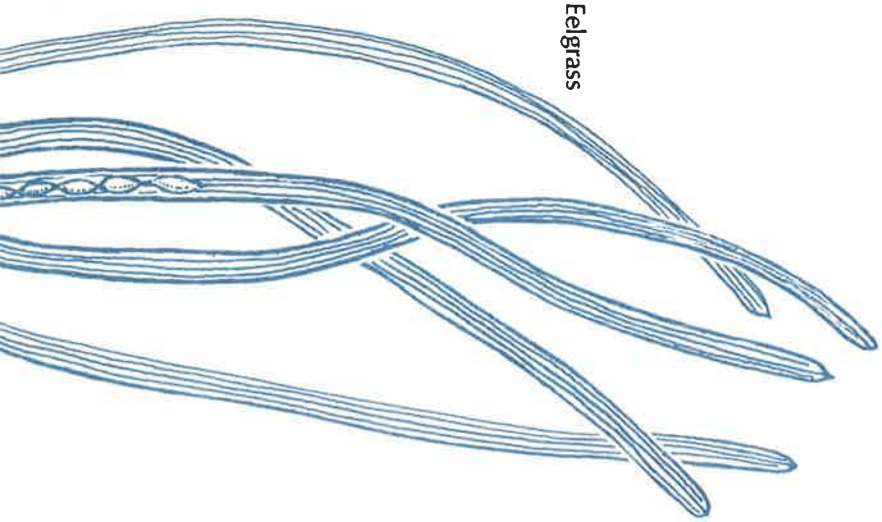
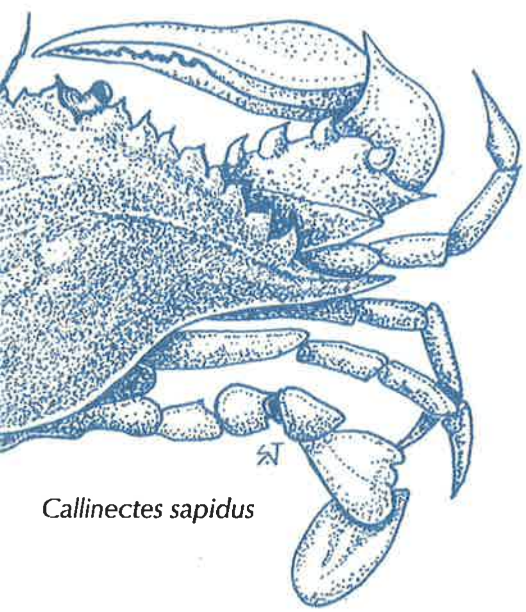


Chesapeake Bay
INTRODUCTION to an ECOSYSTEM



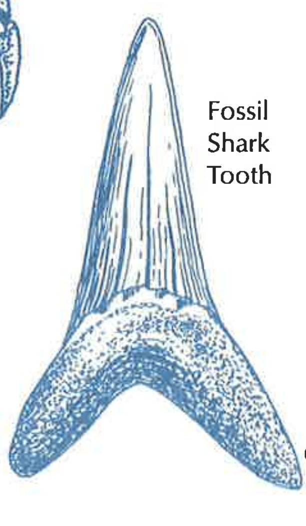


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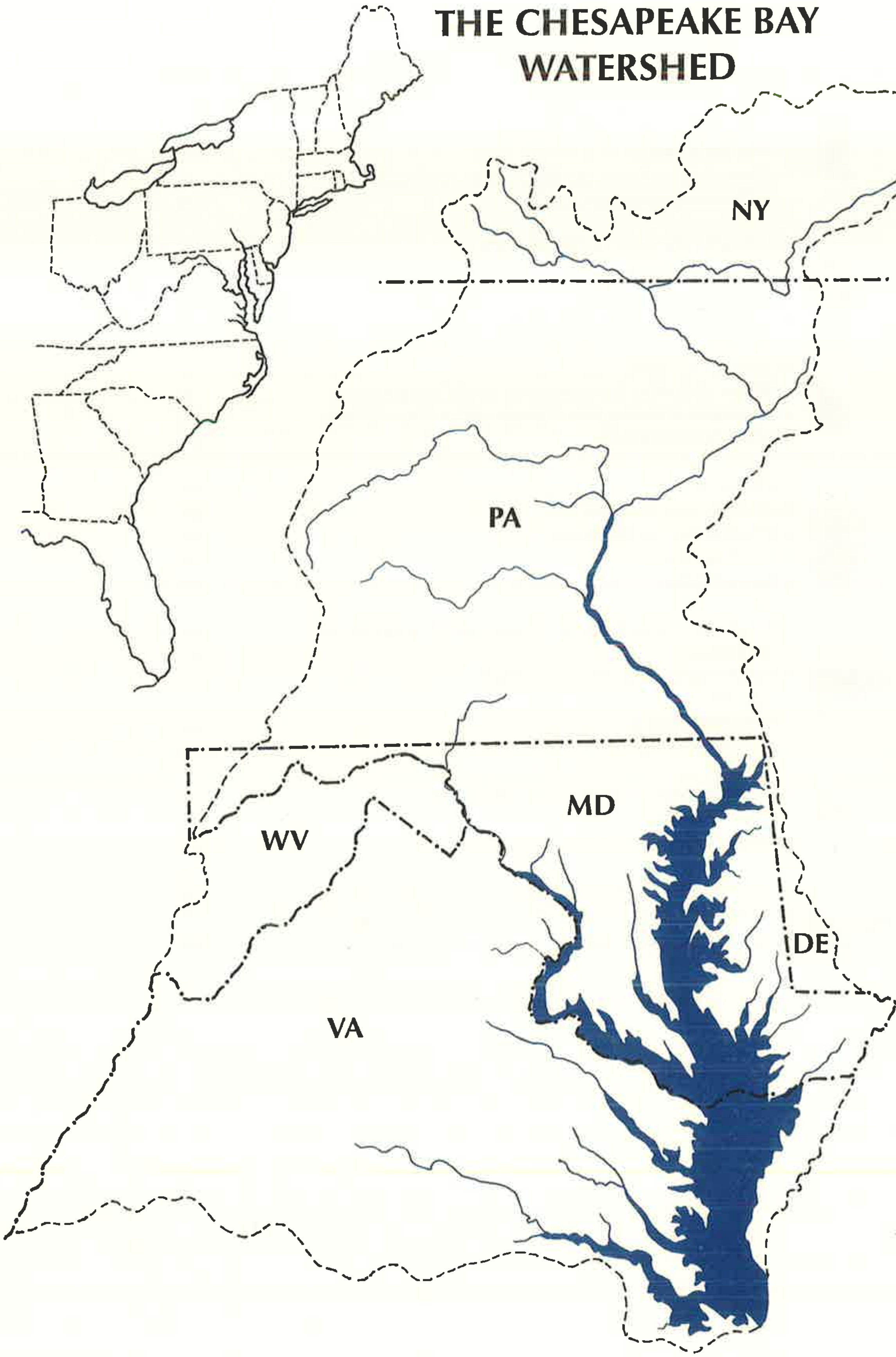
TABLE OF CONTENTS

THE CHESAPEAKE BAY WATERSHED



Chesapeake Bay Ecosystem

The physical processes that drive the Bay ecosystem sustain the many habitats and organisms found there. Complex relationships exist among the living resources of the Chesapeake 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 submerged aquatic vegetation. Unnoticed by the naked eye, phytoplankton and microzooplankton drift with the currents, 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 ospreys, perched high above the water, feed on 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.

BAY FACT:

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

♦

The relentless encroachment of people threatens the ecological balance of the Chesapeake Bay. Fifteen million people live, work and play in the watershed. Each individual directly affects the Bay by adding waste, consuming resources and by changing the character of the land, water and air that surrounds it. However, through the choices we make in our everyday lives, we can lessen our impact on the Bay's health. We must nurture what Aldo Leopold once termed as 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.

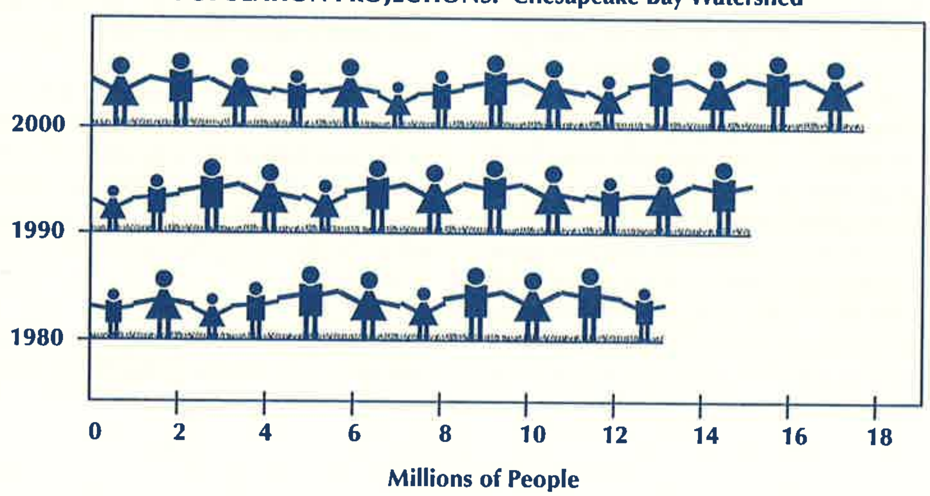
♦ *The Watershed*

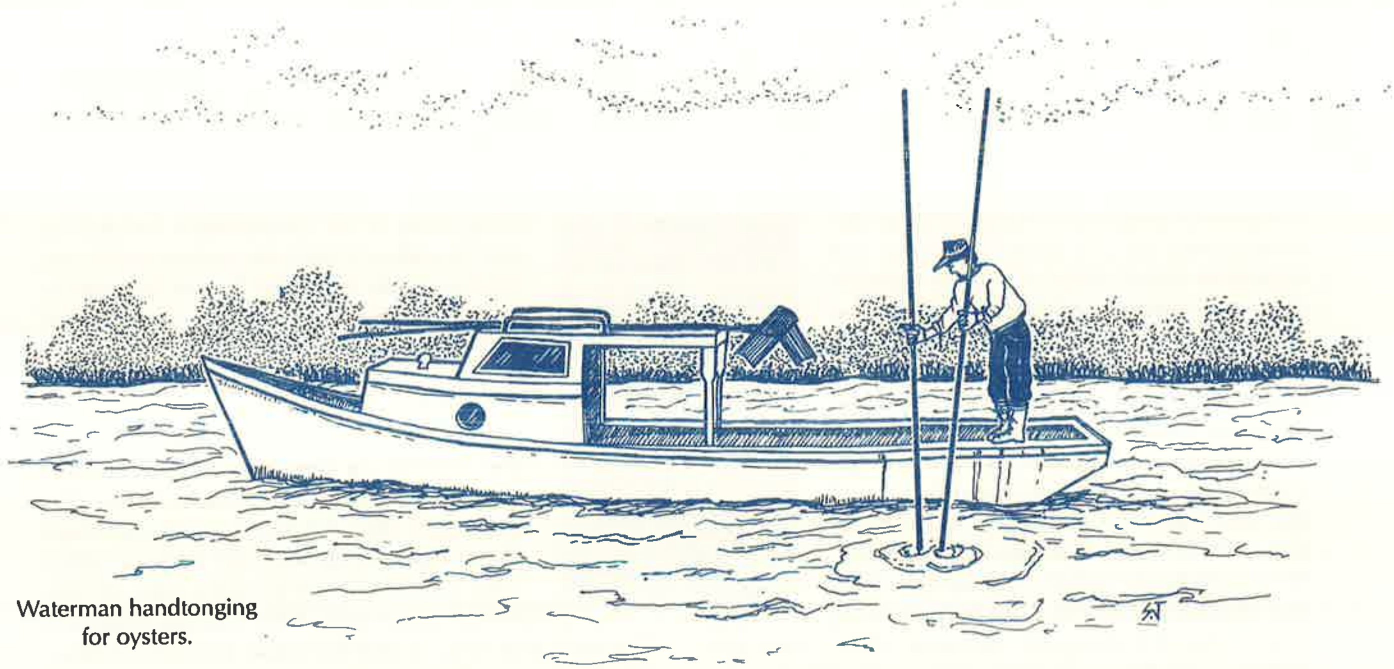
The Chesapeake Bay receives about half its water volume from the Atlantic Ocean. The rest drains into the Bay from an enormous 64,000 square-mile drainage basin or watershed. The watershed includes parts of New York, Pennsylvania, West Virginia, Delaware, Maryland and Virginia and the entire District of Columbia. Freshwater from springs, streams, small creeks and rivers flows downhill mixing with ocean water to form this estuarine system. Soil, air, water, plants and animals, including humans, form a complex web of interdependencies that together make up this Chesapeake ecosystem. The 15 million 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 proper. We must choose whether our role will be destructive or productive.

♦ *Chesapeake Bay – An Important Resource*

Through the years, residents and visitors alike have found the Chesapeake imposing yet hospitable. The Algonquin Indians called it "Chesepiooc," meaning great shellfish bay. Spanish explorers described Chesapeake Bay as "...the

POPULATION PROJECTIONS: Chesapeake Bay Watershed





Waterman handtonging for oysters.

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.

BAY FACT:

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

♦

Today, the Chesapeake 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 Chesapeake Bay delicacies. From the 1920s to the 1970s, the average annual oyster catch was about 27 million pounds of meat per year. In the last 10 years, the catch has declined dramatically due to overharvesting, disease and loss or degradation of habitat. Chesapeake Bay blue crab production averaged 86 million pounds annually from 1983 to 1992, contributing more than half the nation's catch. Although this figure is consistent with past harvests, fishing pressure, both commercial and recreational, continues to grow. The states of Maryland and Virginia have pledged to jointly manage the Bay's blue crab harvests through pot limits, gear restrictions and license restrictions. More than half the nation's soft-shelled clams also come from the Chesapeake. An extensive finfish industry, primarily based on menhaden and striped bass, rounds out the Chesapeake's commercial seafood production. In 1992, the dockside value of commercial shellfish and finfish harvests was close to $80 million.

The hospitable climate, lush vegetation and natural beauty of the Chesapeake has 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 1993, more than 175,000 pleasure craft were registered.

Sportfishing is another major recreational activity in the Chesapeake. The National Marine Fisheries Service reported that close to 1 million anglers from Maryland and Virginia took almost 600,000 fishing trips in 1991. Recreational fishing in the states of Maryland and Virginia is estimated at more than $1 billion per year.

H. L. Mencken once called the Bay, "...a great outdoor protein factory." A study by the National Marine Fisheries Service ranked the Chesapeake as third in the nation in fishery catch. Only the Atlantic and Pacific oceans exceed the Bay in production. That is an impressive ranking, since the Bay is small compared to these other bodies of water.

The Chesapeake is also a key commercial waterway, with two of the nation's five major North Atlantic ports located here. The Hampton Roads Complex, which includes Portsmouth, Norfolk, Hampton and Newport News, dominates the mouth of the Bay. Hampton Roads ranks third in tonnage of foreign water-borne commerce. At the northern end, the Port of Baltimore is ranked ninth in the nation. Baltimore is the leading exporter of trucks and cars in the nation. More than 90 million tons of cargo were shipped via the Chesapeake during 1992. Both Baltimore and Hampton Roads are near the coal-producing regions of Appalachia, making them essential to exporting U. S. coal abroad. The Hampton Roads Complex already leads the nation in exporting coal and lignite.

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 Chesapeake 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 the many 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. Between 1992 and 1994, an average of 28,000 swans, 300,000 geese and 650,000 ducks wintered on the Bay. It is also a major nesting area for the threatened bald eagle. The nation's largest population of another raptor, the osprey, is in the Bay region.

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.

♦ *A Threatened Resource*

Chesapeake Bay, the largest estuary in the United States, is part of an extremely productive and complex eco-

BAY FUN FACT:

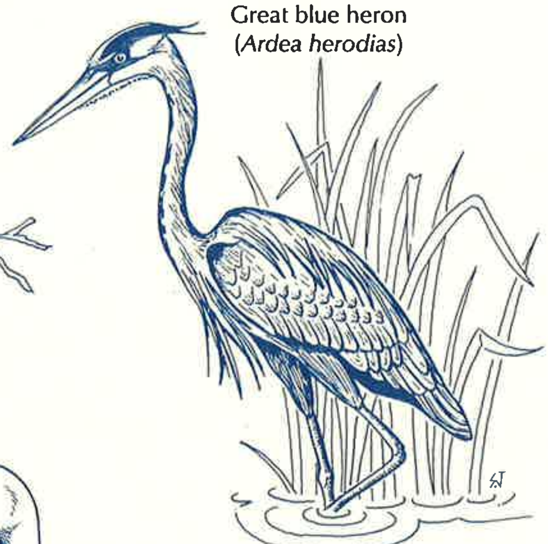
The Bay is fairly shallow. A person 6 feet tall could wade over 700,000 acres of the Bay without becoming completely submerged.

♦

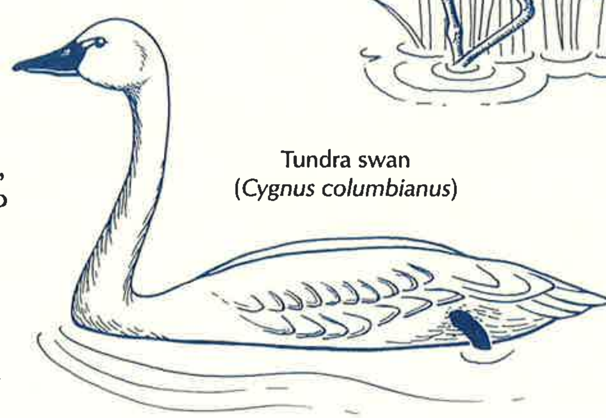
Canada goose
(*Branta canadensis*)

Canvasback
(*Aythya valisineria*)

Osprey
(*Pandion haliaetus*)



Great blue heron
(*Ardea herodias*)



Tundra swan
(*Cygnus columbianus*)

system. This ecosystem consists of the Bay, its tributaries and the living resources it supports. Humans, too, 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 threatens 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. Toxic substances, particularly high in industrialized urban areas, accumulate in the tissues of birds, fish and shellfish.

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 algae blooms that block sunlight from reaching critical bay grasses known as submerged aquatic vegetation or SAV. As SAV 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 are also 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:

Nearly half of the nation's catch of blue crabs comes from the Chesapeake Bay.

♦

Geology of the Chesapeake

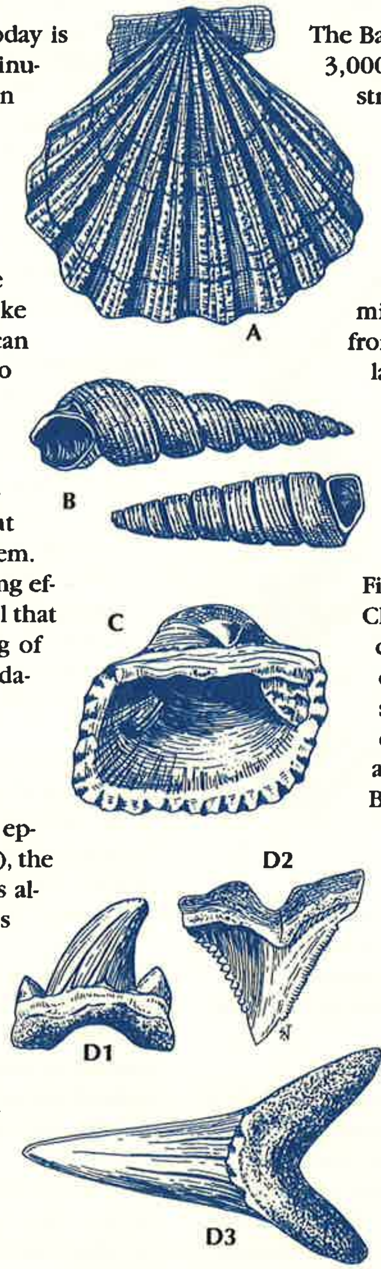
The Chesapeake Bay as we know it today is the result of thousands of years of continuous change. The Chesapeake, less than 10,000 years old, continues to change. Nature, like a dissatisfied artist, is constantly reworking the details. Some modifications enhance the Bay; others harm it. All affect the 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 makeup 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 small-scale 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 Susquehanna River Valley.



FOSSILS OF CHESAPEAKE BAY

- **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 Bay assumed its present dimensions about 3,000 years ago. This complex of drowned streambeds formed the Chesapeake basin we know today.

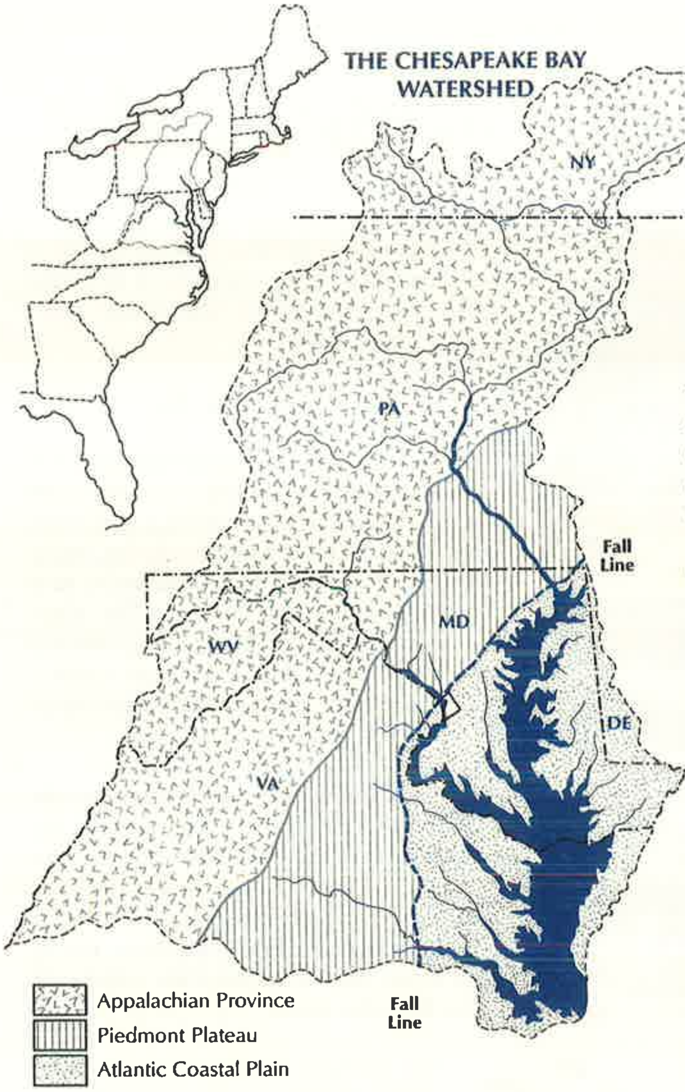
♦ *The Chesapeake Bay*

The Bay proper is approximately 200 miles long but contains more than 4,400 miles of shoreline. The Bay ranges in width from about 4 miles near Annapolis, Maryland, to 30 miles at its widest point, near the mouth of the Potomac. The water surface area of the tidal Bay encompasses more than 2,300 square miles; include the tributaries and that figure nearly doubles.

Fifty major tributaries pour water into the Chesapeake every day. Almost 85-90 percent of the freshwater entering the Bay comes from the northern and western sides. The remaining 10 to 15 percent is contributed by the eastern shore. Nearly an equal volume of saltwater enters the Bay from the ocean.

On average, the Chesapeake holds about 18 trillion gallons of water. Although the Bay's length and width are dramatic, the average depth is only 27 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 Plateau and



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.

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 Washington, D.C. 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 shipped overland. Cities along the fall line became important areas for commerce.

BAY FACT:

More than 600 species are fossilized in the sediments at Calvert Cliffs.

♦

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 calcium and magnesium salts. This makes the water soft or 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 larger 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.

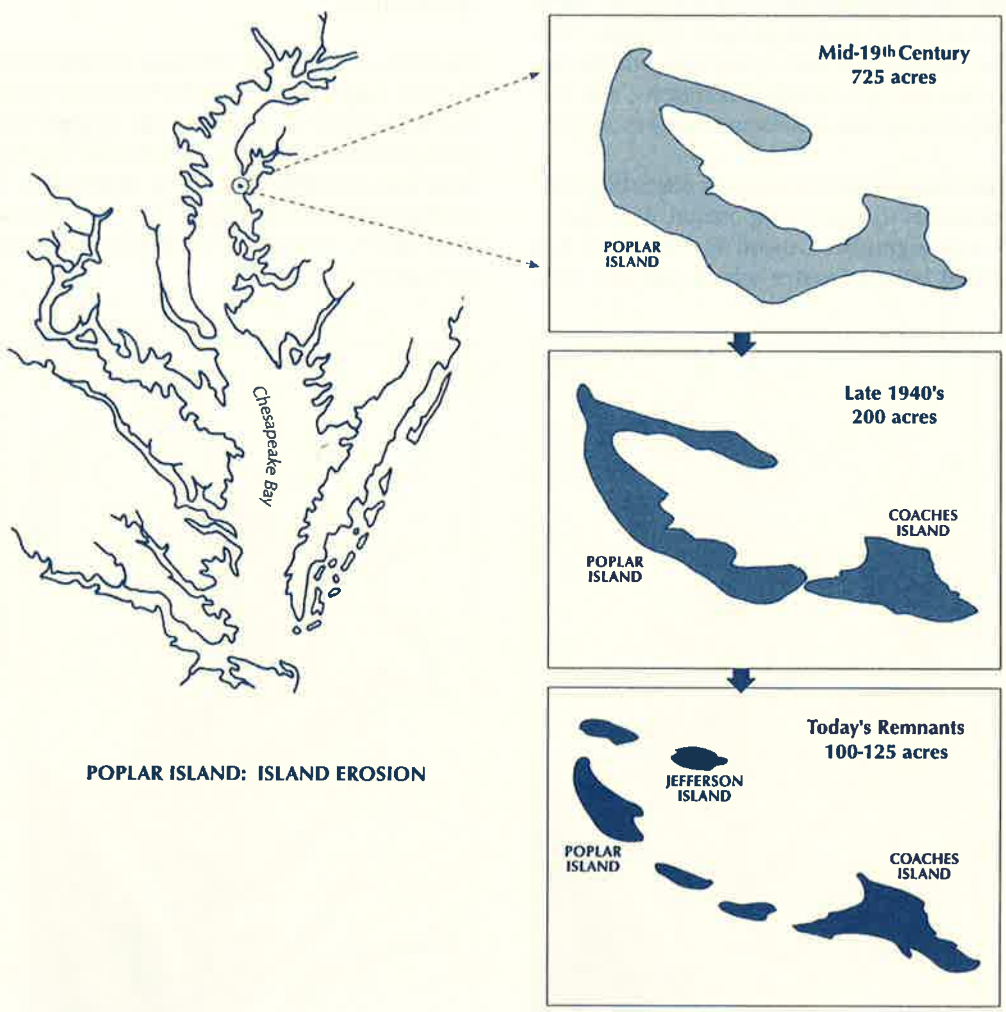
The waters that flow into the Chesapeake Bay have different chemical identities that depend on the geology of their place of origin. In turn, the nature of the Bay itself depends on the characteristics and relative volumes of these contributing waters.

♦ *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, are also 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 are retreating inland as sea level rises. The speed at which these modifying processes 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 underway to stabilize the remnant 100 acres. In addition, the island's original landmass will be rebuilt by creating marshes that will protect the island form further erosion and provide a haven for birds and other wildlife.

In contrast, sedimentation has also 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 2 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 percent of the earth's surface is covered by it. It makes up approximately 80 percent 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 homogeneous rather than a substance with extremely diverse characteristics and properties.

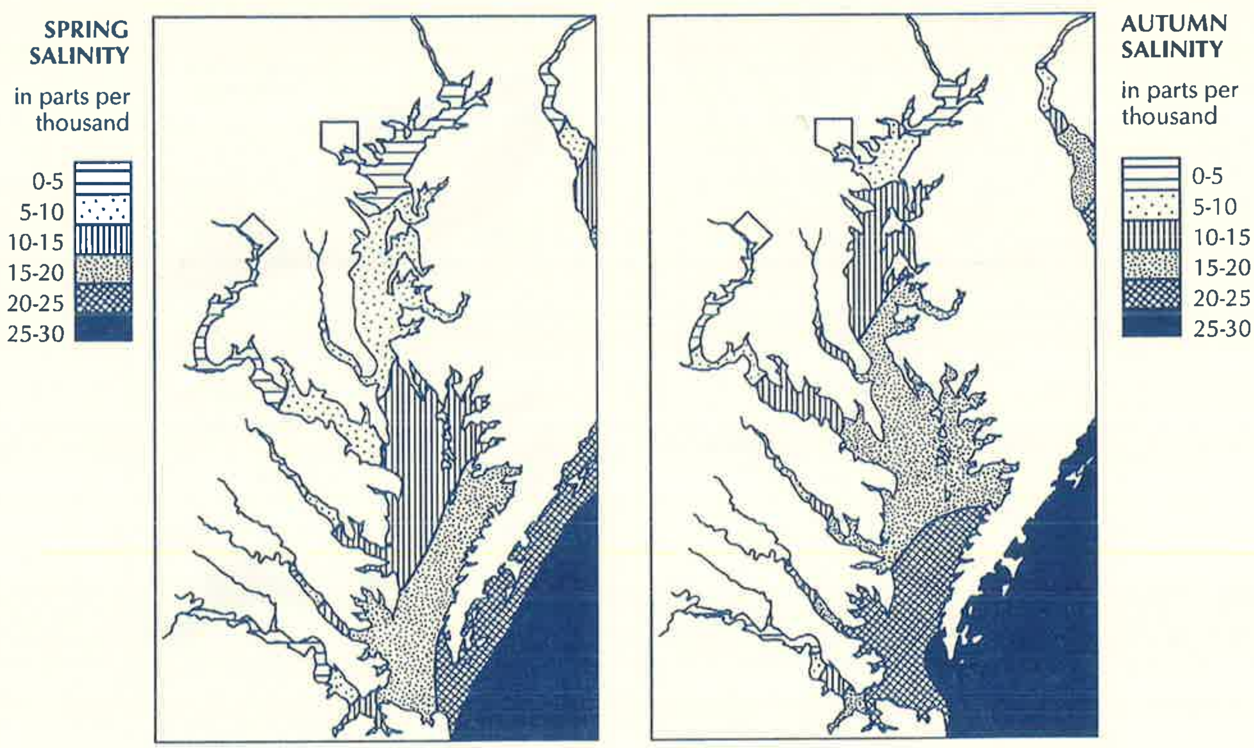
In the natural environment, water is never pure. It tends to hold other substances in solution and easily enters into various chemical reactions. As the universal solvent, water is an important environmental medium. Water normally contains dissolved gases, such as oxygen, and a variety of organic (containing 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 oceanographer Donald W. Pritchard, is a "... semi-enclosed body of water which has free connection with the open sea and within which sea water is measurably diluted by freshwater from land drainage." Within an estuary, freshwater mixes with salt water, with each contributing its own chemical and physical characteristics. This creates a range of environments that supports a wide variety of plants and animals.

♦ *Water: Salinity, Temperature and Circulation*

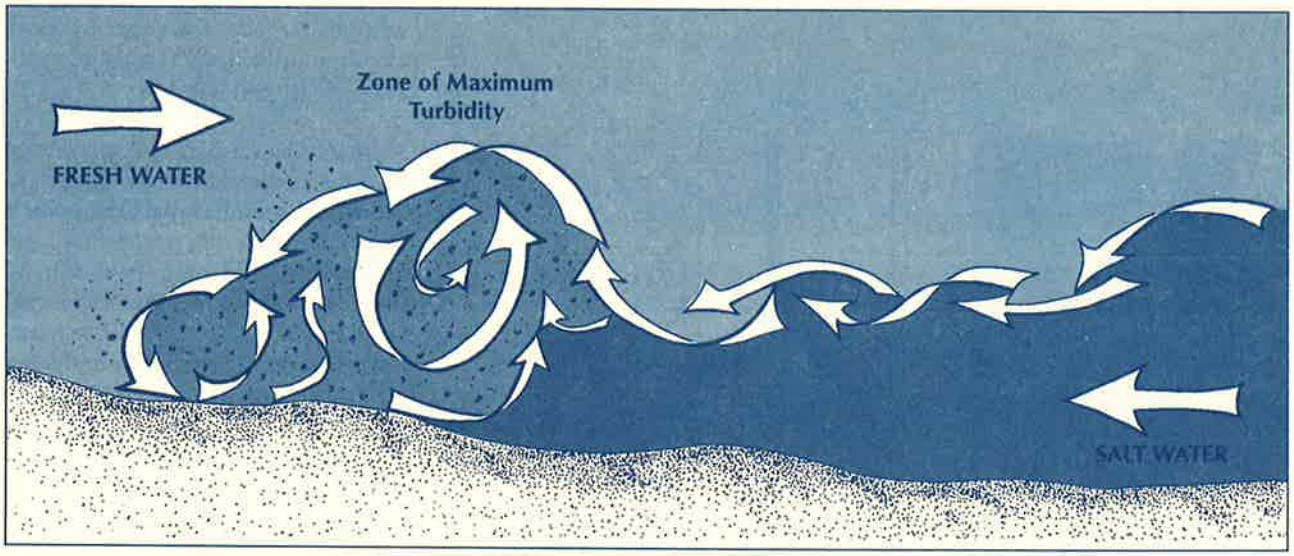
The distribution and stability of an estuarine ecosystem, such as the Chesapeake Bay, depends on three important physical characteristics of the water: salinity, temperature and circulation. Each affects and is affected by the others.

Salinity is a key factor affecting the physical make-up of the Bay. Salinity is the number of grams of dissolved salts 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 strength seawater which averages 25-30 ppt. Salinity increases with depth. Therefore, freshwater tends to remain at the surface.



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.

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 towards the Eastern 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 0-29 C° (32-84 F°). 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 with the coldest water found at the bottom. Often turbulence of the water helps to break down this layering.

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 salt water 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.

BAY QUOTE:

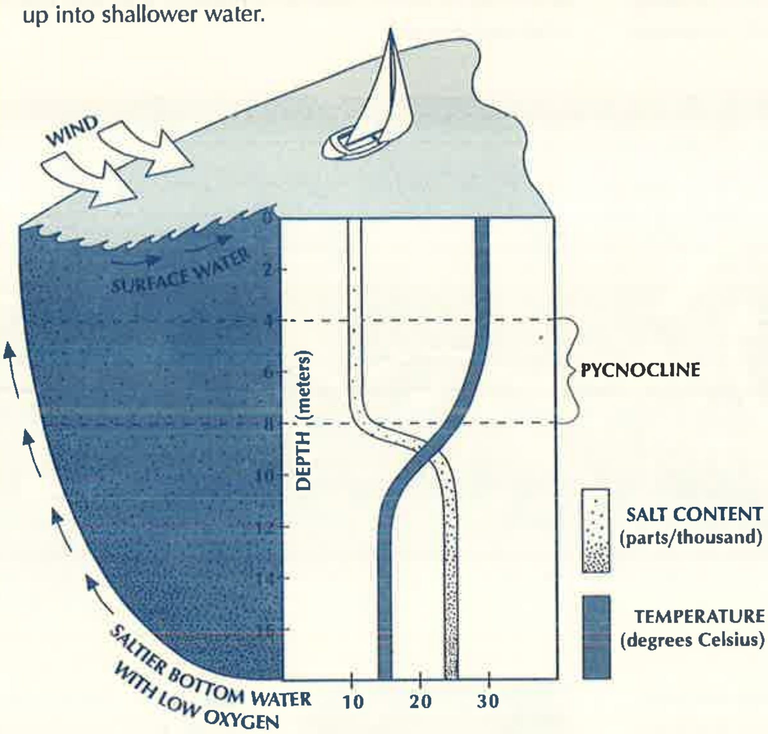
"...the tide is also governed by the wind. Southeast makes the highest flood and northwest the lowest ebb."

Rev. Hugh Jones, 1697

♦

Weather often disrupts or reinforces this two-layered flow. Wind plays a role in the mixing of the Bay's waters. Wind can also 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 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. These fronts are characterized by intensive mixing. A layer separating water of different densities, known as a pycnocline, is formed. This stratification varies within any season depending on rainfall. Stratification is usually highest in the spring as the amount of freshwa-



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.

of freshwater in the Bay increases due to melting snow and frequent rain. Stratification is maintained throughout summer due to 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 sediments, making them available to phytoplankton and other organisms inhabiting upper water levels. This turn-over 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. Accumulation of sediments can fill in ports and waterways. This sedimentation process has already caused several colonial seaports, like Port Tobacco, Maryland, to become landlocked. As they settle to the bottom of the Bay, the sediments can also smother the bottom-dwelling plants and animals. Sediments suspended in the water column cause the water to become cloudy, or turbid, decreasing the light available for SAV growth.

Sediments can also carry high concentrations of certain toxic materials. Individual sediment particles have a large surface area, and many molecules easily adsorb, or attach, to them. As a result, sediments can act as chemical sinks by adsorbing 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.

In the upper Bay and tributaries, sediments are fine-grained silts and clays that are light and can be carried long distances. These sediments are carried 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.

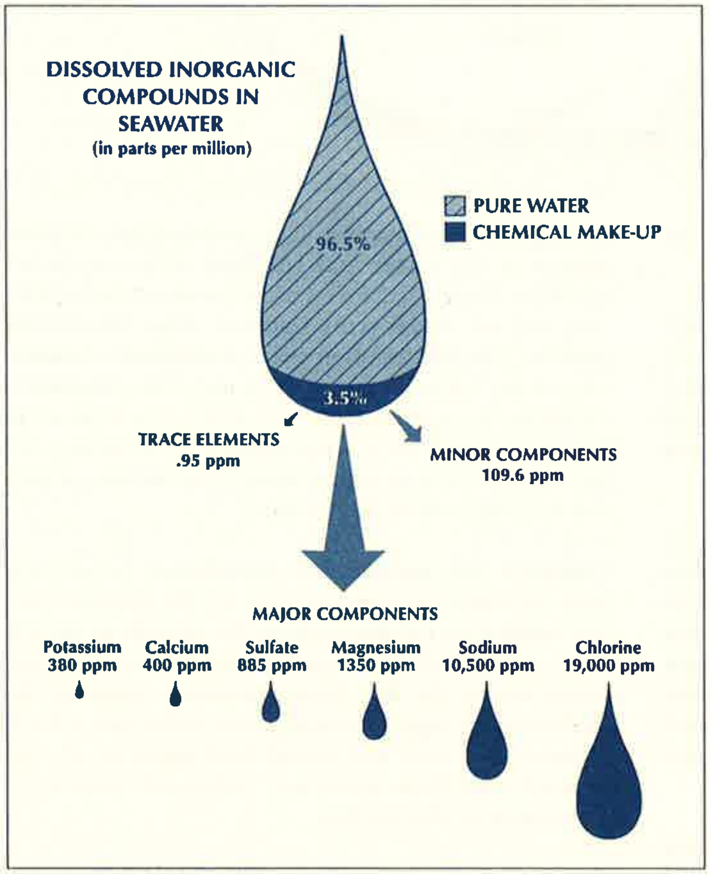
Sediments in the middle Bay are mostly made of silts and clays. These sediments are mainly derived from shoreline erosion. In the lower Bay, by contrast, the sediments are sandier, and heavier. These particles result from shore erosion and inputs from the ocean. Sediments drop to the bottom fairly rapidly,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

♦ *Chemical Make-up*

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.

The more saline waters are chemically similar to seawater. 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.

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 occur in low concentrations.



The composition of seawater is relatively constant from place to place. Freshwater, however, varies depending upon the soil and rocks the water has come in contact with. Both fresh and saltwater contain a myriad of natural dissolved materials. These come 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 mater-ial enters into the Bay via its tributaries and the ocean.

BAY FACT:

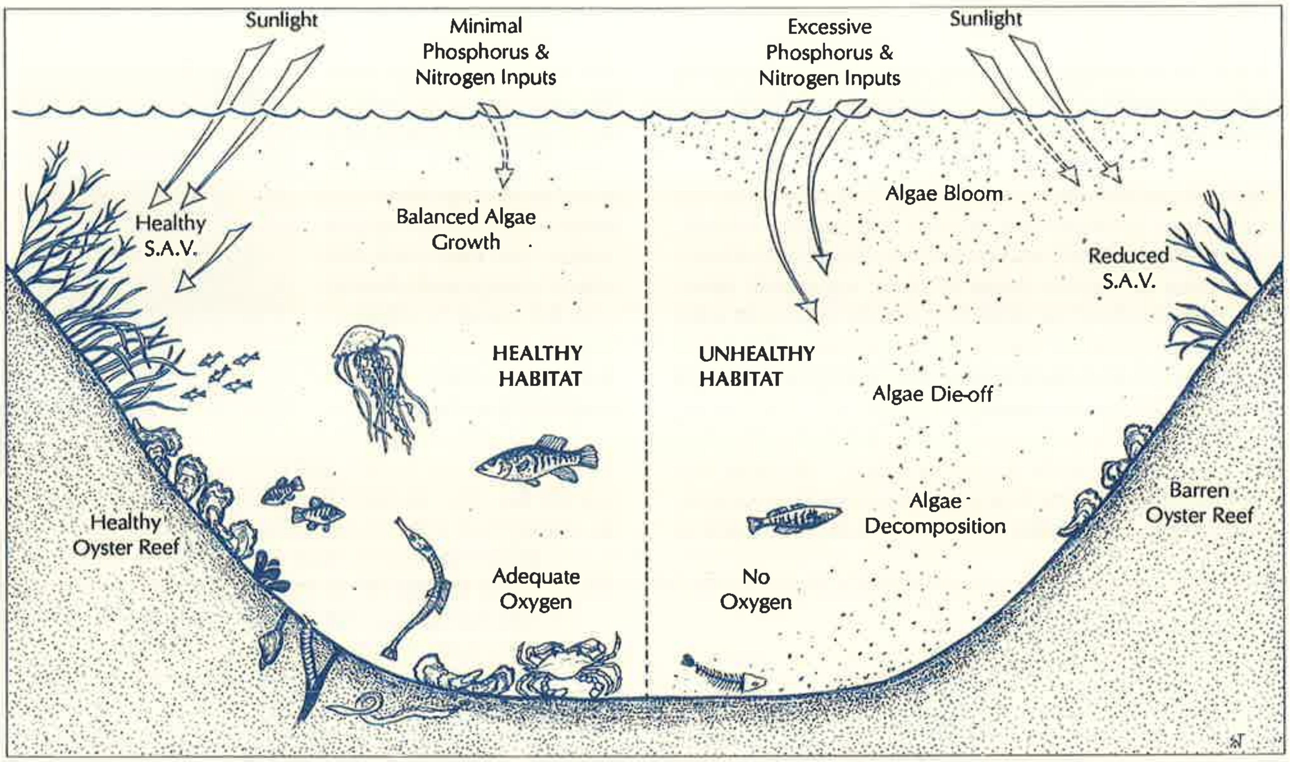
Due to a lack of oxygen in the water, hundreds of blue crabs may run out onto land. This rare phenomena is known as a "crab jubilee".

♦

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 the surface waters by diffusion and the aerating action of the wind. It is also added as a by-product 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 2 meters (approximately 6 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).

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 by-product of respiration. Carbon dioxide is more soluble in water than



oxygen. Its availability is also affected by temperature and salinity in much the same fashion as oxygen.

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 and 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 percent 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 in 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.

Excess amounts of phosphorus and nitrogen cause rapid growth of phytoplankton, creating dense populations, or blooms. These blooms become so dense that they reduce the amount of sunlight available to submerged aquatic vegetation. Without sufficient light, plants cannot photosynthesize and produce the food they need to survive. Algae may also grow directly on the surface of SAV, blocking light. Another hazard of nutrient-enriched algal blooms that are not consumed by zooplankton 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 or 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 by-products can be toxic to living resources. These contaminants reach the Bay through municipal and industrial wastewater, runoff from agricultural, urban and industrialized areas and atmospheric deposition.

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

In an effort to control nutrient pollution, the states of Maryland, Pennsylvania and Virginia and the District of Columbia agreed to reduce the total amount of nutrients entering the Bay by 40 percent by the year 2000. Controllable sources include runoff from agricultural, suburban and urban areas, wastewater treatment plants, and industry. A ban on laundry detergents containing phosphates has reduced phosphorus levels. New technologies implemented at many sewage treatment plants remove phosphorus and some nitrogen before the effluent is discharged into rivers. Other efforts include maintaining forested or other vegetated buffer strips along water sources, reducing fertilizer use on farms and lawns and managing animal waste.

BAY FACT:

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

♦

Habitats

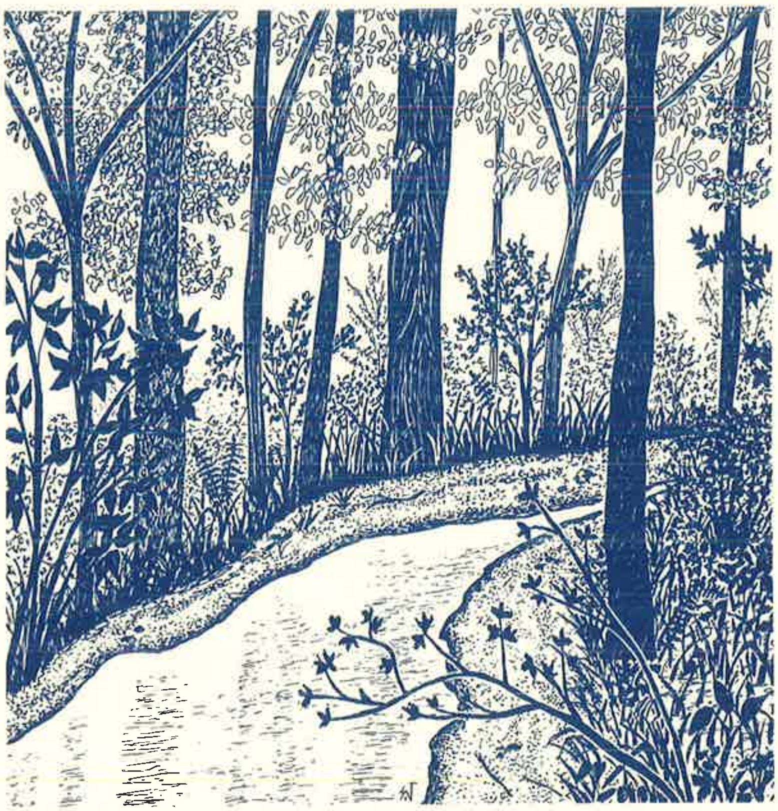
The Bay provides food, water, cover and nesting or nursery areas, collectively known as habitat, to more than 2,700 migratory and resident wildlife species. All plants and animals have specific habitat requirements that must be satisfied in order to live and thrive. Food, temperature, water, salinity, 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 and its surrounding watershed provide 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 that lie 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 upland to water. 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 Chesapeake 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, Chesapeake Bay islands are a haven for colonial waterbirds (terns and herons), waterfowl (ducks) and raptors (ospreys and bald eagles). Islands can also protect submerged aquatic vegetation 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 percent of the freshwater to the Bay. These rivers and other smaller rivers, along with the hundreds of smaller 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 Chesapeake Bay include striped bass, blueback herring, alewife, American and hickory shad, shortnose sturgeon and Atlantic sturgeon. Semi-anadromomous fish, such as white and yellow perch, inhabit tidal tributaries but also require freshwater to spawn.

While all 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. The 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 degrades spawning and nursery habitat.

♦ *Shallow Water*

The shallow water, or littoral zone, provides key habitats for many life stages of invertebrates, fish and waterfowl. Shrimp, killifish and juveniles of larger fish species use submerged aquatic vegetation , tidal marshes and shallow shoreline margins as nursery areas and for refuge. Vulnerable, shedding blue crabs find protection in the SAV beds. Predators, including blue crabs, spot, striped bass, waterfowl, colonial waterbirds and raptors forage for food here. 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.

♦ *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 Chesapeake Bay. Although unseen by the naked eye, microscopic plant and animal life, called plankton, float in the open waters. These tiny organisms form the food base for many other animals. More than 500,000 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 supports other shellfish, finfish and crabs.

BAY QUOTE:

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

John Smith, 1607-08

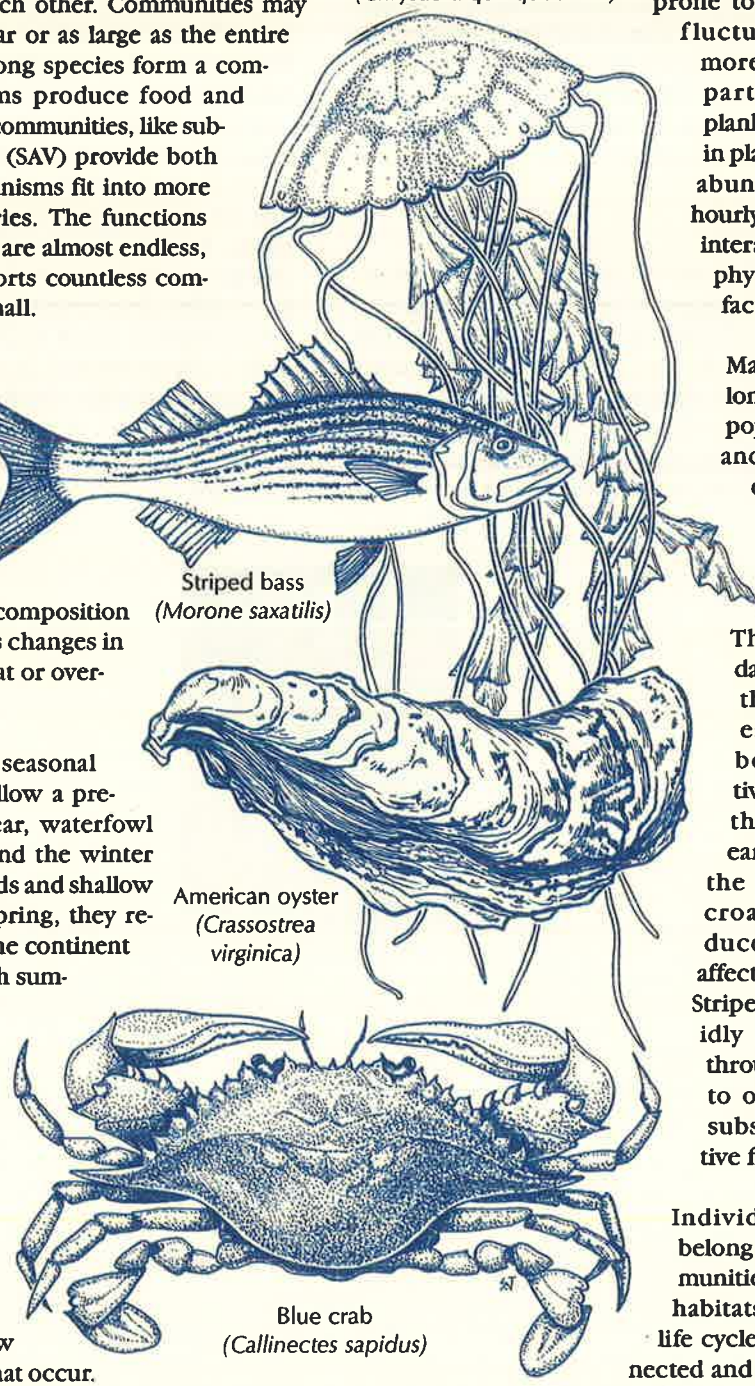
♦

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, like submerged aquatic vegetation (SAV) 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 supports countless communities both large and small.

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

Some variations, such as seasonal changes in abundance, 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 late 1970s and through the 1980s due to overharvesting and subsequent reproductive failure.

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 may not only affect the communities it supports but other habitats and communities as well.

In the Chesapeake, wetlands, SAV beds, plankton, fish and bottom-dwellers are biological communities supported by the Bay's varied habitats. Wetlands are transitional areas between uplands and water. SAV beds range from mean low tide to a depth of about 2 meters or where light becomes limiting to plant growth, although some freshwater species thrive up to 3 meters 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 who move freely throughout the Bay and its tributaries. The bottom sediments support benthic organisms.

BAY FACT:

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

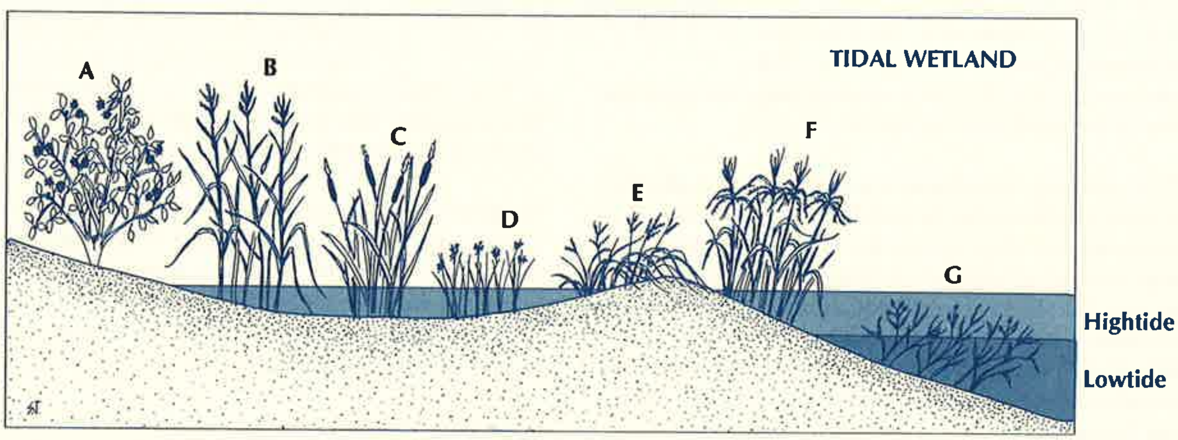
♦

♦ *Wetlands*

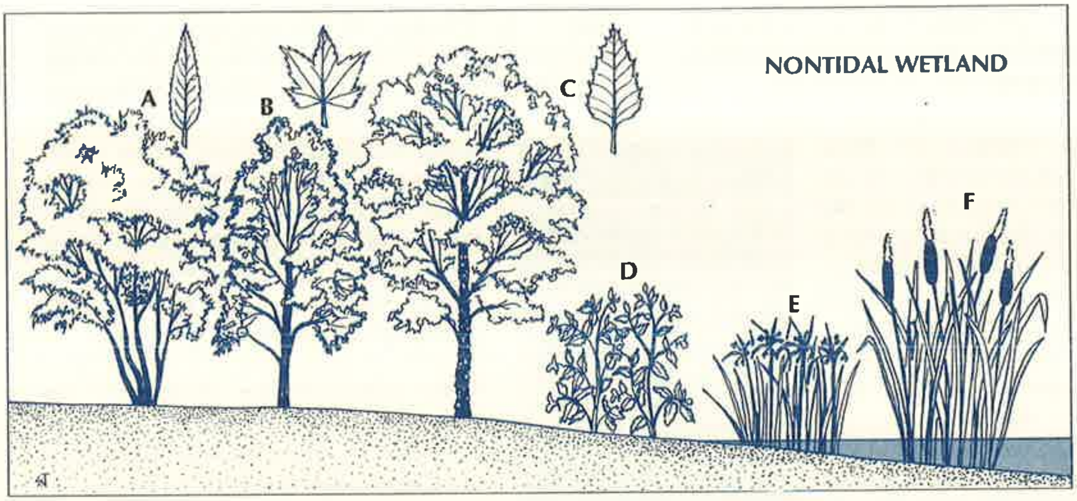
Wetlands, environments subject to periodic flooding or prolonged saturation, produce specific plant communities and soil types. The presence of water affects the types of soils that develop and the types of plants and animals that live there. Wetlands are characterized by hydrophytic vegetation (water-loving plants adapted to wet soils) and hydric soils (saturated or periodically flooded soils). There are two broad categories of wetlands in the Chesapeake 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.

Tidal wetlands are dominated by nonwoody or herbaceous vegetation and 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



A Button bush *(Cephalanthus occidentalis)*
B Big cordgrass *(Spartina cynosuroides)*
C Narrow-leaved cattail *(Typha angustifolia)*
D Black needlerush *(Juncus roemerianus)*
E Saltmeadow cordgrass *(Spartina 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)*

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 1.7 million acres of wetlands remain in the Chesapeake Bay watershed, less than half of the wetlands that were here during colonial times. Of the remaining wetlands, 12 percent are tidal and 88 percent 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.

BAY FACT:

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

◆

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, beaver, otter, song birds 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.

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 many 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 and pollutants, settle and are trapped by vegetation. Nutreints, 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 and much leisure time is spent simply enjoying the sights and sounds these areas can offer.

♦ *Submerged Aquatic Vegetation*

In the shallow waters of Chesapeake 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, SAV produces oxygen, a precious and sometimes lacking commodity in the Chesapeake Bay. These underwater plants filter and trap sediment that can cloud the water and bury bottom-dwelling organisms like oysters. As waves roll into SAV beds, the movement is slowed and energy is dispelled, protecting shorelines from erosion. During the growing season, SAV takes up and retains nitrogen and phosphorus, removing excess nutrients that could fuel unwanted growth of algae in the surrounding waters.

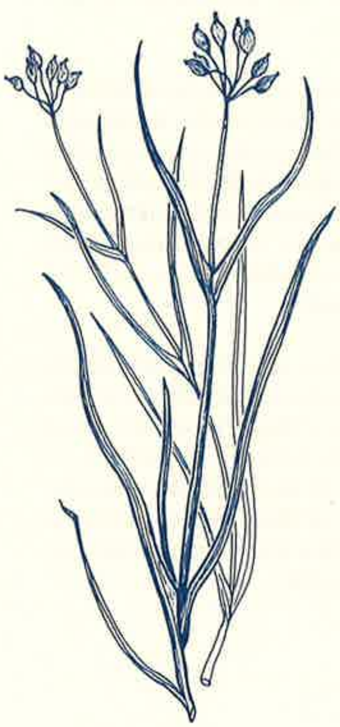
Like a forest, field, or wetland, an SAV bed also serves as habitat for many aquatic animals. Microscopic zooplankton feed on decaying SAV and, in turn, are food for larger Bay organisms. Minnows dart between the plants and graze on tiny organisms that grow on the stems and leaves. Small fish seek refuge from larger and hungrier mouths. Shedding blue crabs conceal themselves in the vegetation until their new shells have hardened. Thus, SAV is a key contributor to the energy cycling in the Bay. SAV is 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 SAV year-round.

There are thirteen species of SAV commonly found in the Bay or nearby rivers. Salinity, water depth and bottom sediment determine where each species can grow. Survival of SAV 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 SAV.

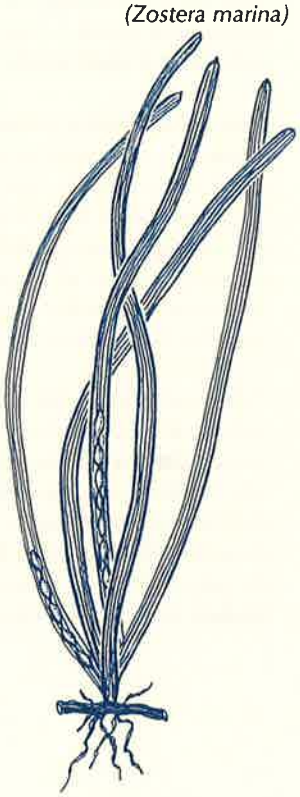
Factors that affect water clarity, therefore, also affect the growth of SAV. Suspended sediment and other solids cloud the water, blocking precious sunlight from the grasses. Excessive amounts of suspended sediment may cover the plants completely. Sources of suspended sediments include runoff from farmland, 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

Widgeon grass
(Ruppia maritima)

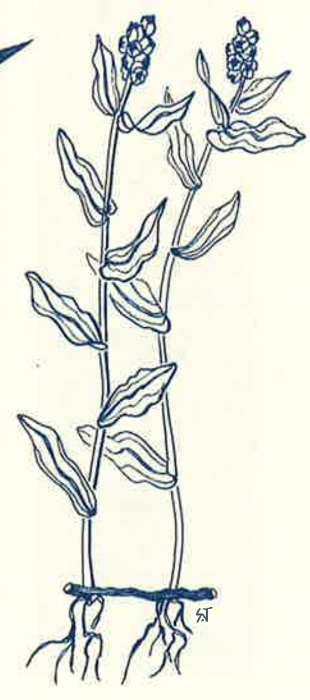


Eelgrass
(Zostera marina)



Wild celery
(Vallisneria americana)

Redhead grass
(Potamogeton perfoliatus)



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. Algae blooms cloud the water and reduce the amount of sunlight reaching SAV. Certain types of algae grow directly on the plants, further reducing available sunlight.

Historically, more than 200,000 acres of SAV grew along the shoreline of Chesapeake Bay. By 1978, a survey of SAV documented only 41,000 acres. Declining water quality, disturbance of SAV beds and alteration of shallow water habitat all contributed to the Bay-wide decline. The absence of SAV translates into a loss of food and habitat for many Chesapeake Bay species.

Water quality is the key to restoring grasses to the Bay. Scientists have identified the water quality conditions and requirements necessary for the survival of five SAV species from wild celery found in freshwater, to 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. SAV is making a comeback. 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. In 1984 only 38,000 acres of SAV were reported in the Bay and its tidal tributaries. By 1993 more than 73,000 acres of SAV were reported, representing an 85 percent increase from the low 9 years earlier.

♦ *Plankton*

Mainly unseen by the naked eye, a community made up of predominantly microscopic organisms also fuels the ecosystem we call the Chesapeake Bay. These tiny plants and animals, called plankton, drift with the water largely 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, an intermediate layer where the increase in salinity is more pronounced, to avoid being washed out to the ocean.

BAY FACT:

One drop of Bay water may contain thousands of phytoplankton.

♦

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 in 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, is 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 percent of total algal production.

Changes in chemical conditions, such as the addition of nutrients, can cause rapid increases in the numbers 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, a group of tiny crustaceans, about one millimeter long, and fish larvae. Zooplankton are distributed according to salinity levels. Distribution patterns are also related to those of their main food source, the phytoplankton. Zooplankton also feed on other particulate plant matter and bacteria.

The tiny larvae of invertebrates and fish are also 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 role in the Bay. They are essentially the decomposers. Their primary function is to break down dead matter. 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 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.

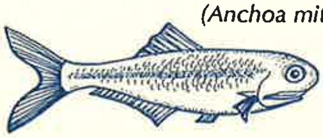
Clearly visible to the unaided eye, jellyfishes and comb jellies are the largest zooplankton. Some of these gelatinous creatures swim, though they are still at the mercy of the water currents. Jellyfishes have tentacles with stinging cells used to stun prey. The most famous jellyfish in the Chesapeake 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.

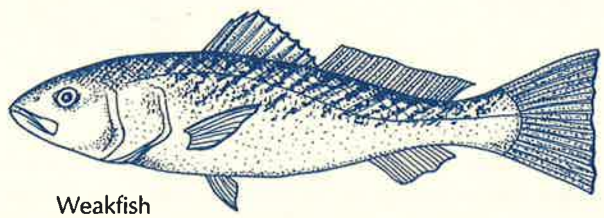
♦ *The Swimmers*

Swimmers comprise the nekton community. These organisms can control and direct their movements. This group includes fish and some crustaceans and other invertebrates. Approximately 250 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 huge distances that migratory species do.

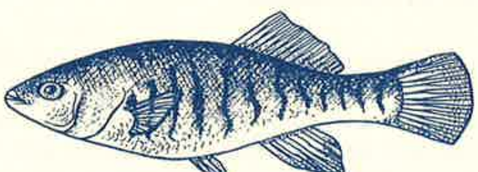
Smaller resident species, like killifish, normally occur in shallow water where they feed on a variety of invertebrates. The bay anchovy, the most abundant fish in the Bay, is a key player in the Chesapeake food web. Bay anchovies feed primarily upon zooplankton. Adult an-

Bay anchovy
(Anchoa mitchilli)

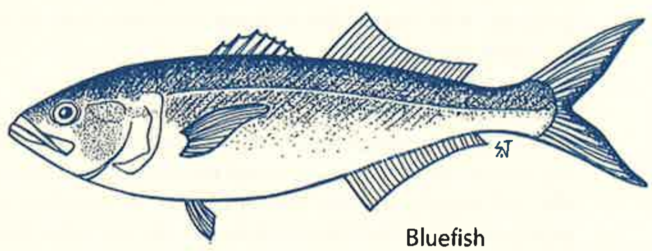




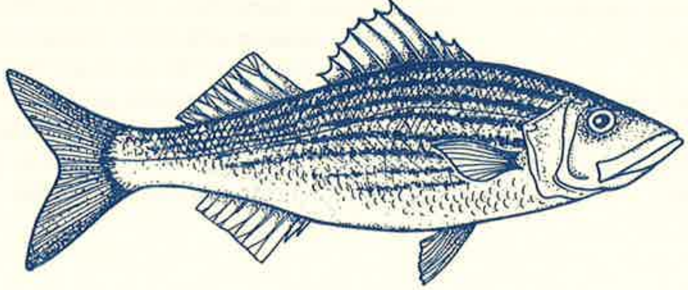
Weakfish
(Cynoscion regalis)



Striped killifish
(Fundulus majalis)



Bluefish
(Pomatomus saltatrix)



Striped bass
(Morone saxatilis)

chovies may also 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 Chesapeake Bay. Although they live in the Chesapeake Bay for long periods, eels eventually migrate to ocean waters in the Sargasso Sea to spawn.

Other fish utilize the Bay strictly for feeding. Some, like 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, like shrimp, crabs and worms, may be part of the nekton community. Larger animals like sharks, rays, sea turtles and occassionally dolphins and whales enter the Bay.

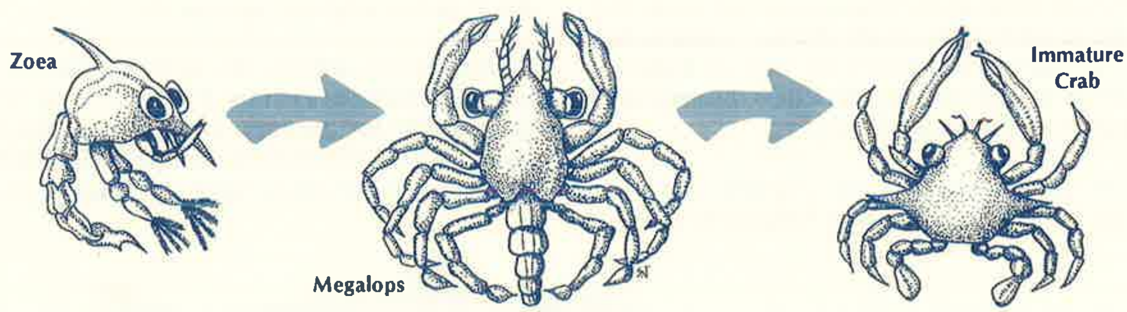
BAY FACT:

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

♦

The blue crab is difficult to place in any one community, needing 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 submerged aquatic vegetation 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.

LIFE STAGES OF A BLUE CRAB

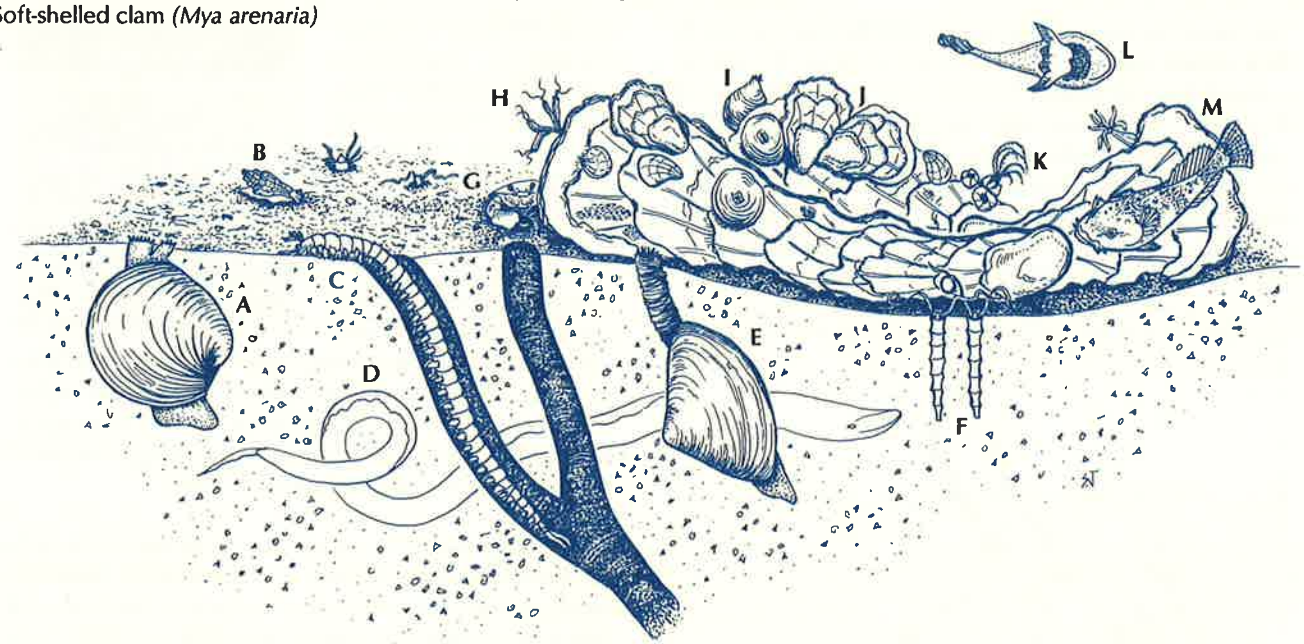


♦ *Life at the Bottom*

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 are often 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 submerged aquatic vegetation supply the physical support for a wide variety of epiphytic organisms. An oyster bar, and the many species it supports, is another example of a benthic community. Benthic communities

BENTHIC COMMUNITY

- **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)*



that exist on or in bare, unvegetated substrates are made up of molluscs, 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 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 the 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.

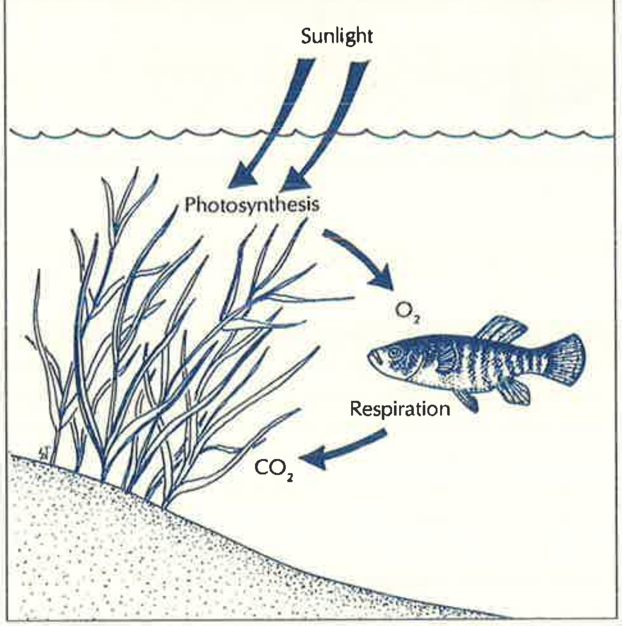
Filter feeders, like oysters and clams, pump large volumes of water through their bodies and extract food from it. As they filter water for food, they also remove sediments and organic matter, cleaning the water. Since many toxic substances are often present in sediments, benthic fauna are often exposed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

Some benthic organisms, such as blue crabs, 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 are also 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 Bay species is their dependence upon each other as food. We are all carbon-based creatures. Carbon is the basic element of all 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.

CARBON-OXYGEN CYCLE



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.

BAY FACT:

Each year, crabbers catch approximately 75% of the adult blue crab population in the Bay.

◆

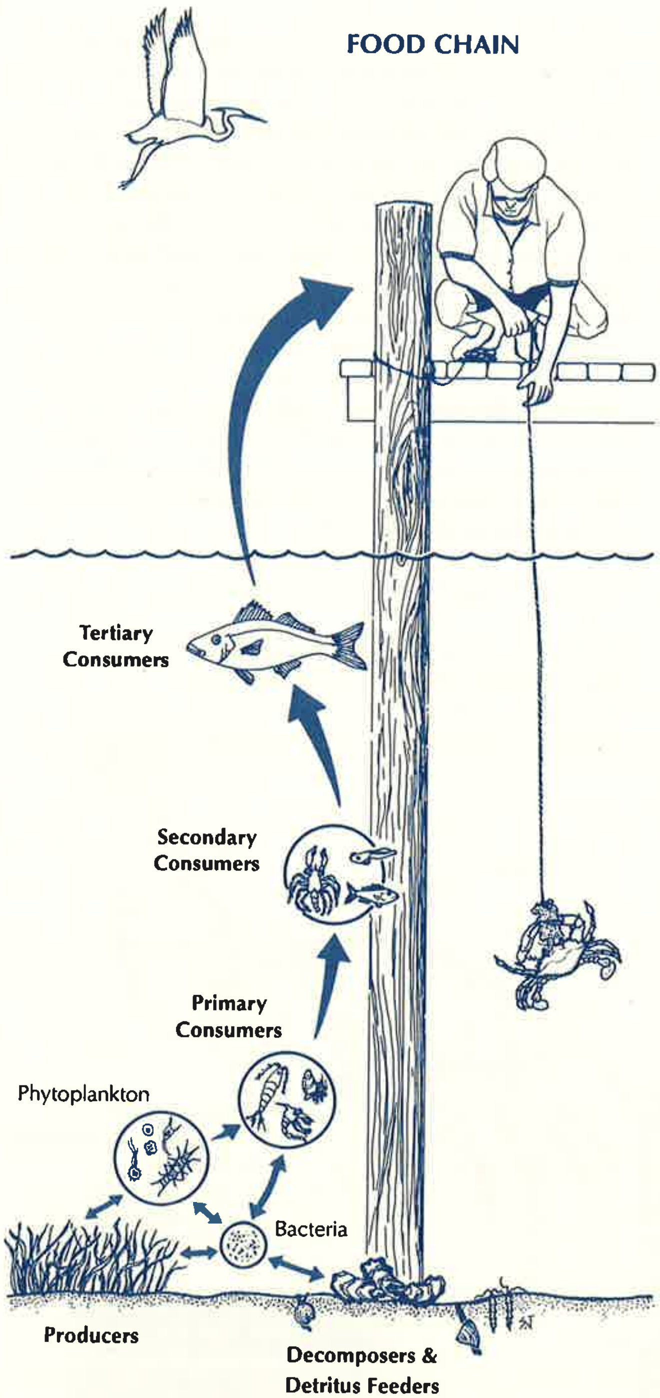
Every biological activity, such as reproduction, growth, movement and bodily functions, requires energy. Whether organisms produce food themselves or ingest it from other sources, they all must break down organic molecules to use the carbon and energy contained within. This process is called respiration.

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

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, other bacteria convert ammonia to nitrite and nitrate, also good nitrogen sources for plants. Under low oxygen conditions, some bacteria convert nitrate to gaseous nitrogen which 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 Chesapeake Bay ecosystem.

To illustrate how these factors affect the productivity of the Bay, lets look at 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 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 which 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 are, in turn, eaten by copepods, members of the zooplankton community. The copepods are then 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, are transferred to higher trophic levels.

Food production and consumption in the Chesapeake Bay is 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.

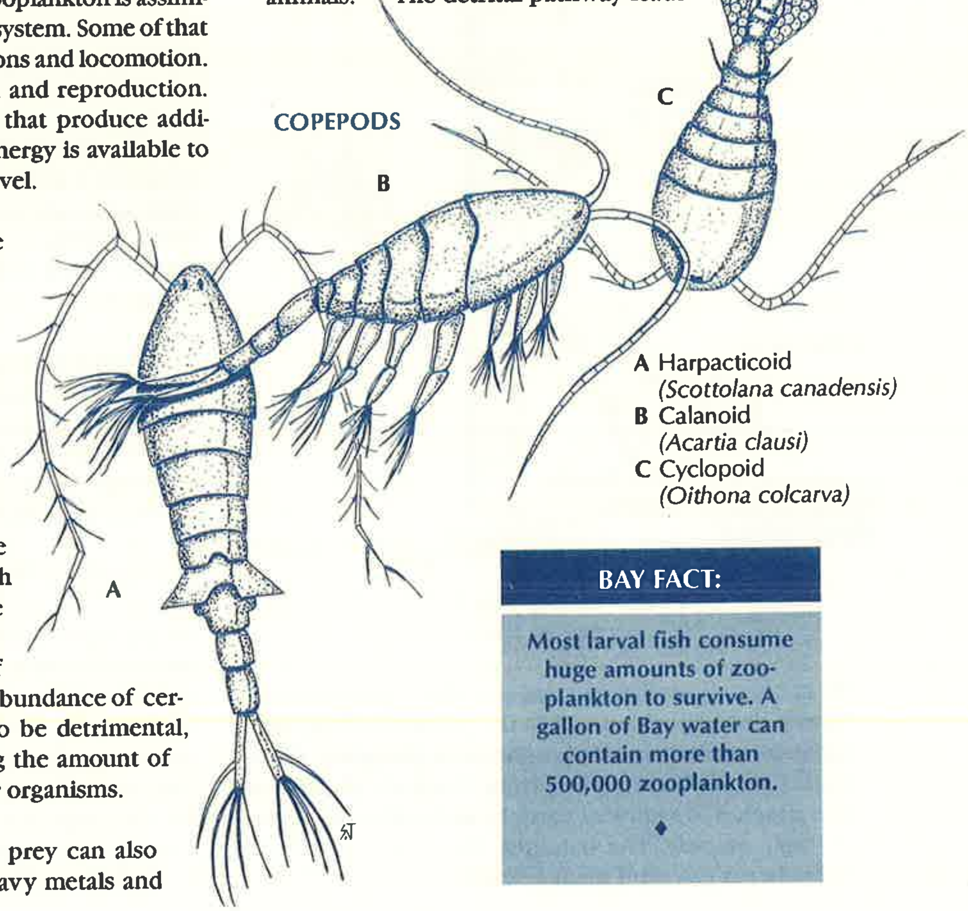
The transfer of energy from one organism to the next is, however, inefficient. Only about 10 percent of the available energy is transferred from one trophic level to the next. For example, only a portion of the total amount of phytoplankton carbon ingested by zooplankton is assimilated by the zooplankton's 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 extremely productive to support large populations of organisms at the highest trophic levels. Massive quantities of plants are required to support carnivores, such as striped bass or bluefish. Because producers are the basis of all food, they influence the production of other organisms. However, an overabundance of certain producers, like algae, can also be detrimental, causing a loss of SAV and reducing the amount of dissolved oxygen available to other organisms.

Toxic substances in contaminated prey can also 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 and 1960s 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 eggs with extremely thin shells, so thin that most eggs broke in the nest and many eagle pairs failed to produce young. Only after banning the use of this chemical were bald eagles 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



BAY FACT:

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

♦

from dead organic matter to lower animals then to higher animals. The detrital pathway is dominant in wetlands and submerged aquatic vegetation beds.

The direct and detrital pathways coexist and are not easily separated. Higher plants, like 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 submerged aquatic vegetation, continually rains down on the Bay floor. Bottom-dwelling animals such as oysters, clams, crustaceans, tube worms, shrimp and blue crabs feed on it.

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.

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.

♦

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 other 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 may also 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.

Preserving 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 is occurring in the Bay itself but 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 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 from farms, sediment from residential developments, and toxic compounds travel in a single direction, downstream to the Chesapeake Bay.

THE BAY'S FUTURE:

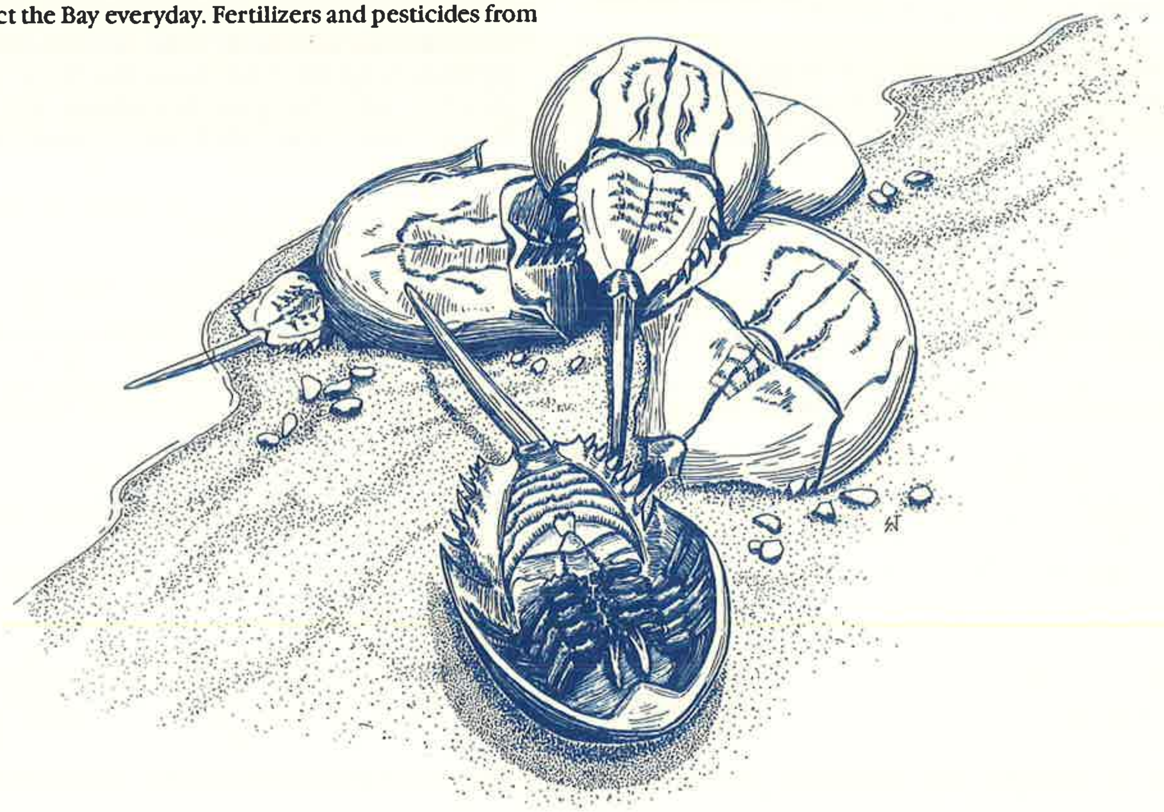
"When we see the land as a community to which we belong, we may begin to use it with love and respect."

Aldo Leopold, 1945

♦

However, even a watershed perspective is not adequate without personal responsibitlity. 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 requires more roads, decreasing vegetated areas that could intercept runoff. Indiscriminate use of water results in more water that must be treated and then discharged into the Bay.

If we want a clean, healthy Bay that can sustain the 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 Chesapeake Bay lie in the life-styles we choose. The Chesapeake Bay ecosystem is one unit where forests are linked to oyster reefs, housing developments to SAV, and choices to responsibility. Education is also required. Informed people choose actions that are beneficial for themselves, their culture, their community and the Chesapeake Bay.



♦ *Be Part of the Solution, Not Part of the Problem*

1. ***Reduce your nutrient input to the Bay.***
Start a compost pile instead of using a garbage disposal. Limit the amount of fertilizers spread on gardens and lawns. Plant native vegetation that requires less fertilizing and watering. Leave grass clippings on lawns and gardens, instead of fertilizing. If you have a septic system, make sure it is functioning properly.

2. ***Reduce the use of toxic materials around your house and yard.***
Use cleaning agents made from natural substances. Talk to a Cooperative Extension Agent to find natural pest controls and alternatives to herbicides.

3. ***Reduce erosion.***
Plant strips of 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 submerged aquatic vegetation beds. Pump out boat waste to an onshore facility

8. ***Get involved.***
Join a citizens' environmental advocacy group or start your own. Talk to your city, town or county elected officials about your concerns. Join or start a watershed association to monitor growth and development locally. Participate in citizen monitoring and clean-up activities.

For more information about the Chesapeake Bay contact:

Maryland Chesapeake Bay Communications Office
State House
Annapolis, MD 21401
(410) 974-5300

D.C. Department of Consumer and Regulatory Affairs
Environmental Regulation Administration
2100 Martin Luther King Jr. Avenue, S.E., Suite 203
Washington, D.C. 20020
(202) 645-6617

Pennsylvania Bay Education Office
225 Pine Street
Harrisburg, PA 17101
(717) 236-1006

Virginia Department of Environmental Quality
P.O. Box 10009
Richmond, VA 23240
(804) 762-4440

Alliance for the Chesapeake Bay
Chesapeake Regional Information Service
1-800 662-CRIS

Other Alliance Offices:
6600 York Road, Suite 100
Baltimore, MD 21212
(410) 377-6270

P.O. Box 1981
Richmond, VA 23216
(804) 775-0951

225 Pine Street
Harrisburg, PA 17101
(717) 236-8825

Save Our Streams
258 Scotts Manor Drive
Glen Burnie, MD 21601
(410) 969-0084

Chesapeake Bay Foundation
162 Prince George Street
Annapolis, MD 21401
(410) 268-8816

U.S. Environmental Protection Agency
Chesapeake Bay Program Office
410 Severn Avenue, Suite 109
Annapolis, MD 21403
(410) 267-5700
1-800 YOUR BAY

National Oceanic and Atmospheric Administration
Chesapeake Bay Office
410 Severn Avenue, Suite 107
Annapolis, MD 21403
(410) 267-5660

U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401
(410) 224-2732

The Chesapeake Bay Program – Leading the Restoration

The Chesapeake Bay Program is the unique regional partnership which has been directing and conducting the restoration of Chesapeake Bay since the signing of the historic *1983 Chesapeake Bay Agreement*. The Chesapeake Bay Program partners include the states of Maryland, Pennsylvania, and Virginia; the District of Columbia; the Chesapeake Bay Commission, a tri-state legislative body; the Environmental Protection Agency, representing the federal agencies; and participating advisory groups.

As the largest estuary in the United States and one of the most productive in the world, the Chesapeake was this nation's first estuary targeted for restoration and protection. In the late 1970's scientific and estuarine research on the Bay pinpointed three areas requiring immediate attention: nutrient over-enrichment; dwindling underwater Bay grasses; and toxic pollution. Once the initial research was completed, the Chesapeake Bay Program evolved as the means to restore this exceptionally valuable resource.

Since its inception, the Chesapeake Bay Program's highest priority has been the restoration of the Bay's living resources – its finfish, shellfish and other aquatic life and wildlife. Recent years brought significant progress in the Bay restoration effort. Improvements have been achieved in several areas including habitat restoration, nutrient reduction, and estuarine science. Examples of specific actions initiated by the Chesapeake Bay Program include a watershed-wide phosphate detergent ban, the introduction of agricultural best management practices, biological nutrient removal, and a public education campaign emphasizing the role each of the watershed's 15 million residents play in the restoration.

Considered a national and international model for estuarine research and restoration programs, the Chesapeake Bay Program is still a "work in progress". Since 1983, milestones in the evolution of the Chesapeake Bay Program include the signing of the *1987 Chesapeake Bay Agreement, the 1992 Amendments to the Chesapeake Bay Agreement, and the 1993 and 1994 Directives* by the Chesapeake Executive Council -- the policy-making body of the Chesapeake Bay Program.

In the *1987 Agreement*, the Chesapeake Bay Program partners set a goal to reduce the nutrients nitrogen and phosphorous entering the Bay by 40% by the year 2000. Achieving a 40% nutrient reduction will ultimately improve the oxygen levels in Bay waters and encourage aquatic life to flourish.

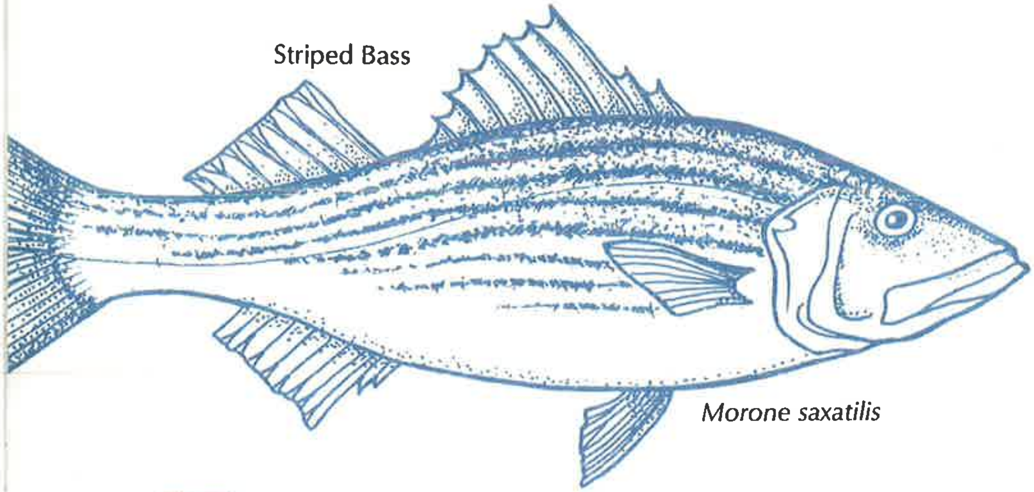
In the *1992 Amendments*, the partners agreed to maintain the 40% goal beyond the year 2000 and attack nutrients at their source – upstream in the Bay's tributaries. In November 1992, the Chesapeake Bay Program established watershed-wide nutrient reduction targets for the Bay's 10 major tributaries. As a result, Pennsylvania, Maryland, Virginia, and the District of Columbia are developing "tributary strategies" to achieve the nutrient reduction targets. The Chesapeake Bay Program also began reevaluating its *Basinwide Toxics Reduction Strategy* in order to better understand the impact toxics have on the Bay's resources.

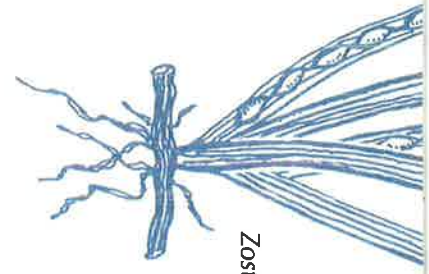
In 1993, the Chesapeake Bay Program partners celebrated a "Decade of Progress" by highlighting the 10th anniversary of the signing of the original Bay Agreement along with some of the restoration successes to date, including an increase in the acreage of underwater Bay grasses, record-setting numbers of young rockfish, and significant reductions of point source pollution. The partners also acknowledged that the Chesapeake Bay Program made a significant transition since 1983, moving from the research phase to the implementation phase.

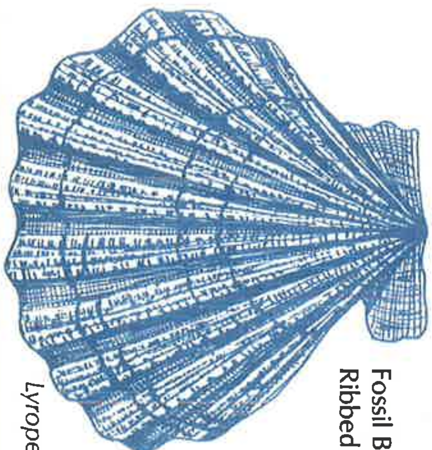
Highlighting the results-oriented emphasis of the Chesapeake Bay Program, the Executive Council guided the restoration effort in 1993 with five directives addressing key areas of the restoration, including the tributaries, toxics, underwater bay grasses, fish passages, and agricultural nonpoint source pollution. Specifically, the Executive Council directed the partners to outline initiatives for nutrient reduction in the Bay's tributaries; revise the *Basinwide Toxics Reduction Strategy* by 1994; develop action plans to address problems related to toxics in specific geographic areas within the watershed; and work with the agricultural community to implement total resource management programs on farms in the watershed.

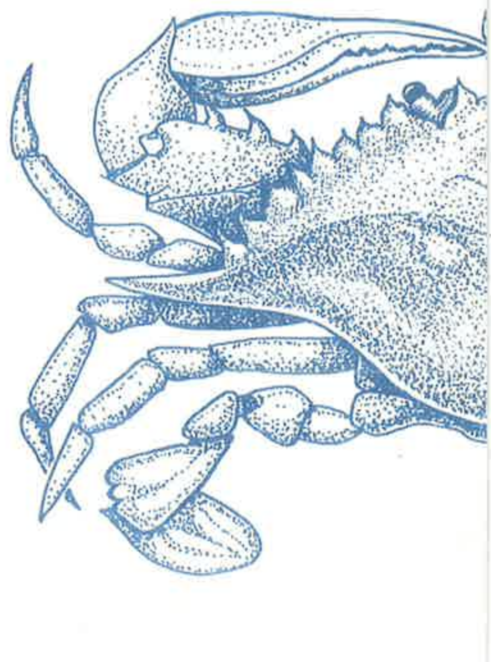
In addition, the Executive Council set an initial goal for recovery of Bay grasses at 114,000 acres by the year 2005; and set five- and 10-year goals for reopening 582 and 1,350 river miles of spawning habitat by the removal of blockages, such as small dams, on the Bay's tributaries which prevent migratory fish from reaching spawning areas.

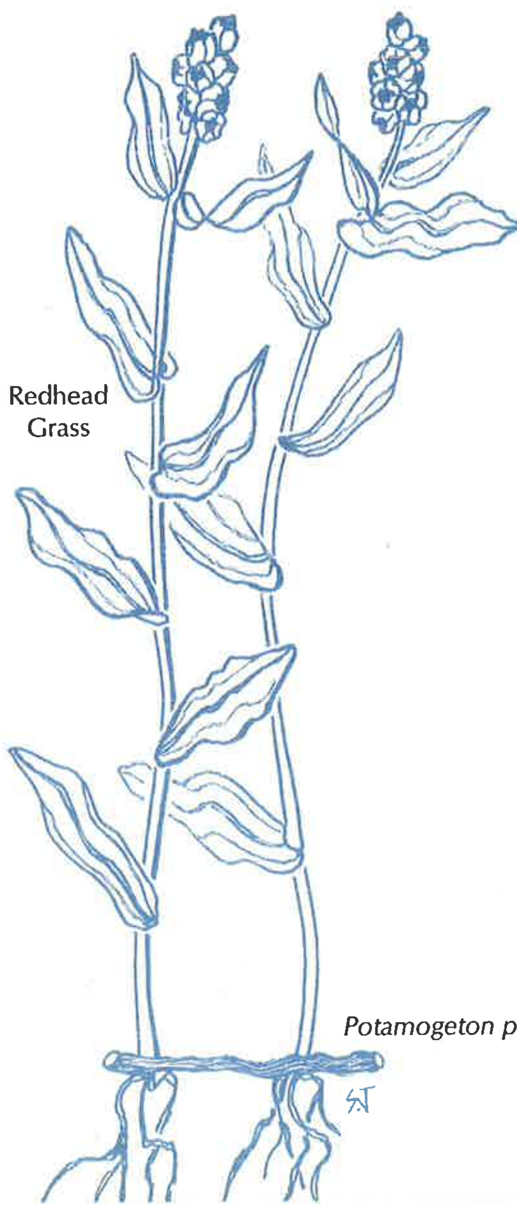
In 1994, the Executive Council called the implementation of the tributary strategies the top priority for the Chesapeake Bay and its tributaries. The Executive Council also adopted the *1994 Chesapeake Bay Basinwide Toxics Reduction and Prevention Strategy*. In addition, the Executive Council issued new initiatives for riparian forest buffers, habitat restoration, and agricultural certification programs.


Striped Bass
Morone saxatilis


Zostera marina


Fossil Broad
Ribbed Scallop
Lyropecten santamaria


Blue Crab


Redhead
Grass
Potamogeton perfoliatus