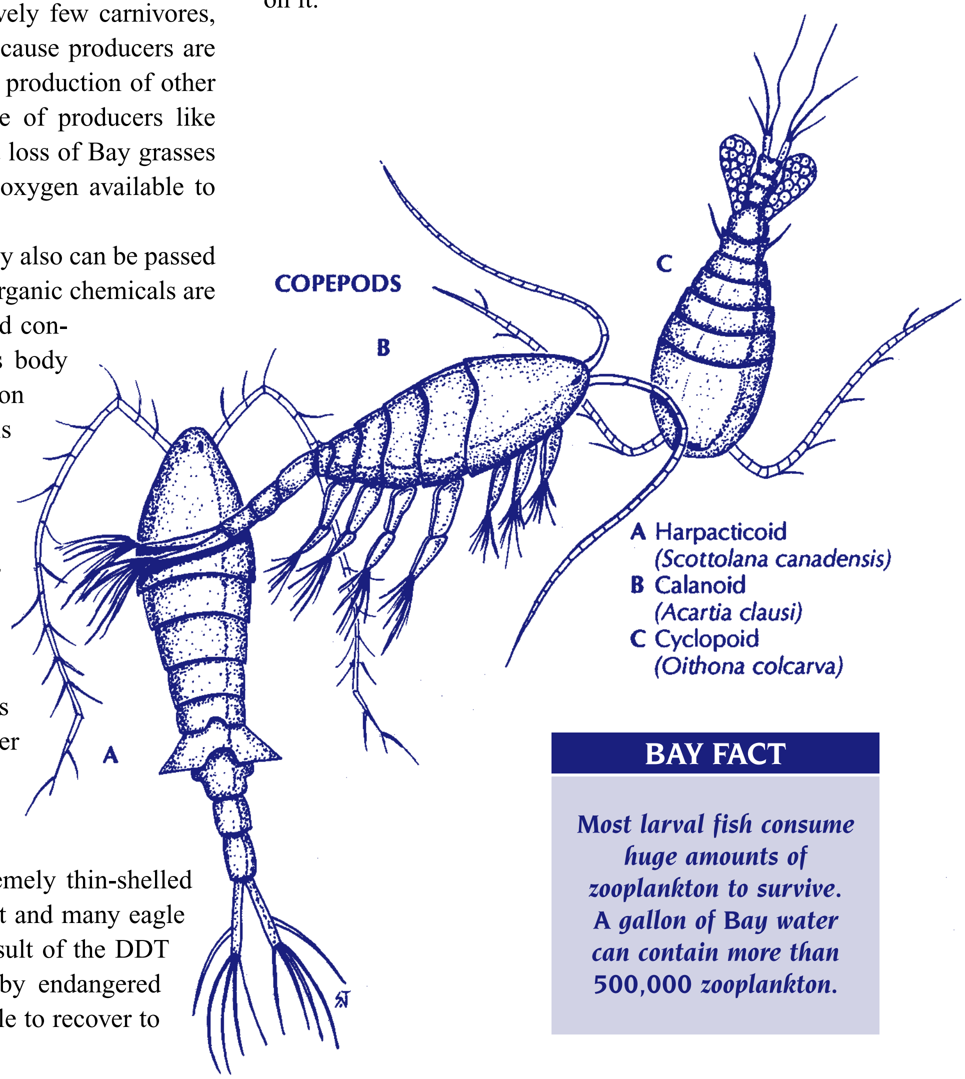
Toxic substances in contaminated prey also can be passed on to the consumer. Heavy metals and organic chemicals are stored in the fatty tissues of animals and concentrate there. As a result, an animal's body may contain a much higher concentration of the contaminant than did its food. This phenomenon is known as bioaccumulation. The severe decline of the bald eagle during the 1950s, 1960s and 1970s was attributed to bioaccumulation. During World War II, a chemical pesticide, DDT, was used to control insects and agricultural pests. Fish and small mammals that fed on these pests were in turn contaminated with higher concentrations. Eagles eating contaminated prey concentrated even higher levels of DDT and its by-product DDE. The DDE caused the birds to lay extremely thin-shelled eggs, so thin that most broke in the nest and many eagle pairs failed to produce young. As a result of the DDT ban in 1972 and protection provided by endangered species status, bald eagles have been able to recover to the population we have today.

## Direct and Detrital Pathways

Two basic pathways dominate the estuarine food web. The direct pathway leads from plants to lower animals to higher animals. The detrital pathway leads from dead organic matter to lower animals then to higher animals. The detrital pathway is dominant in wetlands and bay grass beds.

The direct and detrital pathways coexist and are not easily separated. Higher plants, such as eelgrass, widgeon grass, saltmarsh grass and cordgrass, contribute most of their carbon as detritus. However, epiphytic algae growing on these grasses is usually eaten by consumers, putting them in the direct food web.

In deeper waters, detritus from dead phytoplankton, zooplankton and larger animals, as well as detritus from upland drainage, wetlands and bay grasses, continually rains down on the benthos. Bottom-dwelling animals, such as oysters, clams, crustaceans, tube worms, shrimp and blue crabs, feed on it.




**BAY FACT**

***Most larval fish consume huge amounts of zooplankton to survive. A gallon of Bay water can contain more than 500,000 zooplankton.***

The direct pathway dominates the plankton community. The smallest of phytoplankton, known as nannoplankton, are fed upon by larger microzooplankton. Larger phytoplankton, like most diatoms and dinoflagellates, provide food for larger zooplankton and some fish. Bacteria, fungi, phytoplankton and possibly protozoa provide food for oysters and clams.

Copepods, a dominant form of zooplankton, play a key role in the food web between phytoplankton and animals. Copepods feed on most phytoplankton species and occasionally on the juvenile stages of smaller copepods. In marine waters, most animal protein production from plant material is carried out by copepods. Copepods and a related organism, krill, are the world's largest stock of living animal protein. Larger carnivores feed voraciously on them. Herring, for example, may consume thousands of the tiny creatures in a single day.

Most of the Bay's fish are part of the direct food web, but their feeding habits are complex. Some experts contend that menhaden are the dominant fish in the Bay's intricate food web. The extremely fine gill rakers of menhaden act as a filtering net. Adult menhaden swim with their mouths open, consuming any plankton in their paths. In turn, menhaden are a major food of striped bass, bluefish and osprey. They also support a large commercial fishery that utilizes the fish for animal feed and for products containing fish meal and oil.

Like menhaden, anchovies and all fish larvae are primarily zooplankton feeders. Adult striped bass, bluefish and weakfish feed mainly on other fish. Striped bass and other predators also may feed upon young of their own species. Many fish are omnivorous, eating both plants and animals. Omnivores, like eels and croakers, feed on planktonic copepods, amphipods, crabs, shrimp, small bivalves and small forage fish. Small forage fish, like killifish and silversides, often feed upon the epifauna and epiphytes along wetlands and in shallow water communities.

**BAY FACT**

*Oysters were once so plentiful they could filter the entire volume of Bay water in a few days. This process now takes over a year.*

# Preserving the Chesapeake Bay: the Big Picture

If we want to preserve the Chesapeake Bay and its many delights for future generations, we must change our perspectives. We must view not only what occurs in the Bay itself, but what happens on the land surrounding it. It is not enough to protect shorelines, regulate fisheries and prevent direct disposal of pollutants. We must take into account all of the activities that occur throughout the watershed from Cooperstown, New York, to Virginia Beach, Virginia, and from Pendleton County, West Virginia, to Seaford, Delaware. Released into this watershed, fertilizers, sediment and chemical contaminants from agricultural, residential and urban areas travel downstream to the Bay.

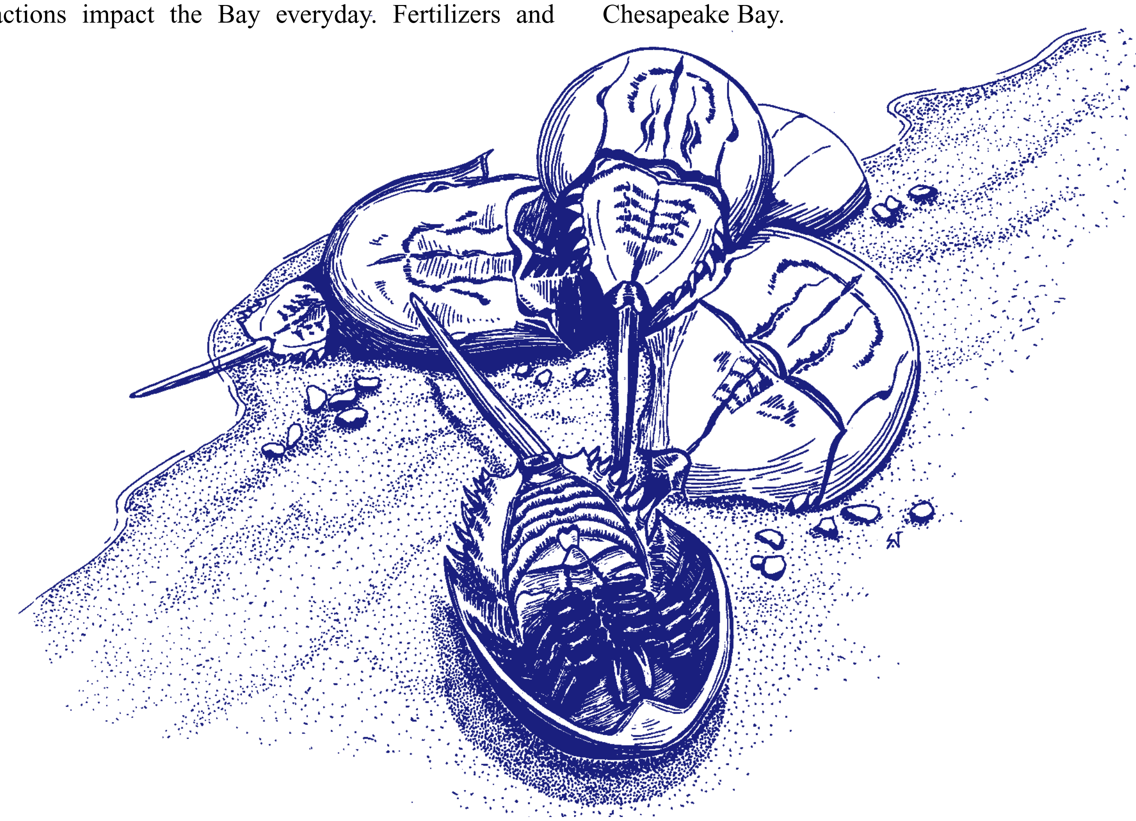
However, even a watershed perspective is not adequate without personal responsibility. Even though we acknowledge that activities in the watershed affect the Bay ecosystem, we must also realize that individual actions impact the Bay everyday. Fertilizers and pesticides from yards and gardens affect the Bay as much as those from large farms. Excessive use of cars produces more exhaust with nitrogen oxides, which contribute to elevated nitrogen levels in the Bay. Indiscriminate use of water results in more water that must be treated and then discharged into the Bay system.

If we want a clean, healthy Bay that can sustain biological diversity and be economically stable, we must identify, alter and, if possible, eliminate our own individual actions that impact the Bay. People alter ecosystems. The solutions to problems threatening the Bay are in the lifestyles we choose. The Bay ecosystem is one unit where forests are linked to oyster reefs, housing developments to Bay grasses and choices to responsibility. Education also is required. Informed people choose actions that are beneficial for themselves, their culture, their community and the Chesapeake Bay.

**THE BAY'S FUTURE**

***"When we see the land as a community to which we belong, we may begin to use it with love and respect."***

Aldo Leopold, 1945



## BE PART OF THE SOLUTION, NOT PART OF THE PROBLEM

**1** ***Reduce your nutrient input to the Bay.***
Limit the amount of fertilizers spread on gardens and lawns. Plant native vegetation that requires less fertilizer and water. Leave grass clippings on lawns and gardens. Maintain your septic system. Start a compost pile, instead of using a garbage disposal.

**2** ***Reduce the use of toxic materials around your house and yard, including pesticides.***
Use safer, non-toxic alternatives for cleaning and for controlling pests.

**3** ***Reduce erosion.***
Plant strips of native vegetation along streams and shorelines. Divert runoff from paved surfaces to vegetated areas.

**4** ***Save water.***
Use water-saving devices in toilets and sinks. Turn off water when not in use. Wash cars in grassy areas to soak up soapy water.

**5** ***Drive less.***
Join a carpool or use public transportation.

**6** ***Obey all fishing, hunting and harvesting regulations.***

**7** ***Be a responsible boater.***
Avoid disturbing shallow water areas and Bay grass beds. Pump boat waste to an onshore facility.

**8** ***Get involved.***
Talk to your elected officials about your concerns. Join or start a watershed association to monitor growth and development locally. Participate in clean-up activities.

**FOR MORE INFORMATION ABOUT THE CHESAPEAKE BAY ECOSYSTEM, VISIT**

**www.chesapeakebay.net**

## For more information about the Chesapeake Bay and its rivers contact:

**Chesapeake Bay Program**
(800) YOUR-BAY/(410) 267-5700
www.chesapeakebay.net

### D.C. & STATE AGENCIES

**Chesapeake Bay Commission**
(410) 263-3420
www.chesbay.state.va.us

**District of Columbia Department of Health**
(202) 442-5999
dchealth.dc.gov/index.asp

**District of Columbia Public Schools**
(202) 724-4222
www.k12.dc.us

**Maryland Department of Education**
(410) 767-0100
www.msde.state.md.us

**Maryland Department of the Environment**
(800) 633-6101/(410) 537-3000
www.mde.state.md.us

**Maryland Department of Natural Resources**
(877) 620-8367/(410) 260-8710
www.dnr.state.md.us

**Pennsylvania's Chesapeake Bay Education Office**
(717) 238-7223
www.pacd.org

**Pennsylvania Department of Conservation and Natural Resources**
(717) 787-9306
www.dcnr.state.pa.us

**Pennsylvania Department of Education**
(717) 783-6788
www.pde.psu.edu

**Pennsylvania Department of Environmental Protection**
(717) 783-2300
www.dep.state.pa.us

**Virginia Department of Conservation and Recreation**
(804) 786-1712
www.dcr.state.va.us/

**Virginia Department of Education**
(800) 292-3820
www.pen.k12.va.us

**Virginia Department of Environmental Quality**
(800) 592-5482/(804) 698-4000
www.deq.state.va.us

### FEDERAL AGENCIES

**National Oceanic and Atmospheric Administration**
Chesapeake Bay Office
(410) 267-5660
noaa.chesapeakebay.net

**National Park Service**
Chesapeake Bay Gateways
(410) 267-5747
www.baygateways.net

**Natural Resources Conservation Service**
(202) 205-0026
www.nrcs.usda.gov

**U.S. Army Corps of Engineers**
District office in Baltimore
(410) 962-7608
www.nab.usace.army.mil

**U.S. Army Environmental Center**
(410) 436-2556
aec.army.mil/usaec

**U.S.D.A. Forest Service**
(410) 267-5706
www.fs.fed.us

**U.S. Department of Education**
(800) USA-LEARN
www.ed.gov

**U.S. Environmental Protection Agency**
Chesapeake Bay Program Office
(800) YOUR-BAY/(410) 267-5700
www.epa.gov/r3chespk

**U.S. Fish and Wildlife Service**
Chesapeake Bay Field Office
(410) 573-4500
www.fws.gov/r5cbfo

**U.S. Geological Survey**
(888) ASK-USGS/(703) 648-4000
www.usgs.gov

### ACADEMIC ORGANIZATIONS

**Maryland Sea Grant**
(301) 403-4220
www.mdsg.umd.edu

**Pennsylvania State University**
(814) 865-4700
www.psu.edu

**University of the District of Columbia**
(202) 274-5000
www.wrlc.org/udc.htm

**Maryland Cooperative Extension Service**
(301) 405-2907
www.agnr.umd.edu

**University of Maryland Center for Environmental Science**
(410) 228-9250
www.umces.edu

**Virginia Cooperative Extension**
(540) 231-6704
www.ext.vt.edu

**Virginia Institute of Marine Science**
(804) 684-7000
www.vims.edu

**Virginia Tech**
(540) 231-6000
www.vt.edu

### NONPROFIT ORGANIZATIONS

**Alliance for the Chesapeake Bay**
410-377-6270
www.acb-online.org

**Chesapeake Bay Foundation**
(410) 268-8816
www.cbf.org

**Chesapeake Bay Trust**
(410) 974-2941
www.chesapeakebaytrust.org

# Glossary of Terms

**Algae** – Simple rootless plants that grow in bodies of water (e.g., estuaries) at rates in relative proportion to the amounts of nutrients (e.g. nitrogen and phosphorus) available in water.

**Amphipods** – Small, shrimp-like crustaceans.

**Anadromous** – Fish that spend most of their life in salt water but migrate into freshwater tributaries to spawn (i.e., shad, sturgeon).

**Angler** – Someone who fishes with a hook, line, and rod.

**Anoxic** – A condition where no oxygen is present. Much of the 'anoxic zone' is anaerobic, with absolutely no oxygen, a condition in which toxic hydrogen sulfide gas is emitted in the decomposition process.

**Aquatic** – Living in water.

**Autotroph** – Any organism that is able to manufacture its own food. Most plants are autotrophs, as are many protists and bacteria. Autotrophs may be photoautotrophic, using light energy to manufacture food, or chemoautotrophic, using chemical energy.

**Benthos (Benthic)** – A group of organisms, most often invertebrates, that live in or on the bottom in aquatic habitats (such as clams that live in the sediments), which are typically immobile, or of limited mobility or range.

**Bioaccumulation** – The uptake and storage of chemicals (e.g., DDTs, PCBs) from the environment by animals and plants. Uptake can occur through feeding or direct absorption from water or sediments.

**Bivalve** – A mollusk with two shells connected by a hinge (e.g., clams, oysters).

**Bloom** – A population burst of phytoplankton that remains within a defined part of the water column.

**Brackish** – Somewhat salty water (0.5 ppt – 25 ppt), as in an estuary.

**Carnivore** – Literally, an organism that eats meat. Most carnivores are animals, but a few fungi, plants and protists are as well.

**Catadromous** – Fish that live in freshwater and migrate to saltwater to spawn (i.e., American eel).

**Coastal Plain** – The level land with generally finer and fertile soils downstream of the piedmont and fall line, where tidal influence is felt in the rivers.

**Consumer** – Any organism that must consume other organisms (living or dead) to satisfy its energy needs.

**Contaminant** – Anything that makes something impure, unclean or polluted, especially by mixing harmful impurities into it or by putting it in contact with something harmful.

**Copepod** – A type of small planktonic crustacean. Copepods are a major group within the mesozooplankton, and are both important grazers of phytoplankton and food for fish.

**Crustaceans** – The class of aquatic arthropods including copepods, isopods, amphipods, barnacles, shrimp and crabs which are characterized by having jointed appendage and gills.

**DDT** – A group of colorless chemicals used as insecticides. DDTs are toxic to man and animals when swallowed or absorbed through the skin.

**Denitrification** – The conversion of nitrite and nitrate nitrogen (after nitrification) to inert nitrogen gas. This treatment process requires that little or no oxygen be present in the system and that an organic food source be provided to foster growth of another type of bacteria. The organic food source can be either recycled waste, activated sludge or methanol. The resultant nitrogen gas is released to the atmosphere.

**Dermo** – Oyster disease caused by the protozoan parasite, *Perkinsus marinus*.

**Detritus** – Accumulated organic debris from dead organisms, often an important source of nutrients in a food web.

**Diatoms** – Microscopic algae with plate-like structures composed of silica. Diatoms are considered a good food source for zooplankton.

**Dinoflagellate** – Algae of the order dinoflagellata.

**Dissolved Oxygen** – Microscopic bubbles of oxygen that are mixed in the water and occur between water molecules. Dissolved oxygen is necessary for healthy lakes, rivers and estuaries. Most aquatic plants and animals need oxygen to survive. Fish will drown in water when the dissolved oxygen levels get too low. The absence of dissolved oxygen in water is a sign of possible pollution.

**Diversity** – An ecological measure of the variety of organisms present in a habitat.

**Ecology** – The study of interrelationships between living things and their environment

**Ecosystem** – All the organisms in a particular region and the environment in which they live. The elements of an ecosystem interact with each other in some way and so depend on each other either directly or indirectly.

**Effluent** – The discharge to a body of water from a defined source, generally consisting of a mixture of waste and water from industrial or municipal facilities.

**Emergent Wetland** – A wetland dominated by nonwoody, soft-stemmed plants.

**Endangered** – A species that is in immediate danger of becoming extinct and needs protection to survive.

**Environment** – The place in which an organism lives and the circumstances under which it lives. Environment includes measures like moisture and temperature, as much as it refers to the actual physical place where an organism is found.

**Epiphyte** – A plant that grows upon another plant. The epiphyte does not 'eat' the plant on which it grows, but merely uses the plant for structural support or as a way to get off the ground and into the canopy environment.

**Epiphytic** – Substances that grow or accumulate on the leaves of submerged aquatic plants. This material can include algae, bacteria, detritus and sediment.

**Erosion** – The disruption and movement of soil particles by wind, water or ice, either occurring naturally or as a result of land use.

**Estuary** – A semi-enclosed body of water that has a free connection with the open sea and within which seawater from the ocean is diluted measurably with freshwater that is derived from land drainage (i.e., the Chesapeake Bay). Brackish estuarine waters are decreasingly salty in the upstream direction and vice versa. The ocean tides are projected upstream to the fall lines.

**Fall Line** – A line joining the waterfalls on several rivers that marks the point where each river descends from the upland to the lowland and marks the limit of navigability of each river.

**Filter Feeder** – An organism which filters food from the environment via a straining mechanism, such as gills (e.g., barnacle, oyster, menhaden.)

**Food Chain / Food Web** – The network of feeding relationships in a community as a series of links of trophic levels, such as primary producers, herbivores and primary carnivores. Includes all interactions of predator and prey, along with the exchange of nutrients into and out of the soil. These interactions connect the various members of an ecosystem and describe how energy passes from one organism to another.

**Habitat** – The place and conditions in which an organism lives.

**Herbivore** – Literally, an organism that eats plants or other autotrophic organisms. The term is used primarily to describe animals.

**Invertebrate** – Animals which lack a backbone and include such as squids, octopuses, lobsters, shrimps, crabs, shellfishes, sea urchins and starfishes.

**Land Use** – The way land is developed and used in terms of the kinds of anthropogenic activities that occur (e.g., agriculture, residential areas, industrial areas).

**Larva** – A discrete stage in many species, beginning with zygote formation and ending with metamorphosis.

**Mammal** – Any of a large class called Mammalia; warm-blooded, usually hairy vertebrates whose offspring are fed with milk secreted by the mammary gland.

**Marine** – Refers to the ocean.

**Marsh** – An emergent wetland that is usually seasonally flooded or wet and often dominated by one or a few plant species.

**Migratory** – Describing groups of organisms that move from one habitat to another on a regular or seasonal basis.

**Mollusk** – The invertebrate phylum which contains bivalves (i.e., oysters), gastropods (i.e. snails) and squids.

**Molt** – To shed the exoskeleton (outer covering) or prior to new growth (i.e., blue crab).

**MSX** – An oyster disease caused by the protozoan parasite, *Haplosporidium nelsoni*.

**Nekton** – Organisms with swimming abilities that permit them to move actively through the water column and to move against currents (e.g., fish, crabs).

**Nitrification** – The process to which bacterial populations, under aerobic conditions, gradually oxidize ammonium to nitrate with the intermediate formation of nitrite. Biological nitrification is a key step in nitrogen removal in wastewater treatment systems.

**Nitrogen** – Nitrogen is used primarily by plants and animals to synthesize protein. Nitrogen enters the ecosystem in several chemical forms and also occurs in other dissolved or particulate forms, such as tissues of living and dead organisms.

**Nonpoint Source** – A diffuse source of pollution that cannot be attributed to a clearly identifiable, specific physical location or a defined discharge channel. This includes the nutrients that run off the ground from any land use – croplands, feedlots, lawns, parking lots, streets, forests, etc. – and enter waterways. It also includes nutrients that enter through air pollution, through the groundwater, or from septic systems.

**Nutrients** – Compounds of nitrogen and phosphorus dissolved in water, which are essential to both plants and animals. Too much nitrogen and phosphorus act as pollutants and can lead to unwanted consequences - primarily algae blooms that cloud the water and rob it of oxygen critical to most forms of aquatic life. Sewage treatment plants, industries, vehicle exhaust, acid rain, and runoff from agricultural, residential and urban areas are sources of nutrients entering the Bay.

**Omnivore** – Literally, an organism that will eat anything. Refers to animals that do not restrict their diet only to plants or other animals.

**Pelagic** – The open ocean, excluding the ocean bottom and shore.

**Pesticides** – A general term used to describe chemical substances that are used to destroy or control insect or plant pests. Many of these substances are manufactured and do not occur naturally in the environment. Others are natural toxics that are extracted from plants and animals.

**pH** – Measure of the acidity or basicity of water.

**Phosphorus** – A key nutrient in the Bay's ecosystem, phosphorus occurs in dissolved organic and inorganic forms, often attached to particles of sediment. This nutrient is a vital component in the process of converting sunlight into usable energy forms for the production of food and fiber. It is also essential to cellular growth and reproduction for organisms such as phytoplankton and bacteria. Phosphates, the inorganic form, are preferred, but organisms will use other forms of phosphorus when phosphates are unavailable.

**Photosynthesis** – The process by which plants convert carbon dioxide and water into carbohydrates and oxygen. The carbohydrates are then available for use as energy by the plant or other consuming organisms ($CO_2$+ $H_2O$ +SUNLIGHT= $C_6H_{12}O_6$ + $O_2$). This process is also referred to as 'primary production.'

**Phytoplankton** – Plankton are usually very small organisms that cannot move independently of water currents. Phytoplankton are any plankton that are capable of making food via photosynthesis.

**Piedmont** – Uplands or hill country above the 'fall line' of coastal rivers, where rapids or cataracts tumble down to the level topography where tidal influence begins.

**Plankton** – Small or microscopic algae and organisms associated with surface water and the water column.

**Point Source** – A source of pollution that can be attributed to a specific physical location; an identifiable, end of pipe 'point'. The vast majority of point source discharges for nutrients are from wastewater treatment plants, although some come from industries.

**ppt** – Parts per thousand (used as a measurement of salinity).

**Predator** – An organism that hunts and eats other organisms. This includes both carnivores, which eat animals, and herbivores, which eat plants.

**Prey** – An organism hunted and eaten by a predator.

**Primary Producers** – Organisms, such as algae, that convert solar energy to organic substances through the molecule chlorophyll. Primary producers serve as a food source for higher organisms.

**Pycnocline** – The zone between waters having different densities. An example from an estuary would be a pycnocline separating deep, more saline water and shallow, more fresh water.

**Riparian Forest Buffers** – An area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water which is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering and converting sediments, nutrients and other chemicals, and to supply food, cover and thermal protection to fish and other wildlife.

**Salinity** – A measure of the salt concentration of water. Higher salinity means more dissolved salts. Usually measured in parts per thousand (ppt).

**SAV** – See submerged aquatic vegetation.

**Sediment** – Matter that settles and accumulates on the bottom of a body of water or waterway.

**Shellfish** – An aquatic animal, such as a mollusk (e.g., clams, oysters and snails) or crustacean (e.g., crabs and shrimp), having a shell or shell-like external skeleton (exoskeleton).

**Spat** – Juvenile, newly attached oysters (i.e., oyster spat).

**Spawn** – To release eggs and/or sperm into water.

**Species** – A population or group of populations that are in reproductive contact but are reproductively isolated from all other populations.

**Submerged Aquatic Vegetation (SAV)** – Rooted vegetation that grows under water in shallow zones where light penetrates. Also known as 'bay grasses'.

**Suspended Sediments** – Particles of soil, sediment, living material, or detritus suspended in the water column.

**Stratification** – The formation, accumulation or deposition of materials in layers, such as layers of freshwater overlying higher salinity water (saltwater) in estuaries.

**Thermocline** – A specific depth at which there is a layer of water where the temperature changes dramatically. Warmer surface water is separated from the cooler deep water. This temperature gradient results in the formation of a density barrier.

**Threatened** – A species that is likely to become endangered if not protected.

**Tides** – The periodic movement of water resulting from gravitational attraction between the earth, sun and moon.

**Tributary** – A body of water flowing into a larger body of water. For example, the James River is a tributary of the Chesapeake Bay.

**Trophic Level** – The layer in the food chain in which one group of organisms serves as the source of nutrition of another group of animals.

**Turbidity** – The decreased clarity in a body of water due to the suspension of silt or sedimentary material.

**Waterfowl** – Any of various birds that swim on water, such as ducks, geese and swans or any bird species that is ecologically dependent on aquatic environments such as wetlands.

**Watershed** – A region bounded at the periphery by physical barriers that cause water to part and ultimately drain to a particular body of water.

**Wetland** – Low areas, such as swamps, tidal flats and marshes, which retain moisture.

**Zooplankton** – A community of floating, often microscopic animals that inhabit aquatic environments. Unlike phytoplankton, zooplankton cannot produce their own food and so are consumers.

# THE CHESAPEAKE BAY PROGRAM
## A Watershed Partnership

### What is the Chesapeake Bay Program?

The Chesapeake Bay Program is a unique, regional partnership leading and directing Bay restoration and protection issues. Formed in 1983, the Bay Program brings together the states of Maryland, Virginia, and Pennsylvania; the District of Columbia; the Chesapeake Bay Commission, a tri-state legislative body; and the U.S. Environmental Protection Agency, representing the federal government. The Bay Program partners work together alongside researchers, policy-makers and resource managers from local, state and federal governments universities, conservation organizations and business and industry from throughout the Bay watershed. The Bay Program partners also have recently enlisted the help of the Bay's headwater states, West Virginia, New York and Delaware, in the restoration efforts.

The Chesapeake Bay Program has become a model for other estuary restoration programs across the nation and throughout the world. A great deal of the Bay Program's success is the result of efforts to reach across state boundaries to work cooperatively on restoring the Chesapeake Bay.

### What's the Bay Program doing to help the Chesapeake?

The most recent Chesapeake Bay agreement, *Chesapeake 2000*, is guiding Bay restoration through the next decade. The Bay Program partners are working with researchers, policy makers, and conservation organizations are to address the many issues affecting the Bay. The commitments in *Chesapeake 2000,* as well as our programs, are focused on five issue areas:

1. protecting living resources
2. restoring vital habitat
3. improving water quality
4. encouraging sound land use
5. expanding community engagement.

CHESAPEAKE 2000
*The Renewed Agreement*

**CHESAPEAKE BAY PROGRAM**
410 Severn Avenue, #109, Annapolis, MD 21403
1-800-YOUR BAY • www.chesapeakebay.net