United States Environmental Protection Agency
CBP/TRS 26/89

April 1989

Bay Barometer Series
April 1987 - March 1989

Chesapeake Bay Program

THE CHESAPEAKE BAY BAROMETER: A REPORT ON THE WATER QUALITY AND ENVIRONMENTAL CHARACTERISTICS OF THE CHESAPEAKE BAY

The Chespeake Bay Barometer is a monthly environmental publication of the federal/state Chesapeake Bay Program (CBP). The Barometer depicts the current water quality of the Bay in terms of water clarity and dissolved oxygen. Additionally, each Bay Barometer highlights a different issue or problem concerning the dynamics or history of the Bay and its surrounding lands.

Initiated by the Monitoring Subcommittee in April 1987 and produced by Computer Sciences Corporation under contract to the Environmental Protection Agency, the Bay Barometer is distributed for publication to 11 newspapers and one magazine in the Bay region as well as numerous citizen newsletters. Several high schools and at least one college use the publication as a source of information for their students. Upon request, other organizations (including law firms, consultants, government offices, conservation groups) and private citizens may receive copies of the Barometer free of charge. Currently, there are over 220 organizations and citizens on the distribution list. Most recipients are in the Bay region; however, the Barometer is distributed to organizations as far away as Wisconsin, Illinois, Rhode Island, South Carolina, Maine, Texas and Washington. Other Estuary Projects have expressed interest in using a similar format for publications on their own areas.

The Chesapeake Bay Program created the Bay Barometer because no other publication was providing Bay water quality information to the public in a timely fashion. The extensive water quality data collected under the auspices of the Monitoring Subcommittee take months to collect, process, analyze, and publish. Using a subset of these data, information on the two most basic water quality characteristics of the Bay now reaches the public through the Barometer only a month after data collection. The graphs of water clarity and dissolved oxygen are the aquatic equivalent of the well-known air quality index.

In addition to the water quality indices, the CBP recognized that there are few scientifically rigorous publications that address issues and problems of the Bay at the layman level. The Bay Barometer, which is reviewed by members of the Bay's scientific community prior to publication, provides up-to-date written and visual information on the Bay at a level the majority of people living in the Bay region can easily understand.

This technical report compiles the first 24 issues of the Bay Barometer. The graphs of dissolved oxygen and water clarity in the Bay provide a look back through time at the seasonal changes in these two variables. The environmental highlights offer a brief view of the character of the Chesapeake Bay as well as the problems which plague it. We will address other issues in the future and from time to time take a new look at old problems.

If you would like to be on the Bay Barometer mailing list or know of a newspaper, magazine or newsletter that would like to publish the Barometer, contact:

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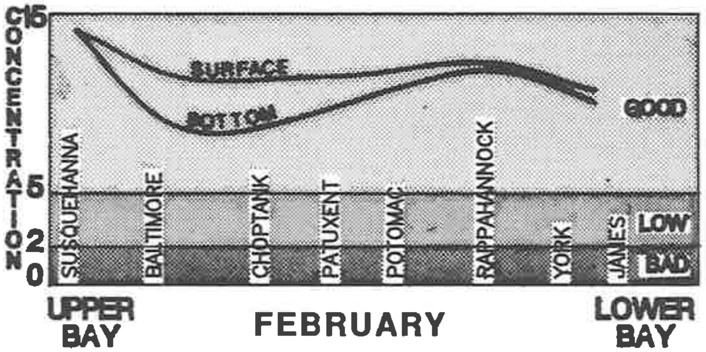
JANUARY 1989 - MARCH 1989

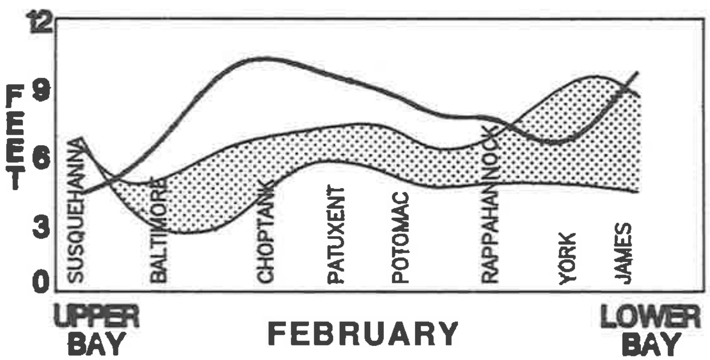
CHESAPEAKE BAY BAROMETER

ENVIRONMENTAL CHARACTERISTICS OF THE BAY



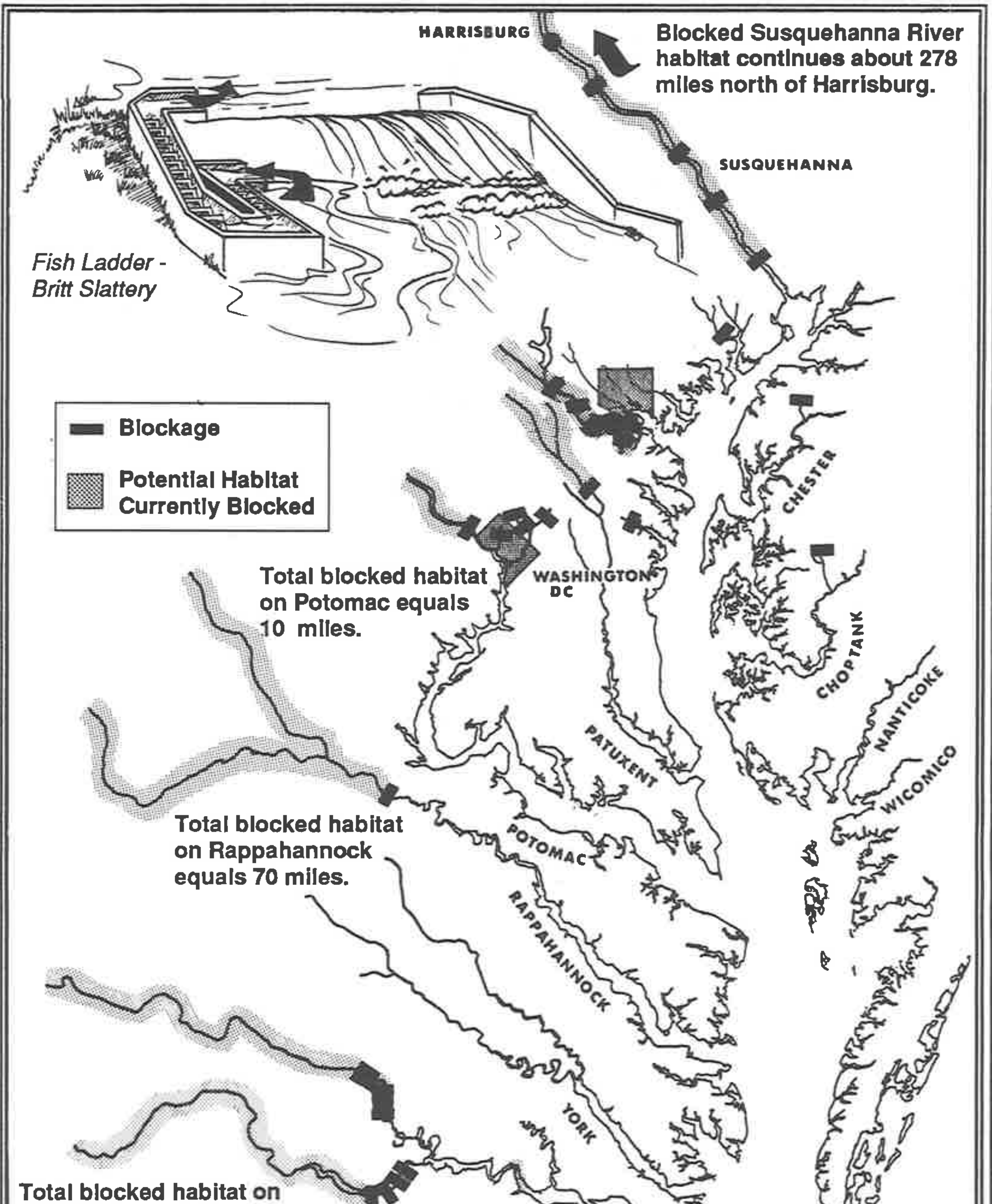
DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. The down-Bay tilt of the DO is consist month after month. It shows that the more saline waters towards the mouth of the Bay cannot hold as much DO as the less saline waters in the northern portion. Overall, the DO for February remained high as expected. As the water begins to warm in March, the DO will slowly start to fall.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspend-



zone for February. Like January, most of the Bay again showed greater than average water clarity in February. Continued low precipitation during the first half of the month kept runoff from the land to a minimum, maintaining the high clarity. With the advent of spring, plankton will soon lower the water clarity.

PRIORITY SITES FOR MIGRATORY FISH PASSAGE

MARCH HIGHLIGHT: CHUTES & LADDERS

As children, most of us remember playing a game called "chutes and ladders" in which the winner was first to reach the designated end of a precarious journey. To migratory fish, the passage through the Bay's tributaries made possible by chutes and ladders has more serious consequences than the outcome of a child's game. For them, the survival of the species greatly depends on their ability to reach native spawning grounds.

Migratory fish, either anadromous or catadromous, need both fresh and salt water to complete the different stages of their life cycle. Each spring, anadromous fish spawn (lay their eggs) in fresh water. The young, born in the upper reaches of the tributaries, swim to the ocean in the fall where they stay for several years before migrating back to their natal rivers. Conversely, catadromous fish spend their lives in fresh water, journeying to the ocean to spawn.

Anadromous fish are well-represented in the Bay. American and hickory shad, striped bass, alewife, blueback herring, and the semi-anadromous yellow and white perch all use freshwater tributaries for spawning. Catadromous species are less common in the Bay, with the American eel being the sole representative of this group.

Both types of fish require unimpeded passage to reach the critical upper tributaries. Yet, hundreds upon hundreds of barriers, both small and large, hamper these fish in their attempted journey. Hydroelectric, water supply and mill dams, road culverts, streamflow gaging stations, and even beaver dams obstruct formerly free-running rivers and streams. Such blockages eliminate hundreds of miles of spawning, nursery and feeding habitat that were once available to the fish.

Man has impounded tributaries to the Bay since colonial times. Early settlers built grist and saw mills in the Bay basin during the 1700s. Canal systems constructed on other rivers, such as the Potomac, facilitated navigation but restricted upriver travel of migratory fish. Later, the industrial revolution provided the impetus to dam rivers and use them as power sources.

Early on, people realized that these impediments were detrimental to the success of migratory fish populations. Primitive attempts to construct fish ladders and routed passageways usually proved futile. Not enough was known about fish preferences and needs to devise a bypass that the fish would use. For example, along with construction of the Holtwood Dam on the Susquehanna River in 1914, the engineers installed a large fish bypass. The bypass never worked and still lies idle today.

Currently, advancements in technology and knowledge have combined to make fish passages successful. There are a variety of bypass options dependent upon the type and height of the obstruction, fish species, slope of the stream and other considerations. Simple measures include notching low dams or demolishing the impoundment. Where dams are still operational, more expensive remedies, such as installation of fish ladders or fish lifts, are the only practical alternatives.

Fish ladders have proved to be highly successful if they are designed and constructed properly. The most effective ladder for Bay fish is known by its designer's last name—Denil. Poised at a slope of 1:8, this metal or wooden chute has a series of baffles which simulate natural, low-velocity rapids. Horizontal rest areas allow the fish some respite before negotiating the next set of baffles. To be successful, the flow of water from the ladder must be sufficiently distinctive to attract the fish away from the dam wall and into its entrance.

Fish lifts become more cost-effective than the ladders in situations where dams exceed about 50' in height. As in fish ladders, a distinctive flow of water draws the fish to the lift. Using a mechanical "crowder," the migrating fish are herded onto an elevator. The elevator lifts the tank of fish level with the top of the dam where they are released back to the river.

With the renewed commitment to restore the Bay, providing fish passages on the Bay tributaries has become a revitalized issue with priority sites now being established. After 15 years of squabbling, the Philadelphia Electric Co. and MD Department of Natural Resources (DNR) recently signed an agreement to provide (among other measures) a permanent fishway at the Conowingo Dam on the Susquehanna. The new facility, used in conjunction with an existing fish lift, will be used to help reestablish the shad population. In the James River at Richmond, crews recently breached both Manchester Dam, built by slaves in 1804, and Brown's Island Dam. The latter dam will also have gates installed. The changes open up 5 miles of spawning habitat with 140 more expected with future passage around 2 upriver dams. The Bloede Dam on the Patapsco River is slated to receive a fish ladder; with assistance from the Chesapeake Bay Foundation (CBF) and DNR, after the historic dam is refurbished.

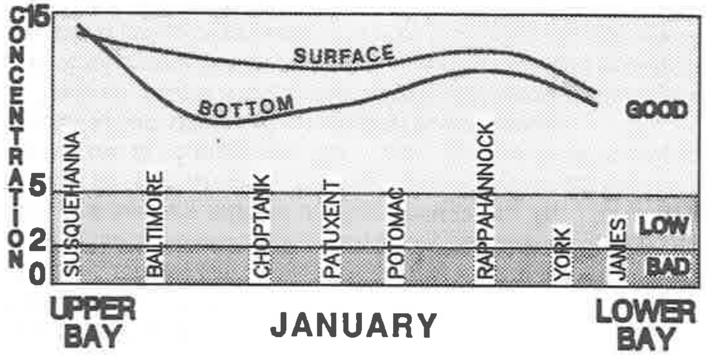
Migratory fish populations have experienced a dizzying plummet from their seemingly infinite numbers of the 1800s. Fish barriers are not fully responsible for the collapse of migratory fish populations. Yet, they are a significant factor. With all the other stresses that fish in the Chesapeake Bay face, we would do well to lessen those burdens for which we have immediate, practical solutions. Ultimately, dollars spent up front to allow these migratory fish access to their rightful spawning grounds will pay us back severalfold in the years to come.

Nina Fisher, Computer Sciences Corporation (3/89)

The Bay Barometer is produced by the EPA and the federal/ state Chesapeake Bay Program. They would like to thank Bill Goldsborough, Chesapeake Bay Foundation, and Janet Norman, U.S. Fish & Wildlife Service, for their assistance.

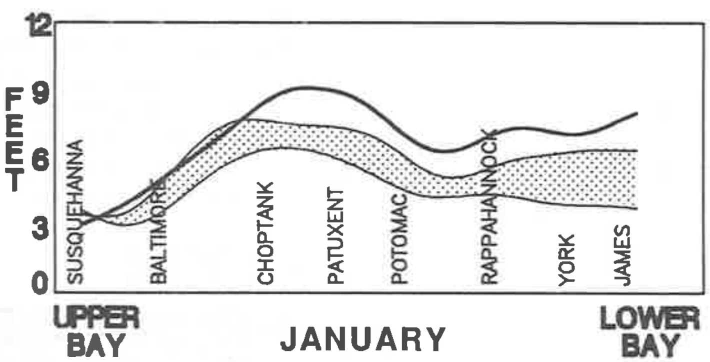
CHESAPEAKE BAY BAROMETER

ENVIRONMENTAL CHARACTERISTICS OF THE BAY



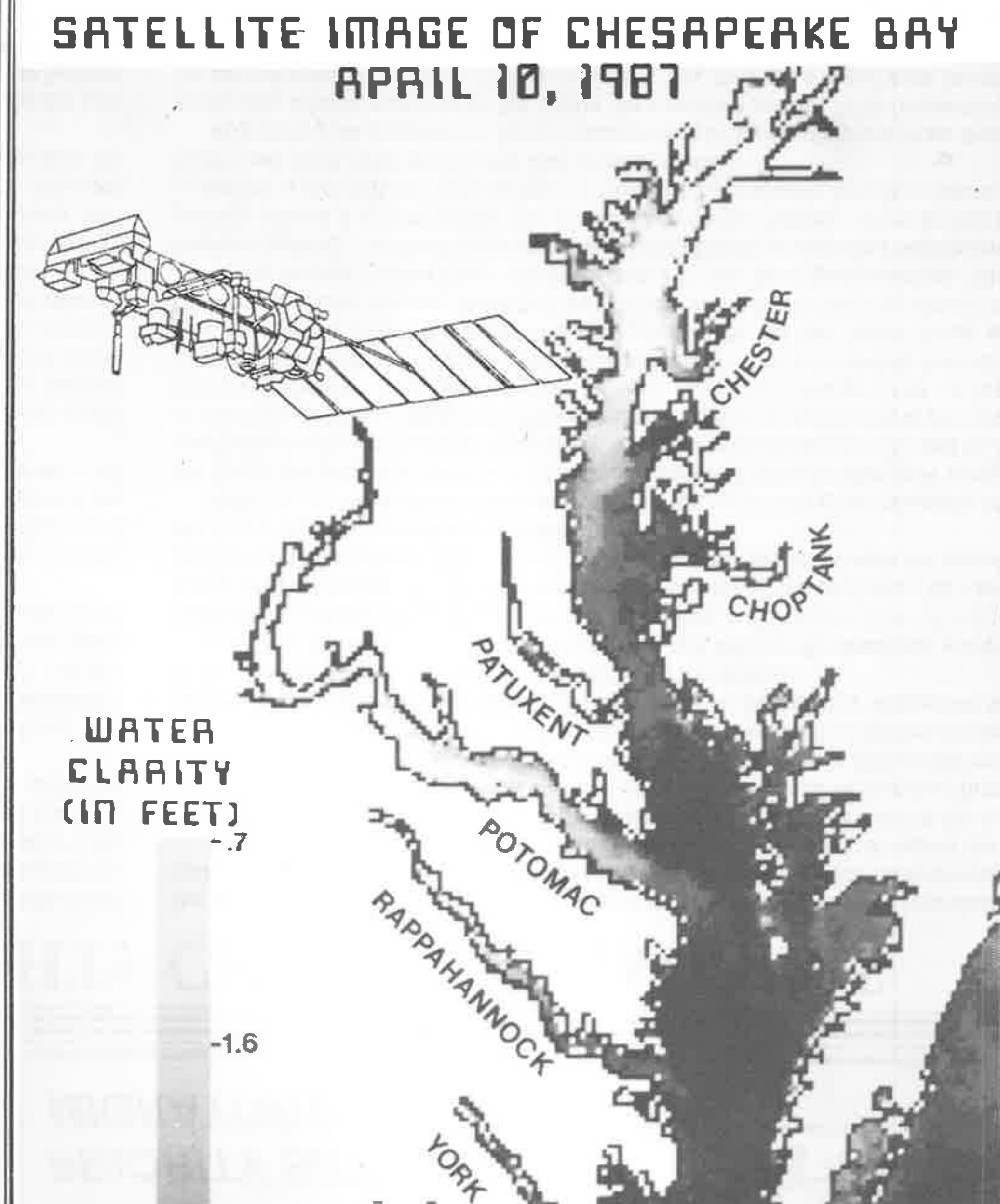
DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. As expected, DO has continued to rise since last month, posting the greatest levels since last winter. Cold temperatures and low biological activity both are factors in causing these high levels of DO. High DO should be sustained through February and into March before the warming temperatures of spring start to force it down once again.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended



zone for January. Almost the entire Bay had greater than average water clarity. This extreme clarity is due likely to the low amount of precipitation during the latter half of the month. With low precipitation, there is minimal runoff from the land. Runoff carries particles of soil which cloud the water, making it less clear.

FEBRUARY HIGHLIGHT: EYES IN THE SKY

Satellites—the very name evokes images of celestial spies peeping at the Russians or maybe Captain Kirk and Dr. Spock photographically zooming in on our planet to take a closer look at their earthling neighbors. Most satellites orbiting the earth perform less exotic, but no less incredible, tasks. While explaining national weather patterns, the evening news routinely posts swirling cloud-filled images of the United States. Intercontinental telephone calls instantaneously traverse the oceans with the aid of a satellite while the Olympics beam live to the U.S. from places as far away as Seoul, Korea.

This high technology is not limited to these modes of communication. Scientists have been quick to seize the technology, molding satellite capabilities to suit their own research interests. Over the past decade, there has been increasing realization that satellites passing over the Bay could be used to gather information on the status and changes of the Bay and the land surrounding it.

The science of gathering information without touching the object being measured is known as remote sensing. Various methods are used to collect this sort of information, including scanning many light frequencies, photography and radar. In the Bay, remote sensing is most often conducted from either earth-orbiting satellites or low-flying airplanes. Spectrometers on the satellite or plane record the different frequencies of light reflected from the ground or water.

Characteristics such as land use, type and abundance of vegetation, wetland distribution, shoreline erosion, amount of suspended material and chlorophyll in the water, circulation patterns, extent of ice and other variables are routinely measured from well above the earth. The satellite information transmits to a receiving station and feeds into a computer. Using mathematical estimations, the data are converted into images which may be enhanced to show a wide range of characteristics of the land or water. Two satellite sensors useful for environmental measures, Landsat and a French sensor known as SPOT, pass over the Bay. They provide only a couple of images per month, however, which is insufficient to characterize short-lived events in the Bay. Onboard a National Oceanic and Atmospheric Administration (NOAA) satellite another sensor, known technically as the Advanced Very High Resolution Radiometer (AVHRR), passes over the Bay every day. Scientists have been using it to gather information on rapidly changing variables such as the temperature of the surface water, occurrence of algal blooms, and turbidity of Bay and tributary waters.

The Barometer map this month displays one such image from April 10, 1987 captured by the AVHRR sensor. The photograph shows the Bay area just after the year's greatest flow of freshwater (the spring runoff) in the Susquehanna and Potomac rivers. Runoff generally carries large amounts of suspended sediment making the receiving waters turbid. The whiter the water appears in the photograph, the more turbid and less clear it is. Sediment flowing from the Susquehanna has clouded Bay water well south of Annapolis. Alternately, the darker water has good clarity—close to 10 feet. The central channel of the lower Bay, along with the offshore coastal area, show the clearest waters.

Aerial photographs focus on a smaller area, in greater detail, than satellite images. They are ideally suited to provide details concerning land use, wetland destruction, vegetation growth and other information which can only be collected with high resolution photographs. These photographs have been used extensively in the past decade to document changes in the distribution and abundance of submerged aquatic vegetation (SAV) in the Bay, providing critical information to determine if the Bay is regaining its health.

Satellite images and aerial photographs are ideal complements to the data that scientists routinely collect on the ground or water. These pictures provide information that cannot be obtained by directly sampling the environment. Most important, all the information on a single image or photograph is collected simultaneously. The Bay is a very dynamic and variable environment. Taking samples to analyze water quality along the entire Bay requires several days; no matter how conscientious the scientist, variations due solely to changes over time are inevitable. Another significant advantage of satellite remote sensing is that the satellite passes over the Bay so frequently that it may be able to capture special events (such as storms) missed by the ship crews and record information on areas not sampled at all by these crews.

Yet, remote sensing is not a panacea. Periodic shipboard measurements are still necessary to verify the information received by satellite or plane. Clouds and haze play havoc with the collection of data. If a cloud cover settles in for several days or the air is hazy, the images captured by the satellites may be worthless. With either satellite or plane, the data sent back give information only about the surface layer of the Bay. Remote sensing may never fully replace the complete depth coverage of standard shipboard sampling.

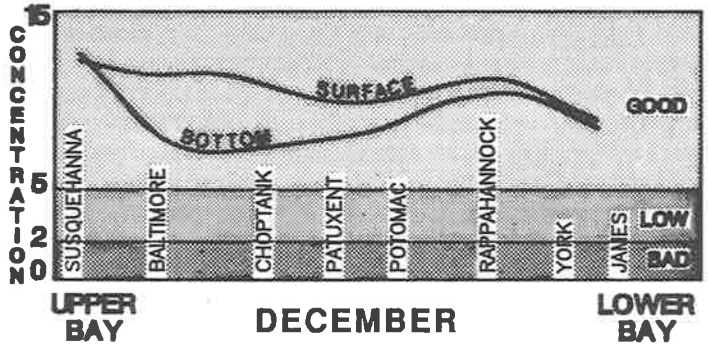
Scientists and managers are using remotely sensed information along with more traditional means of data collection to characterize the Bay and chart its recovery. Programs like NOAA's Coastwatch, which track events of immediate environmental concern such as the red tide, are already using remote sensing as an integral part of their programs. With remote sensing as another tool, we see a more complete vision of the Bay—looking down from high in the sky.

Nina Fisher - Computer Sciences Corporation (2/89)

The Bay Barometer is produced by the EPA and the federal/ state Chesapeake Bay Program. They would like to thank Dr. Richard Stumpf, NOAA, and Dr. Vic Klemas, U. of Delaware, for their assistance.

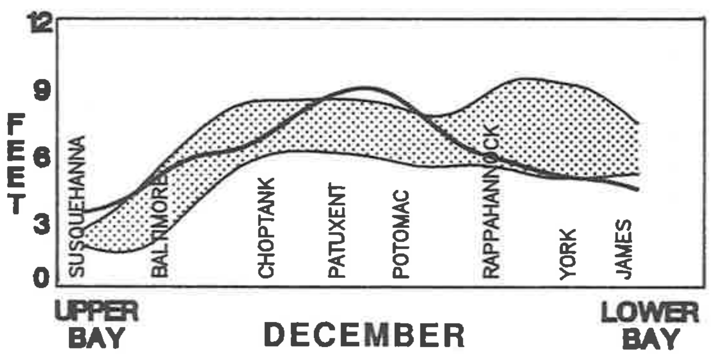
CHESAPEAKE BAY BAROMETER

ENVIRONMENTAL CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

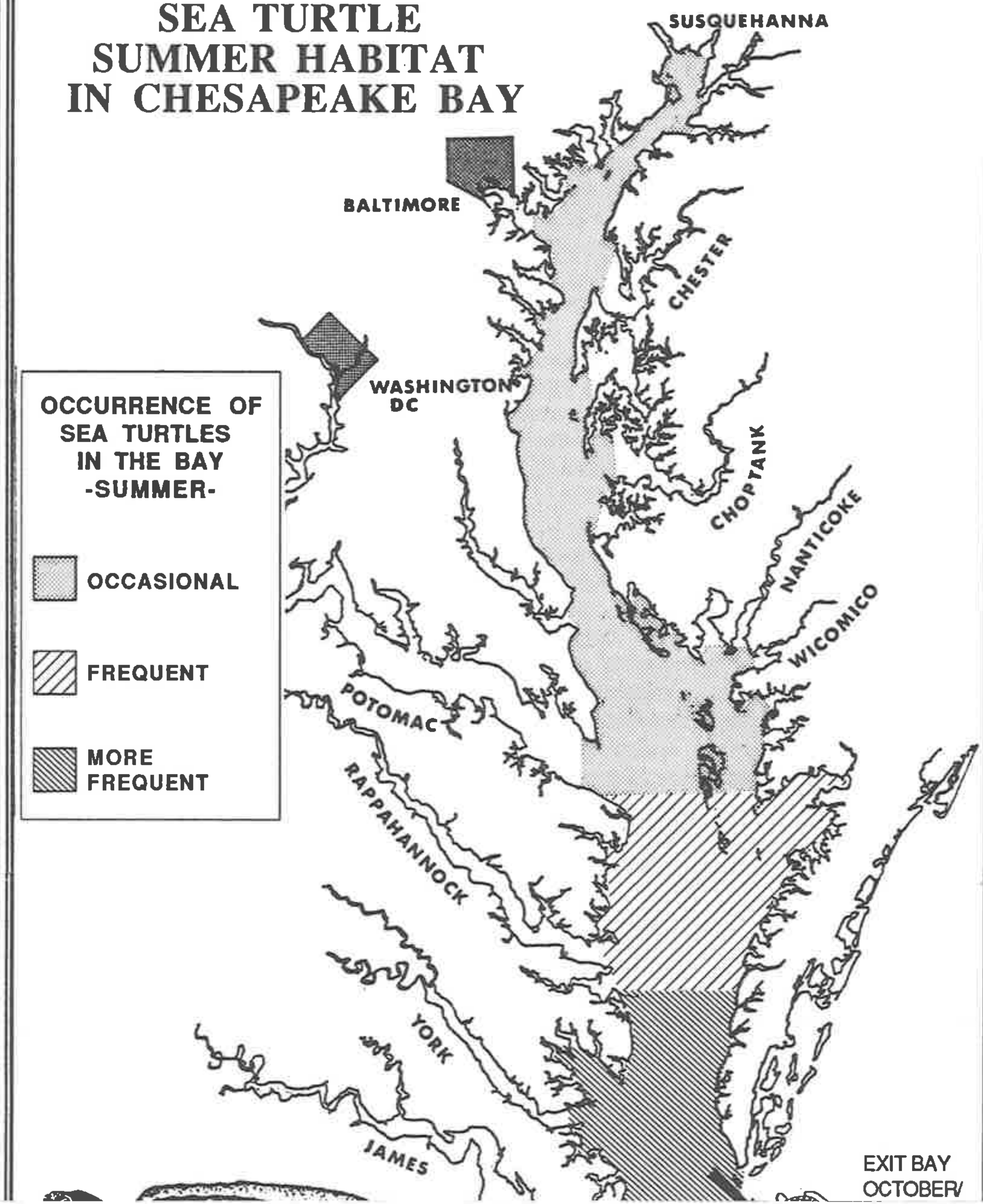
Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. Although the amount of DO in the bottom water of the Bay during December has increased substantially since mid-autumn, it is still lower throughout much of the Bay compared to last year. The DO has improved only slightly since last month. However, the amount of DO in the water should continue to increase well into the winter.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

SEA TURTLE SUMMER HABITAT IN CHESAPEAKE BAY



zone for December. While the extreme upper and middle portions of the Bay had slightly greater water clarity compared to the norm, the lower Bay was on the poor side of normal. Sediment delivered to the upper Bay may have been slowed by ice on the tributaries. Ocean mixing may account for the poor clarity in the lower Bay.

LEATHERBACK TURTLE
DRAWING COURTESY OF
VA SEA GRANT PROGRAM

JANUARY HIGHLIGHT: SEA TURTLES

For many of us, the earliest recollection of a turtle is the tiny, green, pet shop variety which swam lethargically around a water-filled tray complete with plastic palm tree and island. The first glimpse of a giant sea turtle, then, may catch us off-guard. These primeval, beaked creatures can weigh over 1500 pounds and seem to bear little resemblance to the small, green turtles of our childhood.

Of the seven sea turtle species found throughout the world, four appear seasonally in the Chesapeake Bay. The loggerhead turtle, named for its log-like head, is the most numerous of the Bay turtles and accounts for close to 90% of the summer sea turtle population. Between 2,000 and 10,000 young loggerheads visit the Bay each summer. The loggerhead is the largest hardshell sea turtle and may weigh over 500 pounds. A significant portion of the world's most endangered sea turtle, the Kemp's ridley, also summers in the Chesapeake.

On occasion, leatherbacks and green turtles find their way into the Bay, but never in any great number. The leatherback may top 2000 pounds--hard to believe considering the main ingredient in its diet is jellyfish. The green, a medium-sized turtle, was named not for the color of its shell but for its characteristic green fat.

Sea turtles are truly prehistoric; about 150 million years ago, they settled into an evolutionary form that has remained essentially unchanged since this time. These turtles are reptiles--air-breathing, cold-blooded animals which reproduce by internal fertilization. Although some reptiles produce live young, sea turtles lay their eggs on land.

Egg-laying is the only time Atlantic sea turtles come onshore; their legs and shells are adapted to an aquatic existence. Their shells are streamlined while their legs are flipper-like and designed for rapid swimming. The amount of time spent on a dive varies with water temperature; if the water is cold, the turtle minimizes its metabolic activity and may remain underwater for hours.

Sea turtles mate while floating at the ocean's surface. To secure a grip on the female, the male hooks his flipper claws under the shell at her shoulder, often leaving her scratched and bleeding from the encounter. When an Atlantic female is ready to nest, she clambers high onto a suitable sand beach, usually in Georgia or Florida, digs a hole and lays up to 100 eggs. As she strains with the effort, apparent tears flow from a gland near her eyes. Lore has it that she cries knowing the perils her children face; in actuality, she is secreting excess salt from her body. With the eggs laid, she fills in the hole and drags herself back to the sea, leaving the eggs to incubate in the sand.

About 2 months later, the young turtles peck their way out of the leathery shells. After most eggs have hatched, the young turtles simultaneously emerge at night; their trek down to the sea and beyond is often a hazardous one with predators poised to take advantage of this bounty of food. Only a tiny fraction of those hatched (.1-1%) will survive to adulthood.

At the end of each spring, many sea turtles (especially juveniles) which have overwintered in the tropics and subtropics move north along the Atlantic coast. While leatherbacks generally continue north past the Chesapeake Bay, the loggerheads and some Kemp's ridleys veer into the Bay as water temperatures warm to about 68°F.

The Bay, with its rich food supply and extensive shoals, provides ideal habitat for the development of these young animals. Although occasionally sighted in Maryland waters, most turtles remain in the Virginia portion of the Bay where salinities are higher. Loggerheads eat a variety of foods including horseshoe crabs, jellyfish and mollusks. They concentrate their feeding around river mouths and areas of the Bay deeper than 13 feet. Kemp's ridleys inhabit the shallower areas, grazing in the flats and feeding on blue crabs amidst the eelgrass beds. The turtles remain in the Bay for the summer and early fall, leaving only when the first major northeasterly storm of the season drives water temperatures down.

All sea turtles are on the "endangered" or "threatened" species lists. Years of exploiting these turtles for their meat, shells and eggs has taken a devastating toll on their population numbers. It is now illegal to harm sea turtles or even to collect the shells of dead turtles. Despite this protection, natural predation from sharks and other animals, along with injury and death from boat propellors, accidental capture in the leader portions of pound nets, intentional injury, capture by shrimp trawlers, destruction of nesting sites, and ingestion of plastic refuse continue to pose risks to the turtles.

Bay scientists are researching the behavior, migration and other habits of sea turtles to provide a better understanding of these creatures and how they may be saved from extinction. Using small airplanes, the Virginia Institute of Marine Science (VIMS) records the distribution and migration of sea turtles. Metal tagging of healthy turtles also reveals migratory movements. Results of the early research indicated that transplant of eggs from southern U.S. beaches to Virginia was most likely futile and possibly detrimental to loggerhead populations.

VIMS is also conducting a stranding program. Anyone who encounters a dead or sick turtle should report it to the SEA TURTLES project at (804) 642-7313. Information from this program is used to determine causes of death in the sea turtle. Ultimately, this information will assist in making wise management decisions to preserve this ancient, magnificent animal.

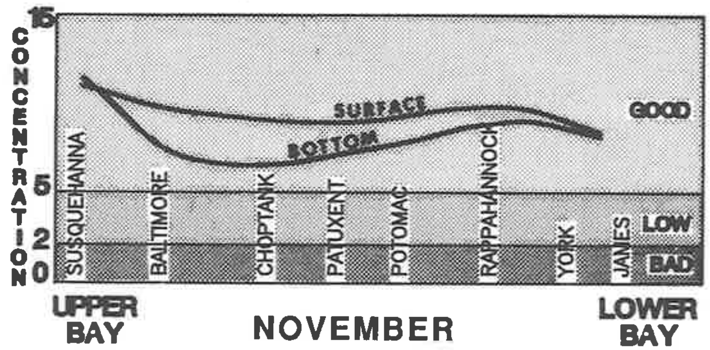
Nina Fisher - Computer Sciences Corporation

The Bay Barometer is produced by the EPA and the federal/ state Chesapeake Bay Program. They would like to thank Jack Musick and John Keinath, VIMS, and Stephen Morreale, Okeanos, for their assistance.

JANUARY 1988 - DECEMBER 1988

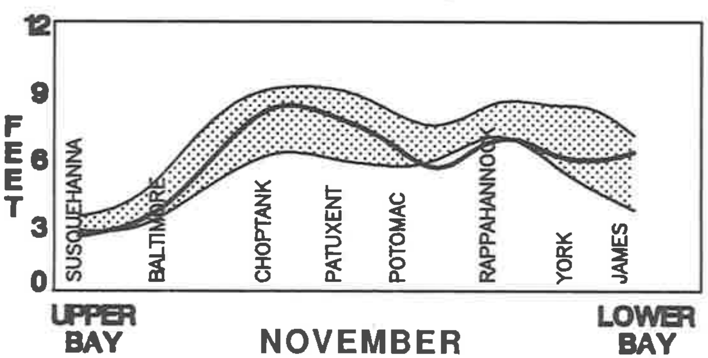
CHESAPEAKE BAY BAROMETER

ENVIRONMENTAL CHARACTERISTICS OF THE BAY



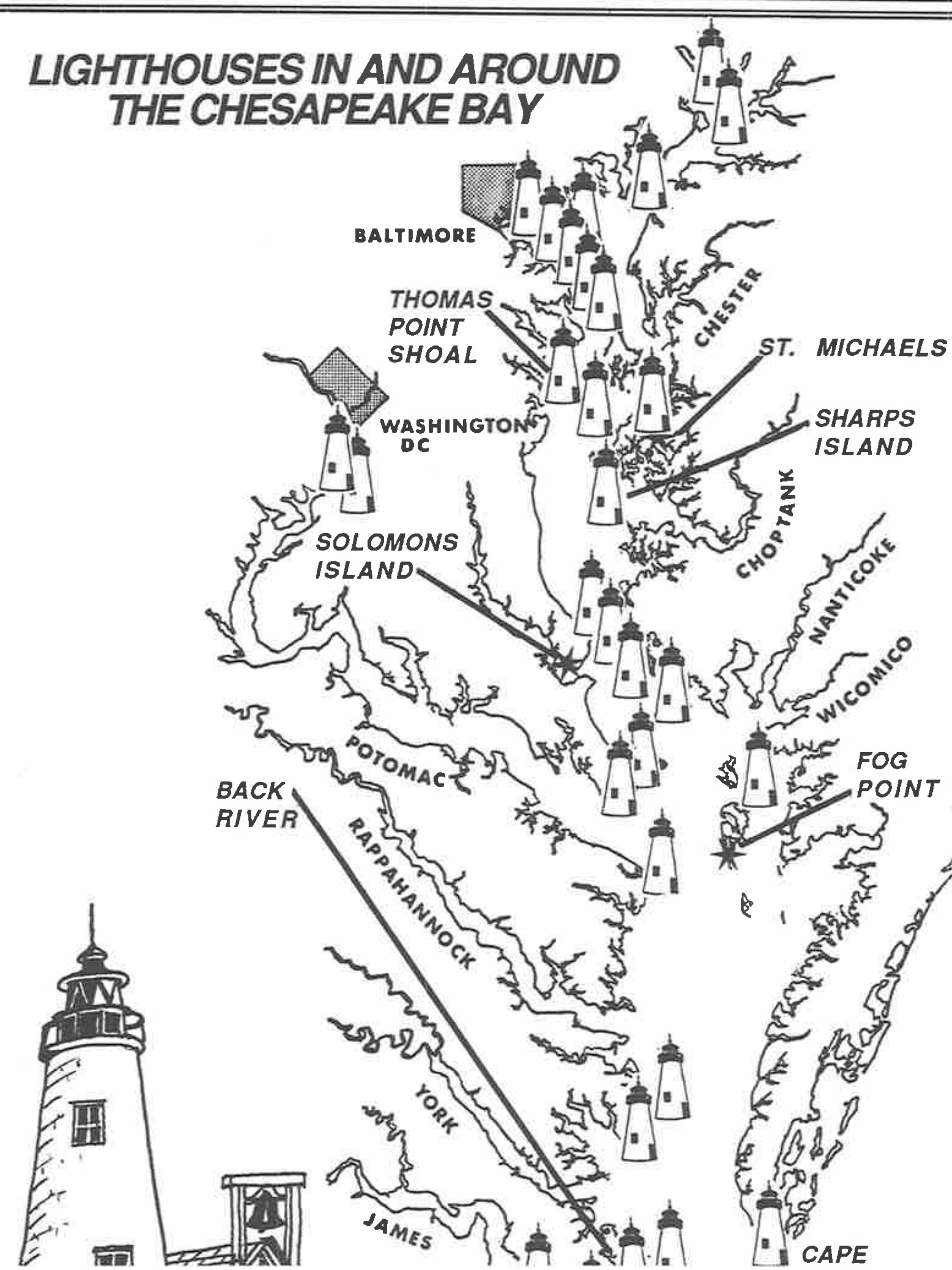
DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. The amount of DO in the bottom water of the Bay has increased dramatically since last month when it was still in the BAD zone. Neither bottom or surface water DO are quite as high as last year at this time. Since cold water can hold more DO, the decresing temperatures of the approaching winter means higher DO levels.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material, including fine sediment and microscopic organisms



about average. Just south of the mouth of the Potomac the clarity drops below normal, possibly due to stormwater runoff. With the progression of autumn, clarity has been generally increasing as the water cools and biological productivity slows.

DECEMBER HIGHLIGHT: THE LIGHTHOUSE

Those flashing beacons of light--the lighthouses of the world--have been saviors to countless generations of mariners. Marking hazardous shoals, projections of land, and entrances to safe harbors, lighthouses have saved innumerable boats from piling onto rocks or foundering on sand bars.

The Chesapeake has not always been well marked; the history of lighthouses in the Bay is brief in comparison with their history elsewhere in the seafaring world. The first known lighthouse in the world, the tower at Pharos, was constructed about 300 BC by the Egyptians. The 450 foot structure, built by a people known for their architectural feats, lasted almost 1500 years before succumbing to earthquake tremors. In 1716, Boston Light, which marked Boston Harbor, became the first lighthouse of the young colonies of North America.

Efforts to mark Chesapeake Bay navigation hazards soon followed the construction of Boston Light. The governor of Virginia, Alexander Spotswood, lobbied for a light at Cape Henry to guide mariners through the entrance of the Bay, without success. The rally to build a lighthouse was picked up by a subsequent governor, but he died without seeing its construction. In 1773, just before the Revolutionary War, an appointed group of men went to Cape Henry "consuming an appropriate amount of liquor and actually selecting a site for the lighthouse." But, once again, numerous logistic and construction problems delayed its completion until 1792.

After 1800, construction of Bay lighthouses took place at a greatly accelerated pace. Twenty-one lighthouses were built in the first half of the 19th century with an additional 49 constructed in the second half of that century. No single architectural style predominated. Although generally simple in construction, all types of material were used for the production of both land- and water-based lighthouses. Many of the lighthouses on dry land had keepers' homes attached.

Two major types of offshore lighthouses mark the Bay: the screwpile and the caisson. In sandy or muddy offshore areas, the broad screwpile base with deep screw-like metal pilings provided a reasonably stable yet inexpensive means of securing the lighthouse. Sea ice poses the greatest hazard to these structures. In areas where conditions were too severe for the screwpile, the more expensive caisson lighthouses, with deeply entrenched central tubes, replaced them.

While relatively few changes took place in lighthouse construction, lights used to illuminate these structures evolved dramatically. Early in lighthouse history, wood fires were kept blazing at the top of the tower. Sustaining the fire kept the lighthouse keeper running; by the 16th century, keepers began using coal, candles and lamps with fish or whale oil as alternatives. In the early 1800s, Captain Winslow Lewis patented a lamp with a parabolic reflector adapted from a Swiss design and installed them in all of the nation's lighthouses.

Soon after, a French physicist named Augustin Fresnel developed a lens so revolutionary that it is still in use today. Shaped like a massive gleaming crystal beehive, prisms at the bottom and top refract the light emanating from the single lamp or bulb in the middle. The refracted light is intensified by the magnifier at the center of the lens. Fresnel devised seven sizes or orders of lens with the first order (almost 8 feet in height) being the most powerful and used to light sea coasts. Only capes Charles and Henry at the mouth of the Bay have 1st order lenses; the Cape Henry light can be seen up to 22 miles away. The majority of Bay lighthouses are outfitted with less powerful 5th order lenses.

One might envision life as a lighthouse keeper as a rather carefree existence. Yet, the maintenance of these structures usually required daily upkeep. At times life was tediously boring; occasionally, frightening storms which lashed the lighthouse punctuated the routine. Over the years, many lighthouses have succumbed to the rough treatment dished out by the Bay. The winter of 1977 was extremely cold. Heavy ice formed in many areas of the Bay. As the ice near the Sharps Island lighthouse shifted with movement of the currents, it pushed into the already skewed structure, causing it to tilt almost 30°.

Over time, more insidious processes also take their toll on the lighthouses. Storm waves attack the base, causing erosion of the substrate to which the lighthouse is anchored. Water infiltrating cracks in the building freezes and thaws, eventually damaging the exterior. Salt water corrodes the metals used in the foundation. Lighthouses such as the ones at Back River and Fog Point were completed destroyed by a combination of these processes.

At one time, 74 lighthouses stood in and around the Chesapeake Bay. Only 32 now exist in relatively good condition. Over recent years, historic preservation organizations have taken interest in protecting these relics of the Bay's past. Calvert Marine Museum in Solomons, MD had the screwpile lighthouse at Drum Point moved from its original site to the museum grounds where it was renovated. The Chesapeake Bay Maritime Museum in St. Michaels, MD and the city of Baltimore also have moved and preserved lighthouses.

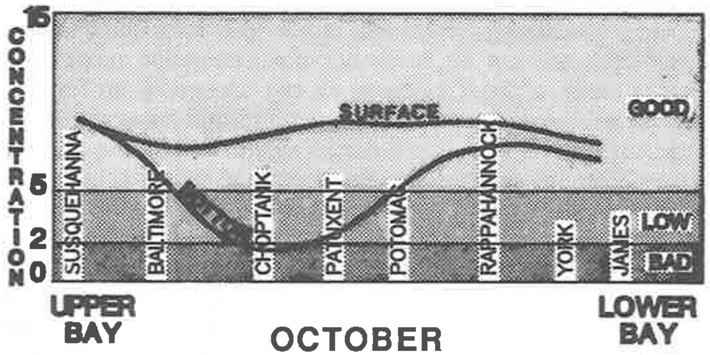
The Coast Guard has held the authority for maintenance of lighthouses since 1939. Since then, it has taken on the task of upgrading lighthouse stations to automatic operation. The last two manned stations in the Bay, Cove Point and Thomas Point Shoal, were automated only a few years ago. Those days when keepers called their lighthouse "home" are now relegated to Chesapeake Bay lore.

Nina Fisher - Computer Sciences Corporation

The Bay Barometer is produced by the EPA and the federal/ state Chesapeake Bay Program. They would like to thank Robert de Gast, author of "Lighthouses on the Chesapeake Bay," for his assistance and data.

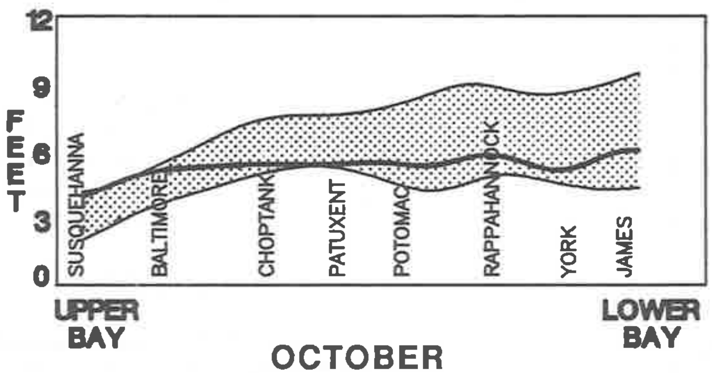
CHESAPEAKE BAY BAROMETER

ENVIRONMENTAL CHARACTERISTICS OF THE BAY



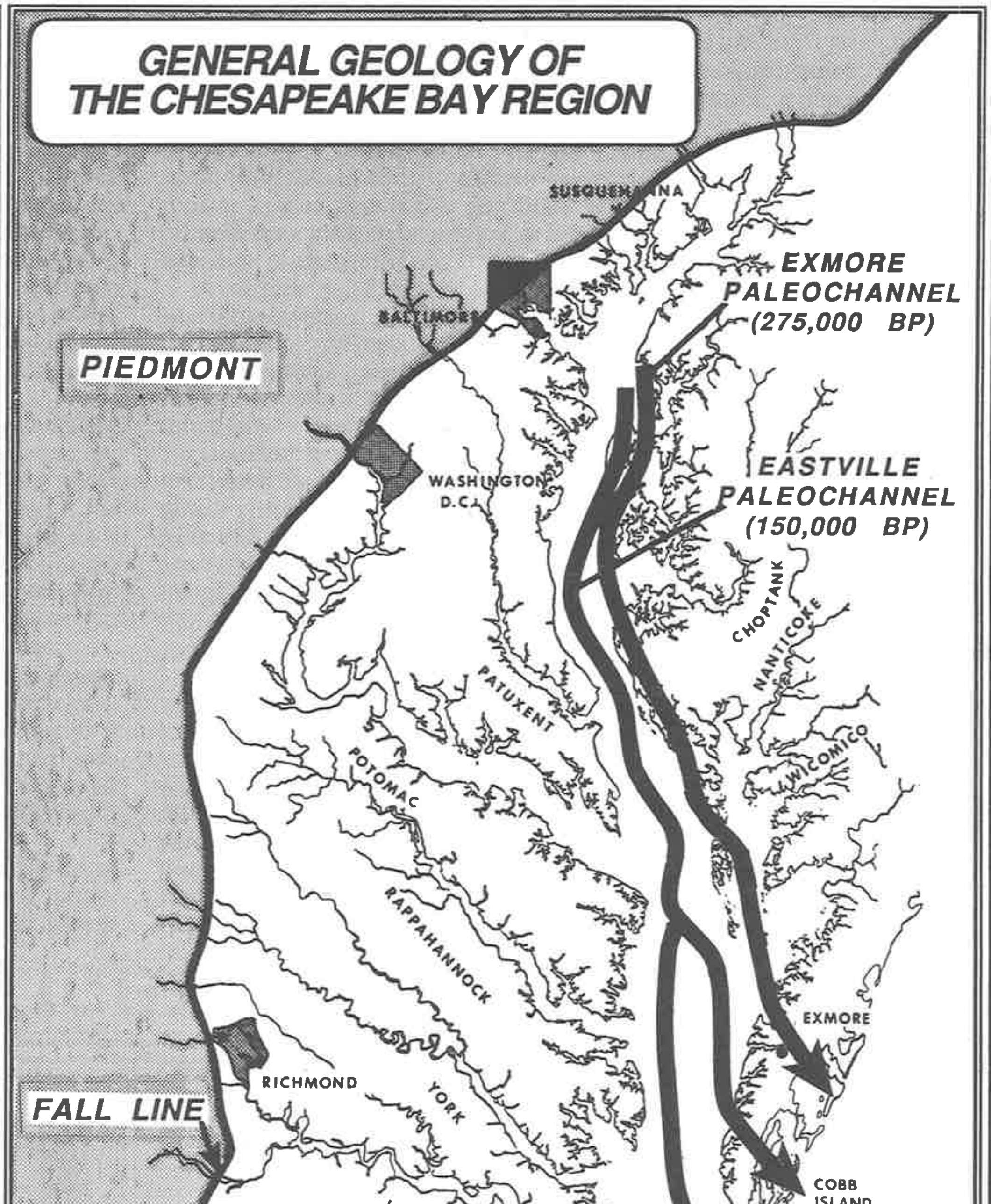
DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. Bottom water DO has increased since September but is still hovering in the BAD zone. Compared to last year at this time, the bottom DO is much poorer in the main Bay off of the Choptank River. Last year, bottom DO in this area was well out of the BAD zone by this time. Surface water DO is about the same as it was in September.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended



zone for October. Water clarity for the Bay fell into the low side of the average zone. Unlike many water clarity profiles of the Bay, there was no increase of clarity near the mouth where clearer ocean water mixes into the Bay. As autumn progresses, clarity is increasing as the water cools and biological productivity slows.

NOVEMBER HIGHLIGHT: BAY AREA GEOLOGY

Imagine standing near Suffolk, Virginia about 125,000 years ago. A strange noise greets you . . . ocean waves breaking at your feet. The mouth of the Bay is far to the northeast, somewhere in the vicinity of Cobb Island. With warmer climates worldwide, sea level is 30-35 feet higher than the 1980s.

Now shift forward in time to 18,000 years ago. Imagine planning a vacation in Virginia Beach. Upon arrival, you discover that neither the beach nor the ocean are anywhere in sight. The Chesapeake Bay does not exist. In its place, a large river only a few miles wide makes its way towards the ocean. The ocean shoreline is 65 miles further east and sea level is about 300 feet lower than the 1980s.

These swings of sea level, called transgressions and regressions, are a commonplace geologic occurrence having taken place many times since the Bay's rudimentary beginnings about 15-18 million years ago. Geologists talk casually of millions of years in the geologic time scale as if they were mere seconds. And, in a sense, they are. The earth is 4.8 billion years old; a few million years hardly register on such a scale.

From the geologic perspective, then, the Bay is an extremely dynamic place. The dramatic changes in sea level have dictated the geologic history of the Bay region. The regional setting for the Bay really began prior to 200 million years ago when the European and African continents collided with North America, shoving up the Appalachians. As the continental plates pulled apart, large cracks opened in the land and huge valleys formed. Eventually, the sea flooded these valleys, creating the embryonic Atlantic Ocean while sediments shedding from the Appalachians began filling in the valleys. These episodes of geologic activity created the rocks that form the spine of North America's east coast.

It wasn't until about 25 million years ago though, that the coastal plain started forming. The coastal plain, upon which the Bay sits, is bounded inland by a geologic feature known as the fall line. This line marks the junction of the harder, crystalline Piedmont rocks with the softer sedimentary rocks of the coastal plain. The fall line is best represented along rivers in areas such as Great Falls outside of Washington DC where waterfalls precisely define the boundary.

During the past 25 million years, the sea repeatedly flooded and withdrew from the land. With each transgression, layers of fossil-rich marine sands and silts were deposited forming rocks known as the Chesapeake Group. In 1658, the first fossil to be described in North America was found in these rocks which also play host to *Ecphora*, the Maryland state fossil. Included in the Chesapeake Group is the famous Calvert Formation, known worldwide for its embedded shells, sharks teeth and whale bones. During periods when the sea regressed, erosion took place, stripping layers of rock from the land surface. This period of sedimentation and erosion continued fitfully until about 2 million years ago.

At the beginning of the Pleistocene epoch, 1.8 million years ago, the Bay area underwent an acceleration of shifts in sea level in response to global climatic change. With the growth of large continental ice sheets or glaciers over much of the northern hemisphere, worldwide sea level dropped several hundred feet. Melt of these ice sheets released water back to the oceans, causing rises that equalled or surpassed current sea level. When sea level was low in the early part of the Pleistocene, the southern part of the land mass known as the Eastern Shore did not exist. The Susquehanna River reached far to the south carving deep channels across the future Eastern Shore, near Exmore, Virginia.

Continental glaciers advanced and retreated several times during the Pleistocene. Each time the glaciers advanced, sea level dropped, and the Susquehanna extended southeast over the former continental shelf, carving a new channel. With retreat of the glaciers, sea level rose and the channel filled with sediment. Sediments continued to accumulate on the east side of the ancient Bay forming the lower Eastern Shore. Scientists know that this sequence of events occurred at least three times because they have found evidence of three relict channels tracking the course of the ancient Susquehanna underneath today's Bay.

With the initial decline of the last major period of glaciation about 18,000 years ago, sea level rose and the present day Bay slowly took form. At first, flooding occurred at the relatively fast rate of 3.3 feet/century then slowed to .6 feet/century. By about 3500 years ago, the Bay probably looked much the same as it does today although sea level continues to rise.

The rocks resulting from broad sweeps of the sea over geologic time are of more than scholarly interest: the geology often translates into substantial economic concerns. As early as 1608, John Smith, realizing the potential benefits of local geology, collected barrels of iron ore and sent them off to England for inspection. Production of iron began soon after. Quarries in the Bay area have supplied a variety of attractive stones for building. In Cabin John, near Washington DC, quarrying of marble began in 1850, providing the nation's capitol with many of its buildings' foundations and curbstones. Sand and gravel, taken predominantly from the coastal plain, form the base of many of the area's roads.

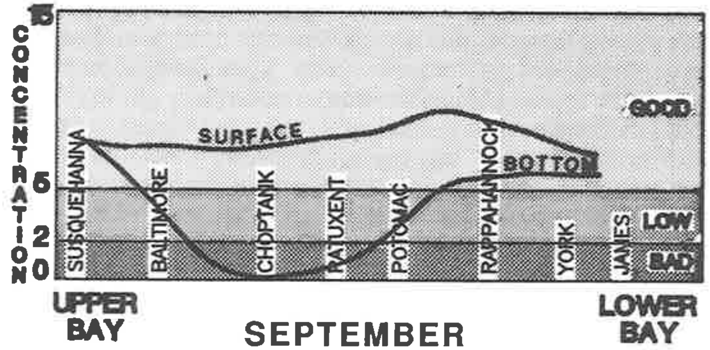
By removing the Bay from the usual framework of time and considering it in geologic time, our perspective invariably changes. Instead of a Bay that has always been here and always will, we have a Bay that is transient and ephemeral. In the end, the geology only reinforces the fragility of our Bay.

Nina Fisher - Computer Sciences Corporation

The Bay Barometer is produced by the EPA and the federal/ state Chesapeake Bay Program. They would like to thank Randy Kerhin and Jeff Halka, Maryland Geological Survey, for their assistance.

CHESAPEAKE BAY BAROMETER

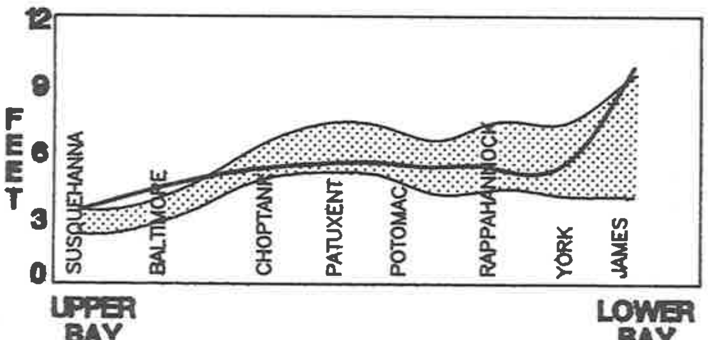
WATER QUALITY CHARACTERISTICS OF THE BAY



SEPTEMBER

DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. DO has finally begun to increase for the first time since last May. However, it remains anoxic (no DO) in the main Bay off the Choptank River and is poorer than this time last year. As the weather cools, the chilling Bay water can hold increasingly more oxygen. Next month will likely show DO levels out of the BAD category.

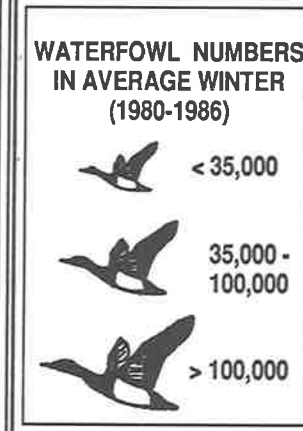


SEPTEMBER

WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

MIGRATORY WATERFOWL WINTERING ON THE BAY



zone for September. September's water clarity is fairly similar to that seen in August with a single exception--near the mouth of the Bay, the clarity veers sharply upward. This increased clarity may be due to temporary increased mixing of Bay water with the clearer ocean water.

OCTOBER HIGHLIGHT: WATERFOWL OF THE BAY

Like Interstate 95 routing humans in their migration to New England summers and Florida winters, the Atlantic flyway channels waterfowl traffic on these birds' annual migration. Strategically located along this flyway, the Chesapeake Bay has historically been a favorite winter residence and stopover point for many species of waterfowl that have moved south from their summer breeding grounds. The shallow waters, coves, rivers, tributaries and wetlands associated with the Bay as well as the temperate climate combine to produce a tremendously rich and diverse environment in which waterfowl thrive.

The name "waterfowl" seems somewhat awkward for a group of birds that epitomize strength and beauty. Four types of birds fit into this group: dabbling ducks, diving ducks, geese and swans. All have the characteristic webbed feet, short legs, and generally wide flattened bills. They migrate seasonally depending primarily upon wetland areas for survival.

Each group has particular adaptations which tailor the bird for specialized behavior. The diving ducks, such as canvasbacks and redheads, have legs situated far back on their bodies, allowing them to dive deep in the water in search of food. The leg position, while making them good divers, also makes them extremely awkward and somewhat comical on land.

The dabblers' legs are positioned in the middle of their bodies. These ducks, including mallards and black ducks, walk well but would hardly win Olympic medals for their diving abilities. To compensate, they feed in shallow water, tipping their rumps skyward as they scan the bottom for bits of food. Unlike the diving ducks which must get something akin to a running start to become airborne from the water, the dabblers can spring into flight with a single leap.

The stately Canada goose is the most abundant of all waterfowl wintering around the Bay. The goose family is also represented by the snow goose and brant. All of these geese have specialized jaws for ripping the vegetation on which they feed. With the Baywide decline of aquatic vegetation, the Canada and snow geese now rely heavily upon grain left in agricultural fields for feed.

Swans represent only a small percentage of all waterfowl on the Bay. Of the two Bay species, the tundra swan is more prevalent than the introduced mute swan. Like the geese, both types of swans feed primarily on submerged vegetation, bowing their heads into the water and tearing off shreds of these plants. In recent years, they too have been seen in fields feeding on leftover grain.

Each spring, as the weather warms, waterfowl migrate to the prairie potholes and wetlands of the northern U.S. and Canada and north to the subarctic and arctic. There, they breed and raise their young, fattening up for the upcoming winter migration. As daylight diminishes during the waning days of the northern summer, the waterfowl embark on the long trek to their wintering grounds. These birds fly from just above sea level to over 20,000 feet, scanning the landscape and night sky for navigation cues.

Migration is hardly a simple feat for many of these birds. Some species will fly up to 3000 miles nonstop at speeds from 40 - 60 miles per hour--equivalent to driving across the U.S. in 2.5 days without a single rest stop! Canvasbacks, aerodynamically streamlined birds, have been clocked during their migration at speeds of 72 miles per hour.

All through the autumn, flocks of birds arrive in Chesapeake Bay, marking the passage of summer. Upon arrival, they set about the task of replenishing their spent energy supplies. In the past, abundant aquatic vegetation and invertebrates in the shallows likely supported millions of waterfowl. Now, the destruction of wetlands and dramatic losses of submerged vegetation have combined with mortality from oil slicks, disease, ingestion of lead shot, and a variety of natural factors, to reduce their number to about 1 million birds.

This estimate is somewhat deceptive, however. Not all waterfowl have decreased over the past several decades. Some, such as Canada and snow geese, have generally increased as a result of their ability to change diets. Other populations such as the canvasback, redhead, wigeon, and pintail, however, have deteriorated dramatically--resulting in a net reduction of waterfowl numbers.

In the early part of this century, concern over declining populations of waterfowl prompted a variety of regulatory actions to protect these animals. Battery guns, capable of killing dozens of ducks at a time, were outlawed in 1918 with the institution of bag limits. Duck stamps have been a mandatory purchase by waterfowl hunters since 1934, providing funds to preserve duck habitat. More recently, Canada and the U.S. agreed to cooperate in establishing goals for waterfowl managment. Locally, a coalition of organizations will develop baywide migratory waterfowl managment plans in the next few years. In conjunction with these efforts, private groups have purchased wetlands for waterfowl habitat, while federal and state organizations have established refuges.

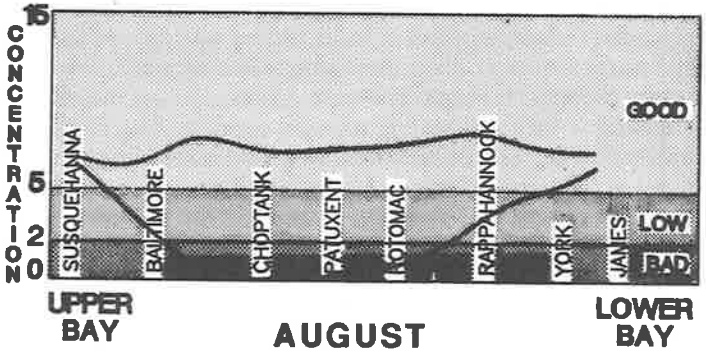
Waterfowl, more than many animals, are key indicators of the state of the environment. The plummet of waterfowl numbers over this century has alerted us that many of the habitats sheltering these birds have degraded. Because a successful winter on the Chesapeake is as important as a fruitful summer, the health of both the Bay and northern breeding grounds are crucial if these birds are once again to "blacken the sky."

Nina Fisher - Computer Sciences Corporation

The Bay Barometer is produced by the Monitoring Subcomittee of the federal/state Chesapeake Bay Program. The Subcommittee would like to thank Steve Funderburk, U.S. Fish & Wildlife Service, for his assistance.

CHESAPEAKE BAY BAROMETER

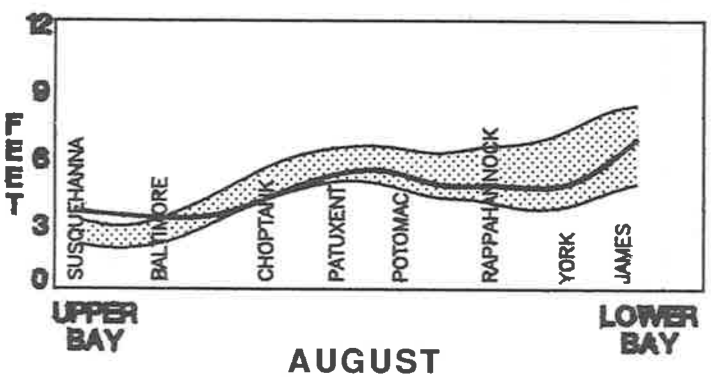
ENVIRONMENTAL CHARACTERISTICS OF THE BAY



AUGUST

DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. DO worsened somewhat throughout the entire Bay. August's bottom anoxic (without oxygen) area off the Choptank spread slightly further south and north than July's. The hot weather throughout much of the month warmed the water so that it could not hold as much DO. Cooler weather should now reverse this summertime trend.

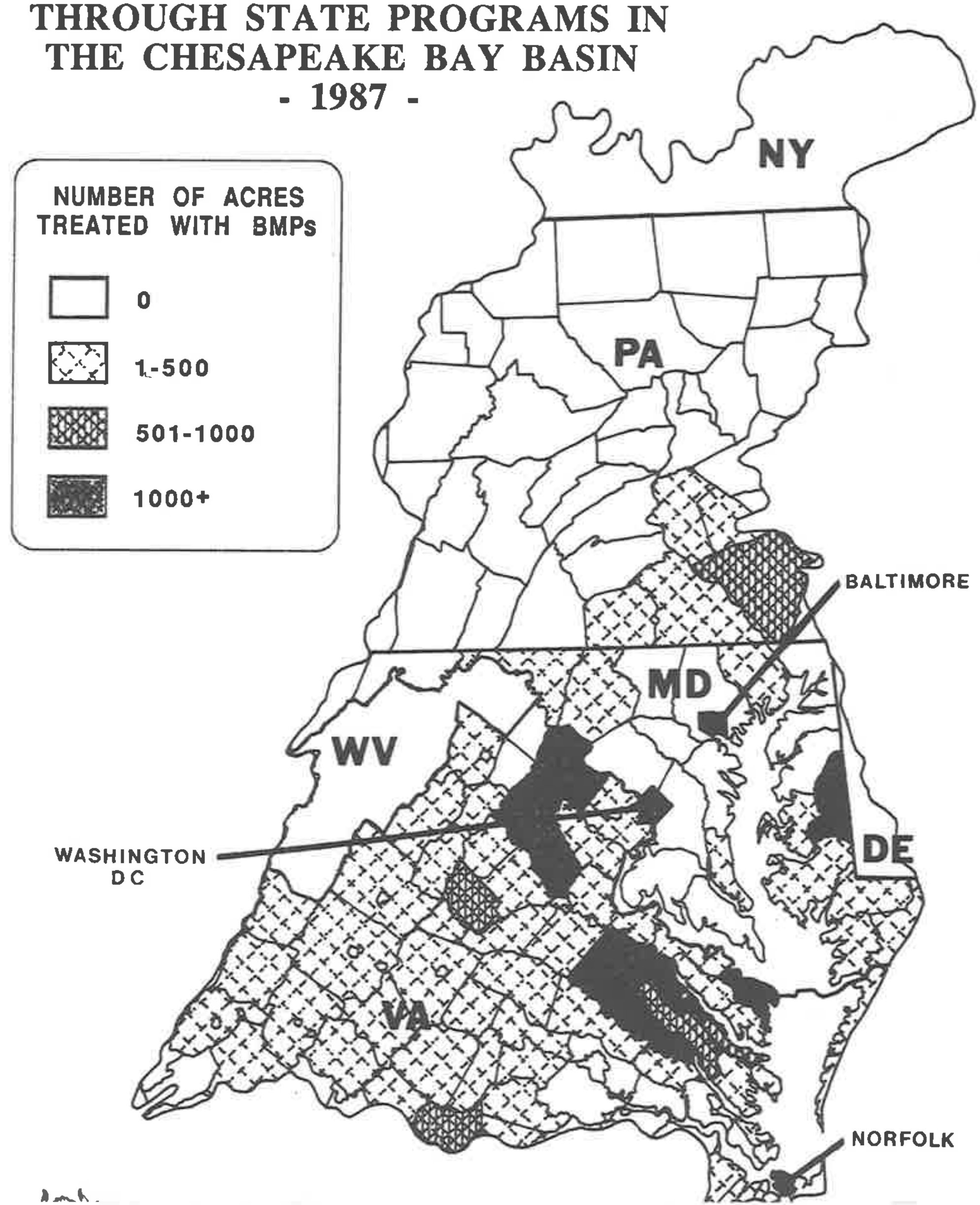


AUGUST

WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

ACRES TREATED WITH BMPs THROUGH STATE PROGRAMS IN THE CHESAPEAKE BAY BASIN - 1987 -



zone for August. This August's water clarity is remarkably similar to the clarity seen in July and is about average for this time of year. The head of the Bay near Susquehanna Flats is slightly more clear than average. Clarity should continue to improve as autumn, and cooler weather, approach.

SEPTEMBER HIGHLIGHT: AGRICULTURAL BMPs

There is nothing quite so enraging to an environmentalist than a pipe discharging waste-ridden waters directly into a stream, lake or bay. The evidence of pollution is unmistakable and the pipe, itself, often leads directly back to the culprit responsible for the discharge.

Yet, over much of the Chesapeake's watershed, pollution creeps into Bay waters much more insidiously. As rainwater falls onto unforested land, the runoff accumulates nitrogen, phosphorus, animal waste, soil particles and pesticides--contamination known as nonpoint source pollution. Without any measures to restrict the flow and trap these pollutants, the tainted water will end up ultimately in the Chesapeake Bay, fueling the problems that are the catalyst for its cleanup.

When the colonists first settled the Chesapeake Bay region, forests covered about 95% of the land. When it rained, the forest canopy minimized the impact of the raindrops. The thick leaf mat on the forest floor allowed rainwater to infiltrate the ground, permitting time for purification before it entered the Bay.

Through time, as forests were toppled to make way for farms, fields, cities and roadways, the cleansing capacity of the land around the Bay diminished. The sheer volume of agricultural and urban land, in addition to traditional methods of cultivating fields, operating farms and developing land, caused progressively greater volumes of pollutants to pour into the Bay.

By the mid-1970s, scientists and managers recognized that farmers could neither afford to watch soil wash from their land nor could the Bay and its tributaries continue to withstand the assault from agricultural runoff. Efforts to develop best management practices (BMPs) for farmers increased. Agricultural BMPs are techniques designed to decrease or eliminate the amount of nonpoint source pollution running from farmlands--including both structural and non-structural methods.

Structural BMPs modify the farm's topography to minimize erosion and runoff, enhance infiltration and allow sediment to settle out of runoff before it enters a stream or the Bay. Erosion strips soil from hillside fields; terraces constructed at appropriate intervals across the slope slow the water's passage, delivering it to a grassed waterway or pipe outlet. Diversions, across-slope ridges, function similarly but channel the runoff away from the field below to controlled outlets such as grassed waterways. These waterways, planted with special varieties of grass, decrease the chances of gully erosion. The waterway may carry the runoff to a pond which can remove additional nutrients and sediment.

Non-structural BMPs include specific tillage and cropping techniques as well as the use of cover crops and crop rotation. These practices demand the farmer's whole-hearted cooperation as they often involve a new approach in managing the farm. Traditional tillage of the soil leaves the ground surface bare and vulnerable to erosion by spring rains. Soil conservationists recommend a variety of tillage practices to reduce the amount of exposed soil; these techniques range from no-till in which the seeds are planted directly in undisturbed soil to conservation tillage in which at least 30% of the surface remains covered by plant residues from the previous crop. As an additional measure on hilly terrain, the plow pattern should parallel the contours of the land.

During the winter, many farmers elect to plant cover crops, such as winter wheat, which use up residual nutrients in the soil. Nitrogen-producing plants, such as legumes, bind the soil and later may be turned under as green nitrogen-rich manure for the successive crop. Strip cropping is also being applied with increasing frequency. In this practice, farmers plant broad strips of differing crops across the slope.

Which BMPs a farmer chooses will depend to a large extent on the characteristics of his farm. The type of soil, topography, crops planted and economic considerations determine which combination of BMPs will prove most efficient. To help educate farmers and to further research the effectiveness of different BMPs, universities in each state have set up experimental demonstration farms. The University of Maryland established a demonstration farm known as Indiantown. Situated adjacent to the Chester River, it drives home the point that agricultural practices do indeed affect local water quality. Indiantown's soil, crops and topography are similar to many other area farms; this similarity means research results from this farm can help make wise BMP decisions on other farms.

Many farmers have been receptive to the idea of using BMPs in management of their farms. Incentives, such as state cost-share programs, educational forums and consultation with county, state and federal agricultural specialists promote farmer involvement. Virginia, Pennsylvania, Maryland and the federal government have a confusing array of cost-share programs; funding rates vary by state, program and BMP type. The Bay map shows only those counties employing state funded BMPs.

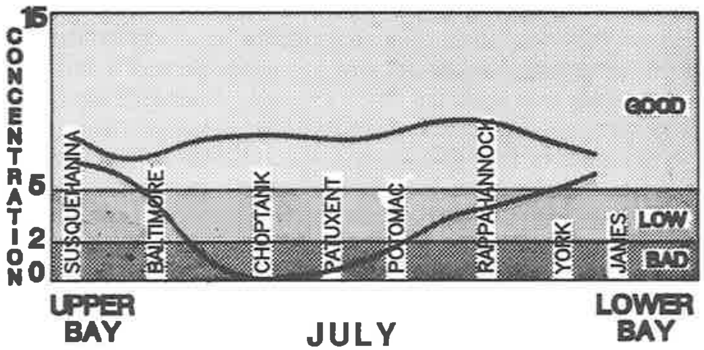
The results are mutually advantageous--not only does water quality improve but the farmer, in the long run, benefits financially. John Nicolai, a farmer, says "As far as I'm concerned, my conservation practices result in a net increase in cropable land." [1] Ultimately, combinations of BMPs tailored to individual landscapes, will yield productive means of farming the land while protecting the Bay.

Nina Fisher - Computer Sciences Corporation

For more information on BMPs, contact your local Soil Conservation District office. The Bay Barometer is produced by the Monitoring Subcomittee of the federal/ state Chesapeake Bay Program. The Subcommittee would like to thank Christopher Miller (U. of MD) and Lynn Schuyler (EPA) for their assistance. [1] From a brochure prepared by MD OEP and U. of MD Cooperative Extension Service.

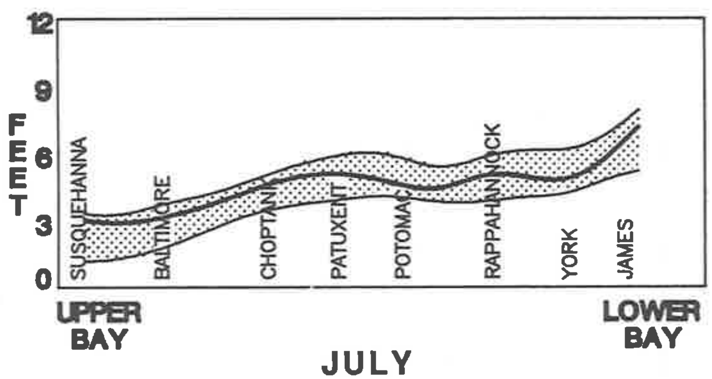
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

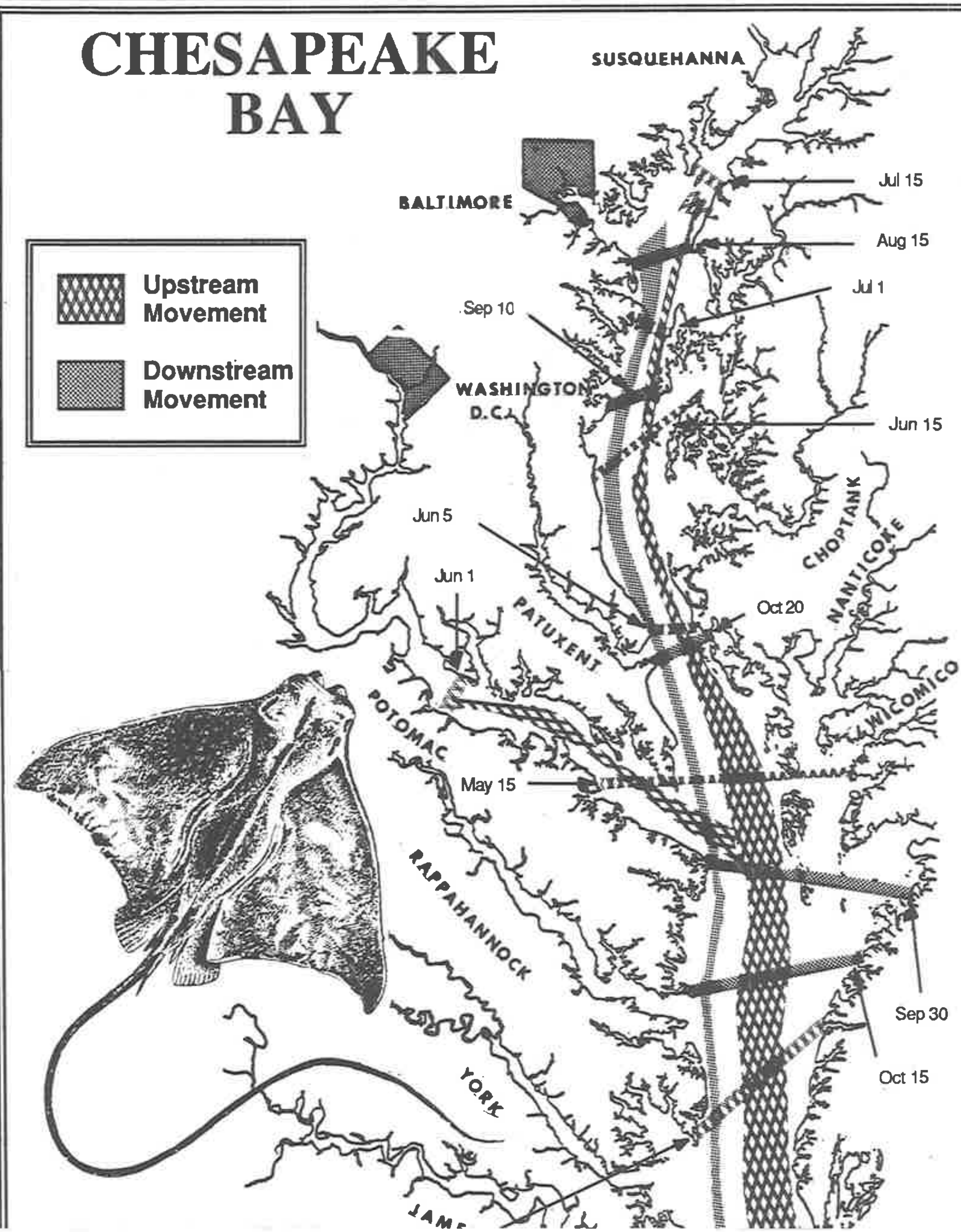
Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. Bottom DO continues to remain anoxic (without oxygen) in the mid-channel of the Bay from just north to just south of the Choptank River. Surface DO has dropped slightly since June. If the rain seen in the latter part of July continues through August, the bottom DO may worsen before cooler temperatures cause improvement.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

CHESAPEAKE BAY



zone for July. July's water clarity was about average for the Bay and fairly similar to the clarity seen in June. It improved slightly near the mouth of the Bay. During the summer, with extremely warm temperatures, the growth of plankton is accelerated, which drives the clarity to the lowest persistent levels for the year.

Ray picture by Lynne Lockhart in "The Oyster" by R. Hedeen, Copyright © 1986, Tidewater Publishers, Reproduced by permission.

AUGUST HIGHLIGHT: THE COWNOSE RAY

Often , when the cry "shark!" is heard on the Chesapeake Bay, the instigator of the panic is the cownose ray. As the ray swims (flies) through the water, its wing tips breaking the surface, the resemblance to the dorsal fins of the shark is remarkable. The excited observer may be a bit shamefaced when the "shark" is discovered to be the passive cownose ray.

Not that the cownose ray is an animal that should be taken lightly. In 1608, John Smith learned about the ray's might in a near fatal encounter. As Smith stood spearing fish with his sword in the shallows of the Bay off the mouth of the Rappahannock, he stabbed a ray which pierced him in the wrist with its toxin-laden spine. Although there was no blood or apparent wound, his arm and shoulder swelled and he was in terrible pain. Convinced that he was about to die, his crew prepared a grave. Whether his body overcame the trauma or the salve applied by the ship's doctor remedied his condition, John Smith felt well enough to eat the same ray for supper that night. The story has been incorporated into Bay lore--the spot where Smith was stung is still known as Stingray Point.

Described as a flattened shark, all rays belong to a group of animals which lack true bone; their skeletons are composed of cartilage. These fishlike creatures are called elasmobranchs and include the rays, sharks and skates. All are characterized by the lack of a swim bladder which helps true fish float. Since the bodies of most elasmobranchs are more dense than sea water, and since they lack a swim-bladder they have a tendency to sink. This condition limits some species to life at the bottom while others have evolved mechanisms to counteract the gravity-induced disability.

Another characteristic of many elasmobranchs, including the rays, is most unusual for fishlike creatures; they are able to give birth to live young. The ray pup grows inside its mother positioned with wings folded over its body, gaining nutrition from the mother's uterine secretions. It emerges in what humans would consider a breech birth--tail first. In this position, there is no damage to the female.

At birth, the cownose ray is about 11-18 inches in width. When mature, it attains a 45 inch width, may weigh 50 pounds or more, and is brown-backed with a whitish belly. This species does not have particularly distinctive coloration but its shape is readily recognizable. Aside from the broad wings and long tail characteristic of rays, the cownose has a notch in its head which creates a double-headed appearance; from the top it looks somewhat like a cow muzzle. Eyes peer out eerily from the side of thebroad head. Hidden within this strange head is a set of equally remarkable teeth plates designed for crushing clam and oyster shells.

Being stung by a cownose ray, though potentially fatal, is uncommon. Unlike some other ray species, the cownose rarely rests on the bottom where a swimmer might step on its stinger. This stinger (spine) is situated on the tail close to the ray's body, so merely flicking the tail does not usually inflict damage. With pointed, recurved teeth lining its lateral edges, the spine processes toxins and mucous in its ventral groves. Spongy venom glands which produce the toxin are situated along the underside of the spine. In the rare instance that a person is stung by a ray of any sort, the wound should be cleaned and immersed in extremely hot water which seems to help deactivate the toxin.

The cownose ray is a migratory animal, arriving in the Bay in May and staying until late September or October. It ranges from Massachusetts to the middle part of Brazil. Migrations to the north in the summer and south in the winter are routine, often with large groups of the animals veering into the Chesapeake for the summer. Once in the Bay, the rays move northward in schools of 5 to more than 200 individuals searching for good feeding grounds. They arrive in the Eastern Shore portions of the upper Bay by early June. Cownose ray pups are born in mid June; refertilization of the mother usually takes place within 10 days of birth.

The cownose ray is a voracious feeder, preferring to feast on the soft clam, *Mya arenaria*. Rays will also prey on oysters, hard clams and other invertebrates. During feeding, these animals move as a group regardless of time. The rays seem to be cavorting but actually are using rapid wing movements to churn the bottom sediment to uncover hidden clams and oysters. Once they have located a victim, they clasp it in their powerful jaws and crush the shell in search of the meat inside.

In the mid-1970s, some scientists expressed concern that the cownose ray was responsible for extensive damage to the eelgrass beds of the Bay. Others disputed this finding, contending that the decline of sea grass beds throughout the Bay resulted from the cumulative effect of pollutants, disease, and sediments entering the system. Rays may disrupt small areas of sea grass beds, but probably are not responsible for the wholesale destruction of the eelgrass.

Another concern is the apparent increase of cownose rays in the Bay. Substantive evidence for this increase is lacking, for rays are not included in the surveys of any fish management program -- a larger number of cownose rays would result in greater shellfish consumption. In an era when pollution, disease and overharvesting have decimated much of the shellfish population, increased predation by rays may pose an additional problem.

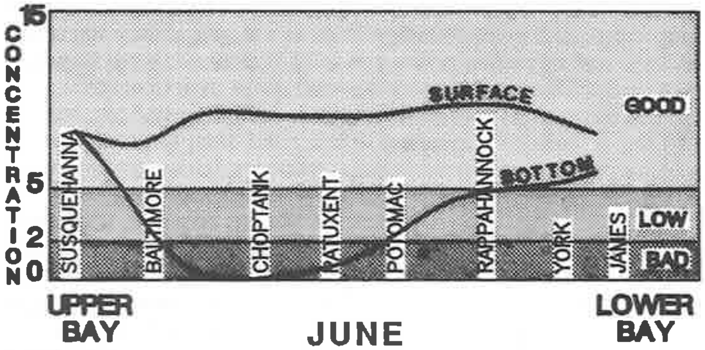
One method of controlling the ray population is to promote both commercial and recreational cownose ray fisheries, however this may not be feasible. Not the most exciting of game fish, a large cownose does put up a lengthy fight and, once landed, provides about 5 lbs of meat. Until the government discovered the fraud, ray wings were often punched into small plugs to mimic scallops. Under this guise, the public willingly consumed the ray. Perhaps, as consumers become more experimental with the foods they eat, introduction of cownose ray meat as a commercial product under its own distinctive name may prove economically and environmentally advantageous.

- Nina Fisher, Computer Sciences Corporation

The Bay Barometer is produced by the Monitoring Subcomittee of the federal/ state Chesapeake Bay Program. The Subcommittee would like to thank Dr. Frank Schwartz, UNC, for his map data and technical assistance.

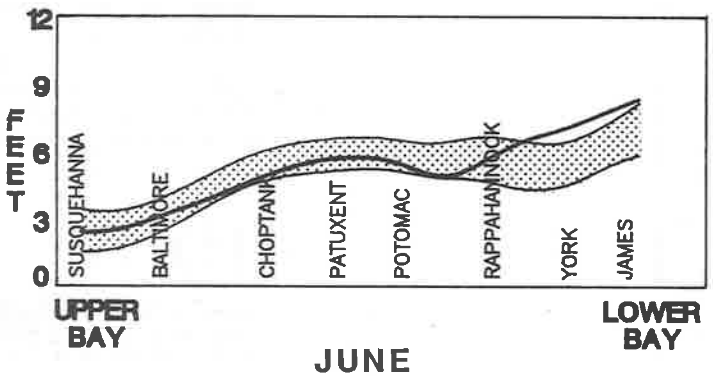
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

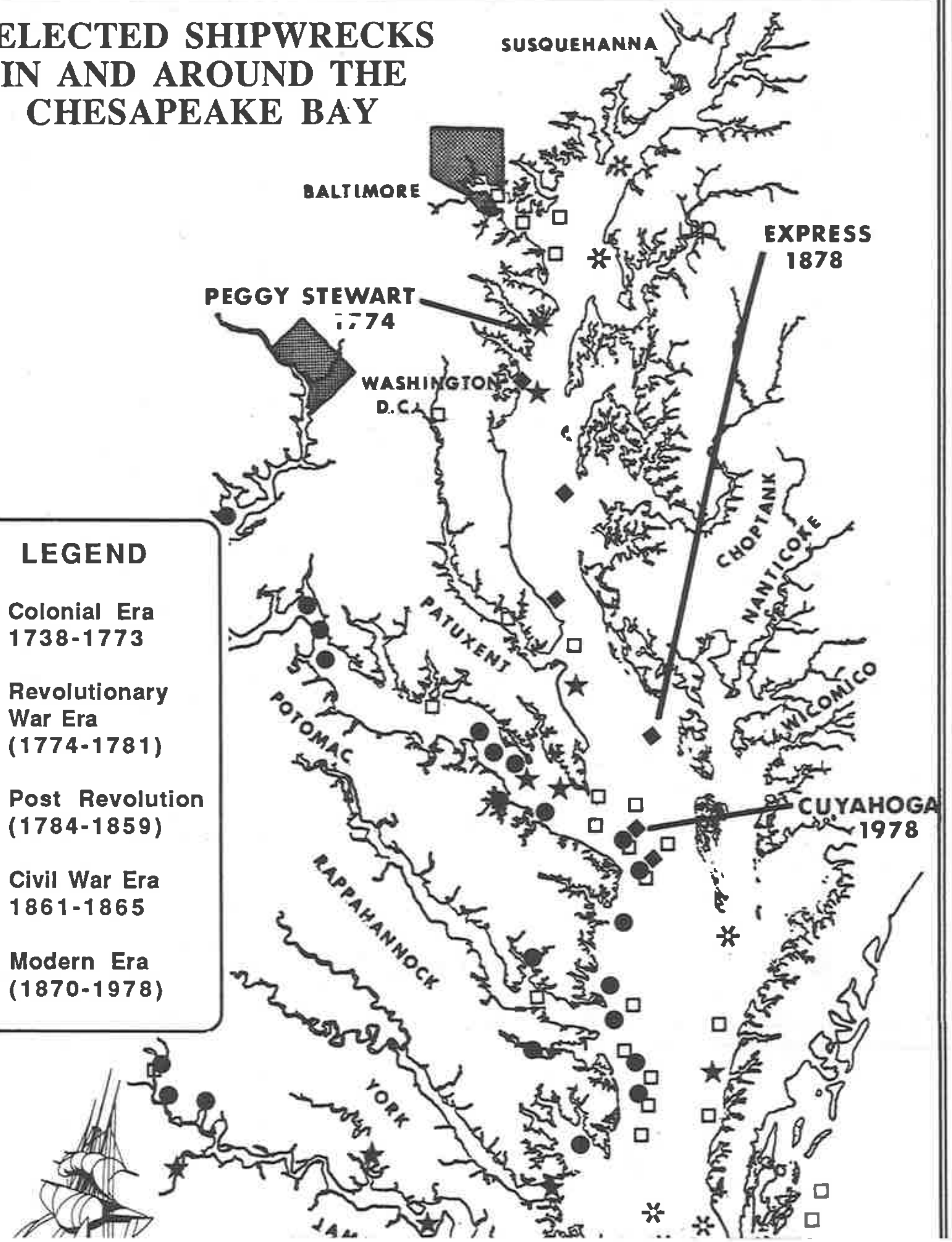
Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. For the first time this summer, DO has become anoxic (no dissolved oxygen) off the Choptank River. This drop in DO occurred at approximately the same time as last year. This year, however, the DO between the Potomac and York rivers is not as low. DO levels are likely to worsen until the weather begins to cool.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

SELECTED SHIPWRECKS IN AND AROUND THE CHESAPEAKE BAY



zone for June. Water clarity in June was about average for the entire Bay and was quite similar to the clarity seen in May. Despite the lack of rainfall which kept sediment loads low, growth of plankton in response to the warm temperatures likely kept water clarity relatively low.

JULY HIGHLIGHT: SHIPWRECKS IN THE BAY

To look out at the Chesapeake Bay on a fair day, alive with boats and ships of all varieties, one would hardly suspect that the remains of once seaworthy vessels litter the Bay's bottom. From the mysterious shipwreck lying off the tip of Tangier Island (possibly dating from the 16th century) to the Coast Guard cutter *Cuyahoga* which sank after slamming into a freighter in 1978, over 1800 vessels have met their end in Bay waters.

Storms and collisions are only two of the possible hazards facing vessels on the Bay; explosion, stranding, ice and poor judgement also cause ships to go down, but fire was the disaster most feared in the past. Fire spread swiftly through early wooden ships, destroying them in a matter of minutes.

Certain areas in the Bay are known for their treacherous shoals or exposure to dangerous storms. The area at the mouth of the Bay between Capes Henry and Charles is particularly infamous for its shifting sand bars: so well known, in fact, that it has earned a proper name—the Middle Ground. Ships often became stranded on the shoals of the Middle Ground. Incapacitated and vulnerable to storms, ships were pounded with incoming waves until they broke apart, often spewing cargo and crew into the waters of the Atlantic. Not only was the middle passage through the capes hazardous, but sailing too close to the capes themselves often proved disastrous. Willoughby Spit, at the mouth of the James River, also caused the demise of many ships.

During wars, calamities of battle heightened the usual hazards of ship travel. Many of the shipwrecks in the Bay are casualties of the Revolutionary War, the War of 1812, and the Civil War. Direct hits from cannons, explosives and torpedoes brought down many of the ships, but fires and collisions also played a role.

Sometimes, it was not direct confrontation between the war enemies that destroyed a ship. Internal dissension among members of the same community could be equally effective. One of the most celebrated examples is the wreck of the *Peggy Stewart*. In 1774, as unrest grew in response to British treatment of the colonies, the *Peggy Stewart* entered the Port of Annapolis with a load of tea on board—a product which had been explicitly banned by the county association. At a public meeting to determine the fate of the brig, opinion was swayed in favor of burning the ship as an example to others that would follow suit. Having no other choice, her owners set the ship ablaze and her remains now rest in the reclaimed land below Luce Hall at the U.S. Naval Academy.

During the latter part of the 1800s, steamboats became a popular means of traveling around the Bay. These boats were vulnerable to the whims of hurricanes or northeaster storms, especially if caught in the open Bay with no cover. In October 1878, a steamer on the Potomac Transportation Line named *Express* discovered just how violent the Chesapeake can become. *Express* was working her way south in the main Bay when a storm with gale force winds struck. Unable to make safe harbor and with anchor chains snapped by the fury of the waves, the steamer felt the full brunt of the storm's swell. *Express* capsized, forcing her passengers to cling to bits of floating debris to save their lives. Lifeboats from another steamer driven aground that night rescued many of the victims, but 16 of the 31 on board lost their lives.

As early as 1726, local newspapers reported accounts of shipwreck disasters. At first, the news stories were printed to inform the few who might have family members aboard or a financial stake in the ship. Later, spectacular catastrophes often appeared in the newspapers for their sensationalistic effect.

Marine archaeologists use whatever records may be available, including old news reports, to help locate wrecks of possible historic interest. The Calvert Marine Museum sponsored excavation of the remains of a ship in the Patuxent River known as the "Turtle Shell Wreck." The excavation team removed the sediment from the river bottom and found the well-preserved wreck and a variety of artifacts 4.5 feet below the surface. Information retrieved from the river bottom confirmed that the ship had belonged to the Chesapeake Flotilla which was mobilized against the British during the War of 1812.

While the "Turtle Shell Wreck" was found in remarkably good condition, not all wrecks are found intact. The initial damage to the ship which caused it to sink as well as bacterial decay, burrowing by animals, and breakdown due to water saturation and rust of metal parts, all degrade the wreck over time.

Such excavation projects are invaluable in providing clues to our history. In an effort to preserve the wrecks, Maryland recently passed legislation protecting all cultural submerged sites. Access by divers is not restricted, but which artifacts they may collect is still vague. In Virginia, the state claims title to a wreck's artifacts; compensation may be awarded to the discoverer of the artifacts. Legislation along with education should help preserve the wrecks as part of our heritage.

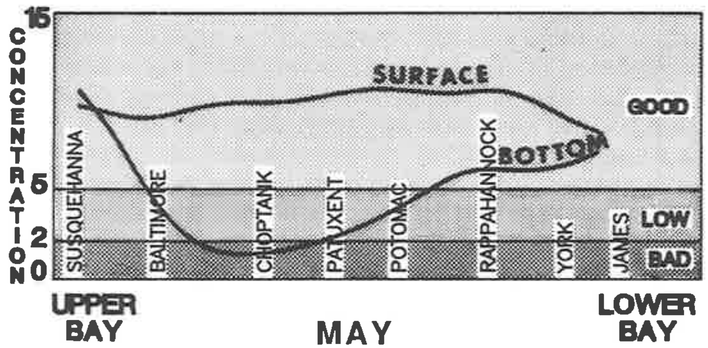
The fright, panic and horror that the passengers and crews of the sinking ships must have felt is barely conceivable. Yet, years later these same ships, lying broken and battered on the floor of the Bay, allow us to glance back at the way our forefathers lived, worked and traveled on the Chesapeake Bay.

- Nina Fisher, Computer Sciences Corp.

The Bay Barometer is produced by the Monitoring Subcomittee of the federal/state Chesapeake Bay Program. The Subcommittee would like to thank Donald Shomette for the use of the shipwreck data displayed on the map.

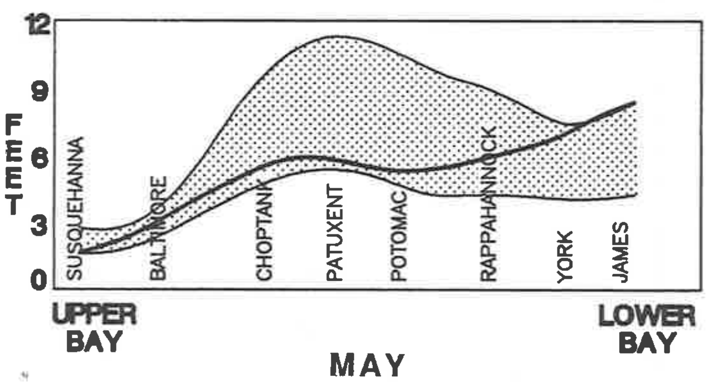
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

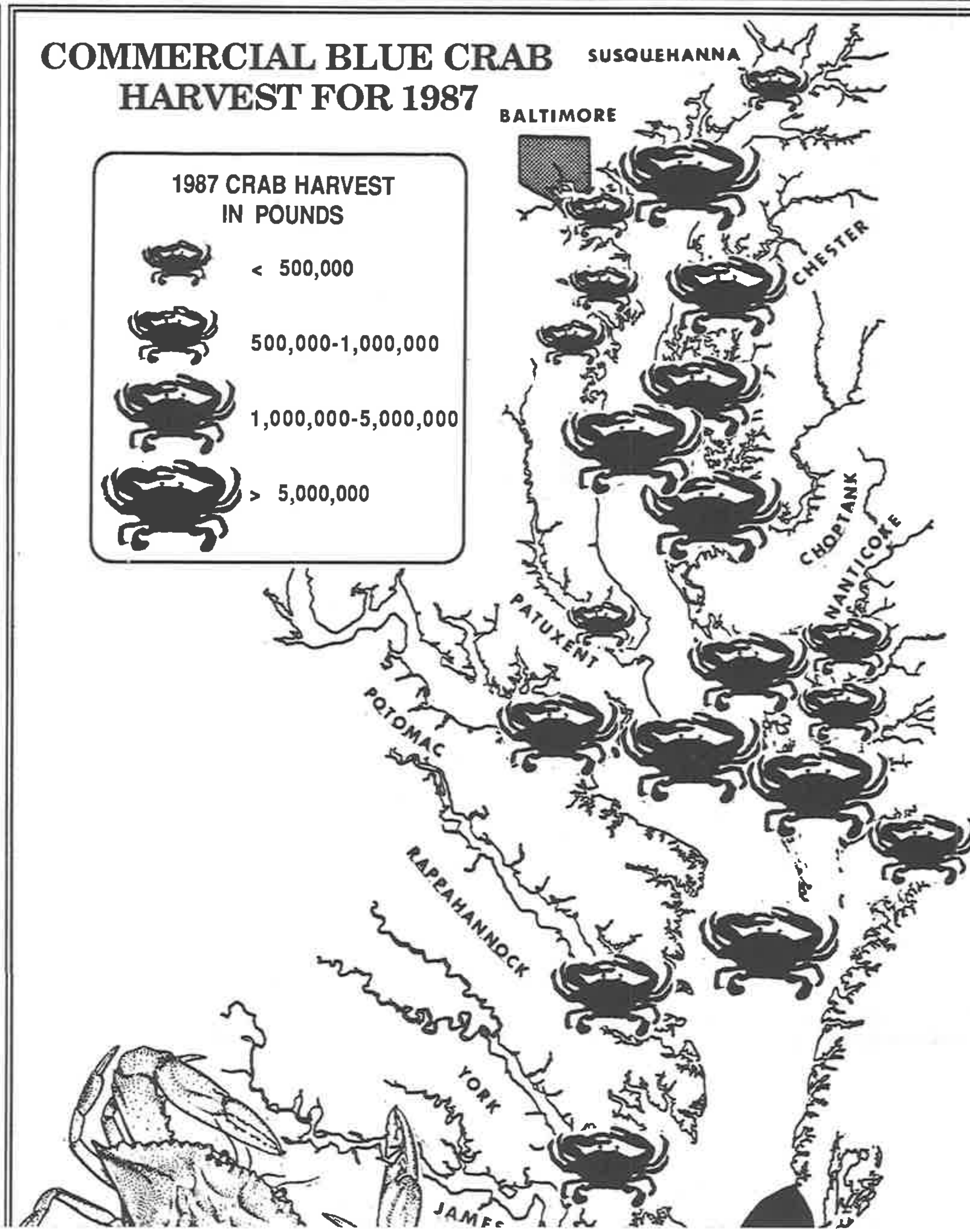
Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. After months of below average rainfall, May had much higher than average rainfall over the entire Bay region. The high rainfall caused stratification to develop--freshwater on top and heavier saltwater on the bottom. When strong stratification exists, the oxygenated surface water cannot mix into the bottom water, resulting in low DO levels.



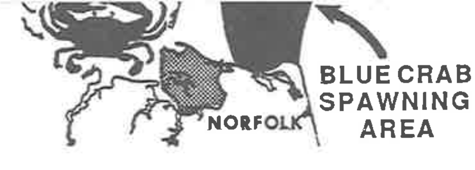
WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material including fine sediment and microscopic organisms

COMMERCIAL BLUE CRAB HARVEST FOR 1987



(plankton), reduce water clarity. The stippled area is an average zone for May. Water clarity was on the low side of average for the Bay from the Susquehanna to the Potomac. This may be due to the unusually high amount of rainfall in the second half of May. The runoff from the rain would likely have brought large quantities of sediment to the Bay.



JUNE HIGHLIGHT: THE BLUE CRAB

". . . a retired Smith Island waterman once looked hard at me and raised his arms in supplication. 'Oh my blessed,' he said very slowly. That old crab is hard to figure out." - William Warner in "Beautiful Swimmers"

The crab, more than any other creature, embodies the life of the Chesapeake Bay. Driving around the Bay, "Maryland is for Crabs" bumper stickers and the aroma of Old Bay seasoning wafting from buildings with "Steamed crabs sold here" signs, give ready testimony to the popularity of this crustacean. Despite this love affair, certain aspects of the crab's existence remain mysterious even to the waterman whose life revolves around the ways of the crab.

To an outsider, the name "blue crab" may seem something of a misnomer. Predominantly olive-green and creamy white, this crab's name is derived from the vivid blue on its claws. Mature females have brightly colored leg tips that appear to have been dipped in red nail polish.

The crab belongs to a group of animals called crustaceans that includes shrimp and crayfish and whose members are readily distinguished by their 10 legs. The 3 middle pairs serve as walking legs upon which the crab tiptoes along the Bay bottom. The front pair are strong pinching claws used for defense and securing food. The remaining leg pair gives the blue crab the first part of its scientific name (*Callinectes sapidus*). *Callinectes*, in greek, means beautiful swimmer: the crab's hind legs are designed like paddles, making it a remarkably good swimmer.

The blue crab ranges from the upper, nearly fresh, waters of the tributaries to the salty mouth of the Bay. A young crab's life usually starts sometime in summer or early fall as a minute floating animal known as a zoea, hatched near the Bay mouth. This young shrimplike creature, at the whim of currents, is usually carried into nearshore ocean waters where, after undergoing a series of molts over a 6-week period, it develops into a megalopa and is somewhat more crablike in appearance. The megalopa moves back into the Bay and crawls northward along the bottom, assisted by inflowing currents. Continuing to molt periodically, the megalopa develops into a distinctive miniature blue crab.

At 12-20 months, after overwintering in the Bay, the juvenile crab reaches sexual maturity. At this stage, the crab is approximately 5 inches in width--legal size for harvesting. Courtship begins with both male and female crabs performing ritualistic claw waving. The male embraces the female from above, cradling her in his legs. In this fashion, the male carries the female for several days as he searches for suitable cover. When he finds vegetated beds, travel ceases and the male stands protectively over the female as she undergoes her final molt. Only when she has shed her shell is mating possible. After mating, the male resumes cradling the female for a few more days until her new skin has fully hardened. The two crabs finally part company; the female heads south down the Bay while the male searches for new receptive females.

The females dig themselves into the sand near the Bay mouth and become dormant as the second winter approaches. Males rest through the winter in the deep mid-channels of the Bay and its tributaries. With the advent of spring, the females which mated later in the season now carry their fertilized eggs under their bodies. Originally bright orange, the 0.5-2 million eggs, known collectively as a sponge, darken as they mature. Once the eggs hatch, the cycle starts again.

With each female producing such a proliferation of eggs, it seems the Bay would soon be overrun with crustaceans. Of the close to 2 million eggs produced by each pair, however, only an average of two eggs survive to adulthood. The rest of the eggs, larvae and juvenile crabs succumb to the perils of the ocean, weather, and voracious appetites of other Bay animals. It is the two surviving crabs per pair that form the base of the crab fishery--one of the few generally thriving fisheries remaining in the Bay.

In a good year, the commercial harvest from the Chesapeake Bay yields close to 100 million pounds of crab. The Bay is the largest producer of crabs in the country. Several methods are used to harvest the crabs: baited trotline, dip net, crab pot, crab pound net, and crab scrape. The method used depends upon state restrictions, personal preference, depth, season, and bottom substrate.

The softshell, a crab that has just molted, requires special treatment. A waterman can tell how close a crab is to molting by subtle color changes on its swimming legs. Peelers, as they are called, are dredged from the bottom and often held in floats until they molt. Sent to market as softshells, they bring a much more desirable price than hardshells.

The Barometer map shows the commercial blue crab harvest for 1987. Catches in Maryland and Virginia yielded over 78 million pounds of hard and soft crabs, representing over $36 million at dockside. As the crab works its way through the middleman and onto resturant tables, this dollar value swells accordingly.

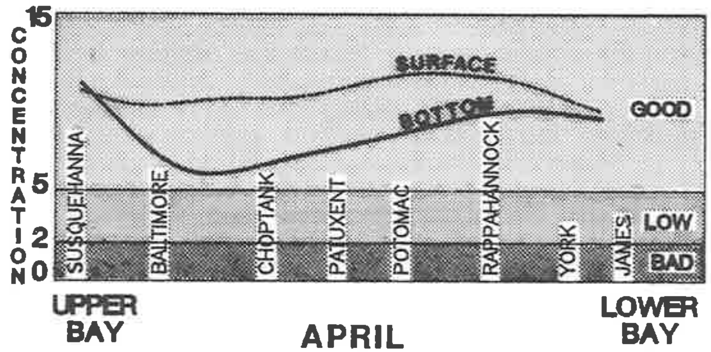
In addition to the commercial catch, recreational crabbing is a popular pasttime around the Bay. On hot summer days, kids with line in one hand and a bag of chicken parts in the other are a common sight, trotting to the shore in search of the not-so-elusive blue crab. Although recreational crabbing is a casual affair, with hand lines or dip nets making up the requisite gear, recreational catches are 15-25% of Maryland's commercial catch and a lesser amount in Virginia.

The Bay's crab fishery, while known for its abundance, is also known for its wild and mysterious fluctuations. Several years of good catches may be followed by a spell of poor harvests. Scientists are unravelling some of the secrets of the blue crab's existence, but full understanding of its ways remains a distant goal. Perhaps, this is just as it should be; we tend not to respect an animal that yields its secrets too easily. - Nina Fisher, Computer Sciences Corp.

The Bay Barometer is produced by the Monitoring Subcomittee of the federal/state Chesapeake Bay Program. The Subcommittee would like to thank Dr. John McConaugha, Old Dominion University, for his assistance.

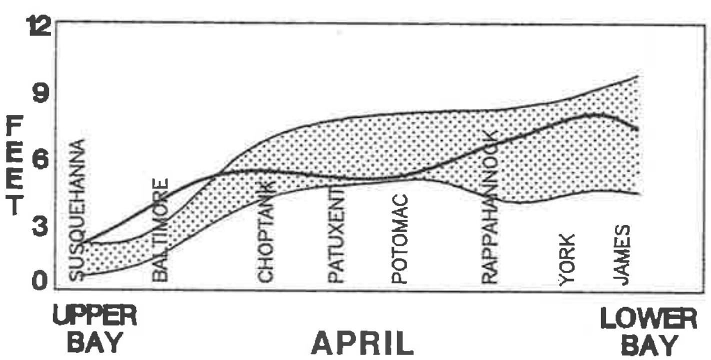
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

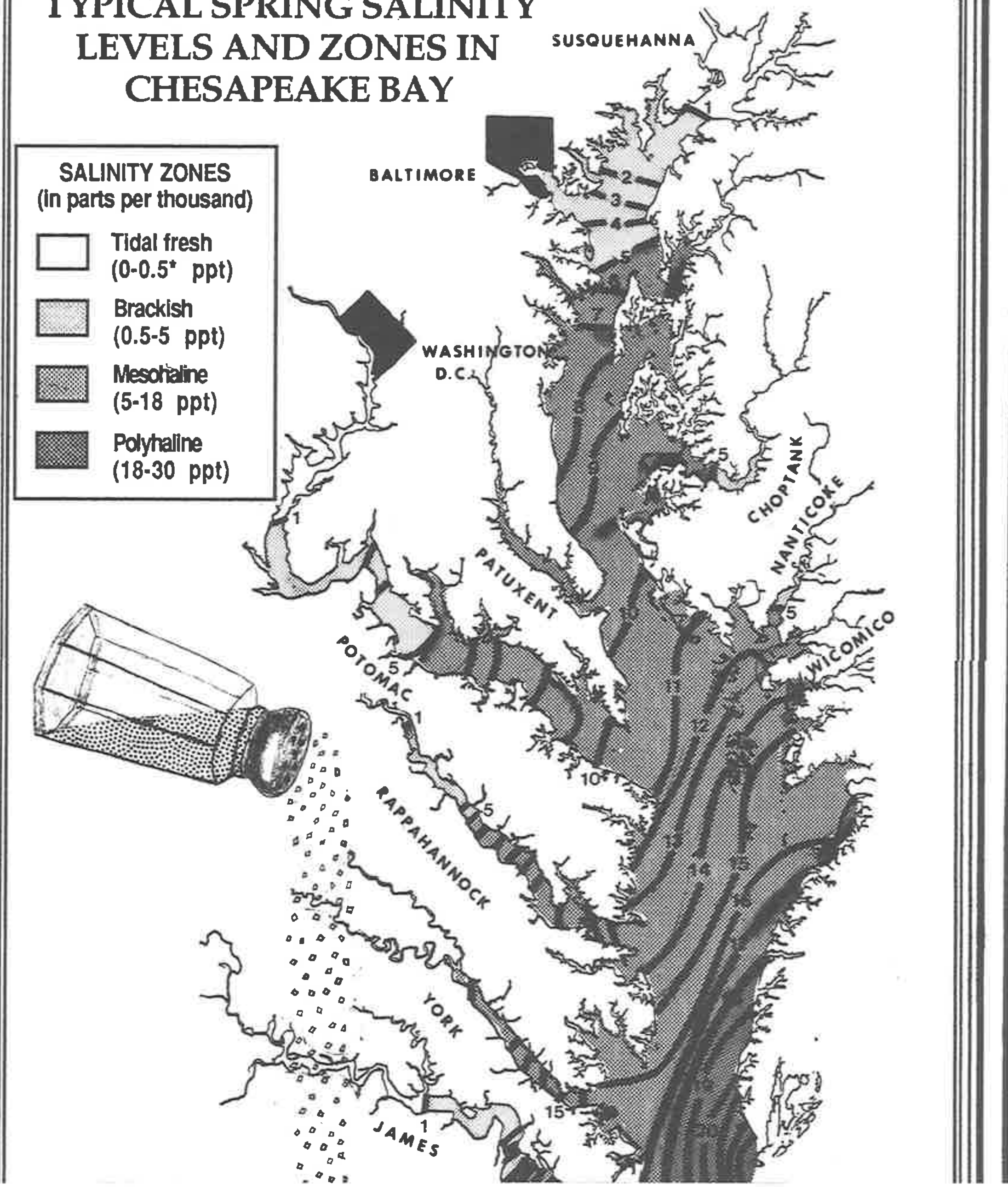
Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. As water temperatures started warming in early April, the amount of DO in the water began to drop. April's levels are similar to those of March but surface water DO is slightly lower along the entire mainstem. Both surface and bottom DO levels are somewhat less than May, 1987 levels. As summer approaches, DO will continue to drop.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material, including fine sediment and microscopic organisms (plankton), reduce water clarity. The stippled area is an average

TYPICAL SPRING SALINITY LEVELS AND ZONES IN CHESAPEAKE BAY



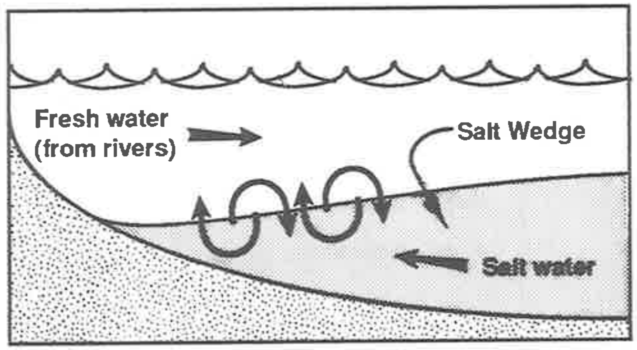
zone for April. Most of the Bay had average water clarity. The upper Bay was a bit clearer than normal for this time of year--probably due to the low amount of rainfall in the Susquehanna River basin. With this low rainfall in April, less sediment was washed into the Bay, making the water clearer than usual.

MAY HIGHLIGHT: THE SALTY BAY

When it comes right down to it, humans have a lot more in common with the salty sea than one might imagine. An average-size man has about 16.5 quarts of salt water in his body--with the same constituents and about the same concentration as ocean water. It's not surprising, then, that periodically we get the urge to journey down to the sea.

A taste of bay or ocean water makes it seem as if salt water is merely freshwater with a bit of salt added. In actuality, it is a very complex mixture, containing not only the elements of table salt (sodium and chlorine) but also salts of potassium, magnesium and sulphates as well as a variety of less plentiful constituents. Although the ratio of each constituent remains remarkably constant from place to place, the amount of total dissolved salts, known as the salinity, may vary considerably. Salinity is expressed by a number which approximates the parts (by weight) of dissolved material in 1000 parts (by weight) of solution.

Within the bounds of the Chesapeake Bay, salinity ranges from freshwater (0-0.5 parts per thousand or ppt (1.0 ppt on map)) near Susquehanna Flats to water of nearly oceanic salinity at the mouth (about 32 ppt). The Barometer map shows the broad surface water salinity zones within the Bay for a typical spring. Each line on the map is called an isohaline and connects points of equal salinity. From north to south in the main Bay, the isohalines gradually increase showing salinities rising towards the ocean.



Along with this general trend, salinity also varies with locale, depth and season. Adjacent to the Eastern Shore the isohalines bend to the north, evidence that the saltier ocean water pushes farther north on this side of the Bay. The Coriolis effect, resulting from the spinning of the earth on its axis, causes the salty ocean water moving north into the Bay to be deflected towards the Eastern Shore. At the same time, the Coriolis effect directs the fresher water moving south down the Bay towards the western shore. The large amounts of freshwater runoff from the western shore compared to relatively minor amounts flowing in from the Eastern Shore magnify this pattern.

Not only does the salinity vary over the Bay, but it also changes with depth. Freshwater flowing out of the tributaries is relatively light and tends to ride over the denser, salty water creeping up the Bay from the ocean forming a "salt wedge." The Susquehanna River contributes 60% of this freshwater to the Bay. There is some mixing between the fresh and salt water, but despite this, the surface salinity is somewhat less salty than the bottom water at the same location.

The salinity of the Bay also changes seasonally. At winter's end, snow melt feeds the streams in the Bay's headwaters. The snow melt, along with the advent of rainy springtime weather, adds large amounts of freshwater runoff into the Bay. The spring runoff dilutes saline water and the isohalines move down the Bay. With the return of drier conditions in the summer or fall, salinity levels once again start to climb.

Salinity levels are a harbinger of upcoming conditions in the Bay. In particularly wet springs and summers, the salinity difference between the surface and bottom waters becomes accentuated and restricts mixing; the resulting stratification is very important in determining bottom water dissolved oxygen levels during the summer. Spring salinities can also be used to predict summer abundance of sea nettles in the Bay. In dry springs, higher salinity waters move up the Bay--prime territory for the stinging sea nettle which thrives in salinities of 7-20 ppt.

The salinity of different portions of the Bay and its tributaries affects not only the Bay's water circulation but, to a large extent, controls which plants and animals inhabit each salinity zone. Some plants and animals, such as widgeongrass, striped bass and blue crab, can tolerate a wide range of salinities and move easily among the zones. Others, such as freshwater mussel, sheepshead fish and wild celery, are restricted to a very specific salinity zone. Immobile salt-sensitive animals may be particularly vulnerable to changes in salinity.

Several species, including anadromous fish (those fish which live in ocean water but migrate to the freshwater portions of the Bay's tributaries to spawn), are remarkable in their ability to tolerate the whole range of estuarine salinities. This feat requires unique physiological adaptations which allow the organism to cope with changing salinity level: regulating the fluid content in their bodies, changing body volume, shutting down bodily functions or changing body form.

Unlike most topics discussed in the Barometer, salinity is one which (to date) has remained essentially unchanged with the presence of man in the Bay area. Although it is one of the most important factors influencing the abundance and distribution of the Bay's plants and animals, it is also naturally variable. When the torrential rains from a storm such as Hurricane Agnes lower salinity levels to the point of decimating several species, it reminds us that there are some variables which remain out of our hands and are subject only to the whims of nature.

- Nina Fisher, Computer Sciences Corp.

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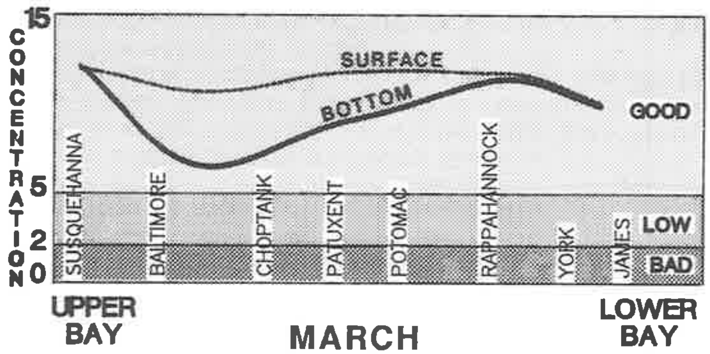
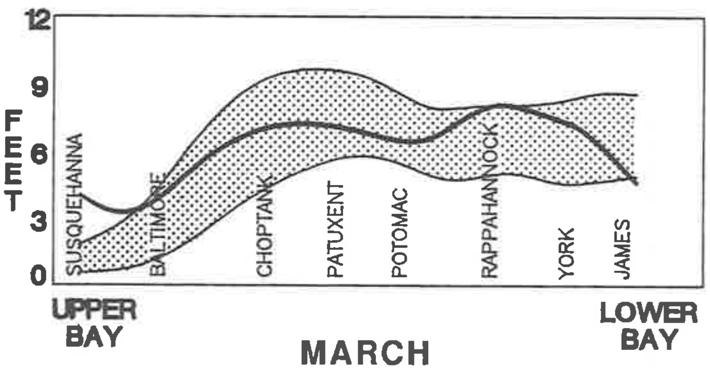
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. With the advent of spring and warming temperatures, the amount of DO that can be held in the water has decreased. Although March's DO values still remain in the GOOD zone, there has been a substantial decrease in bottom water DO since February. As summer approaches, DO levels will continue to drop.



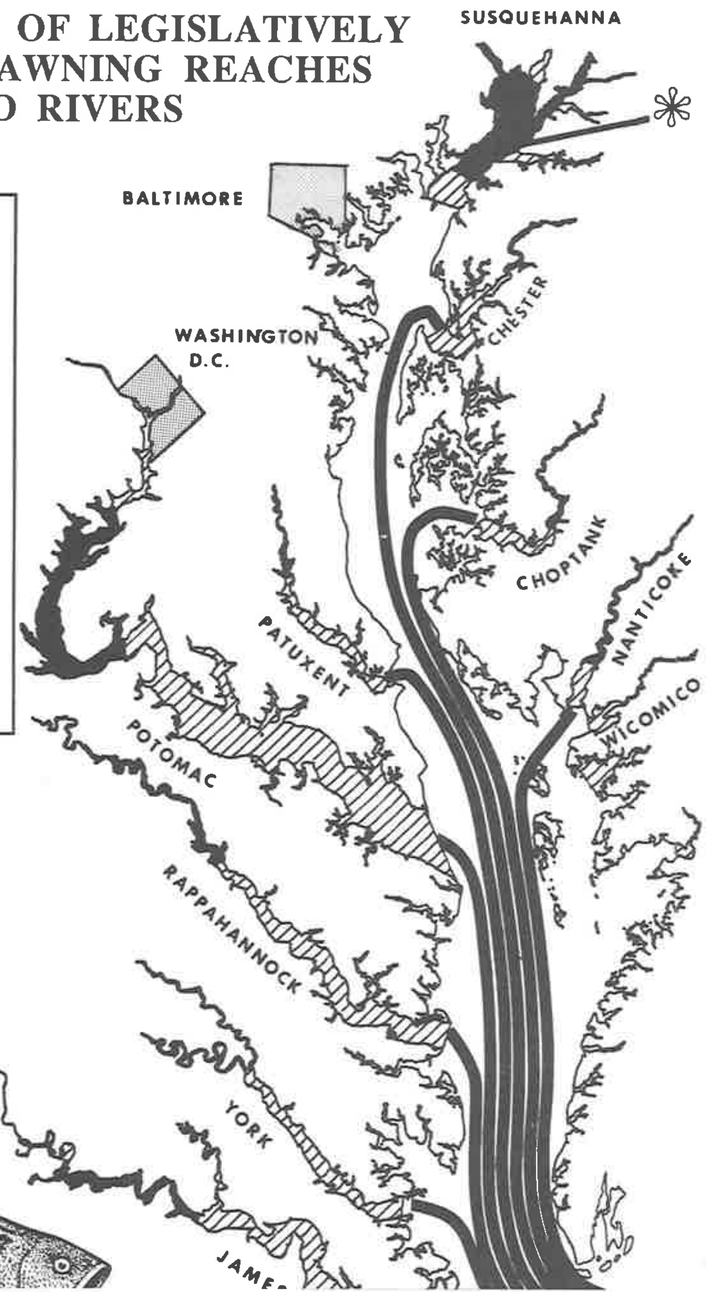
WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material, including fine sediment and microscopic organisms [illegible]

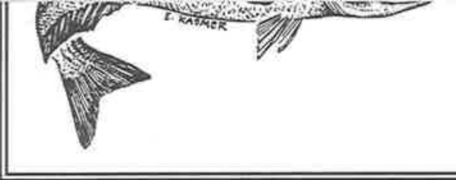
DISTRIBUTION OF LEGISLATIVELY DEFINED SPAWNING REACHES AND RIVERS

LEGEND

- Spawning Reach
- Spawning River
- Migration paths of striped bass to major rivers in which bass have been surveyed as of mid-April,1988.
- ✳ Only a few spawning fish seen this spring (to date).

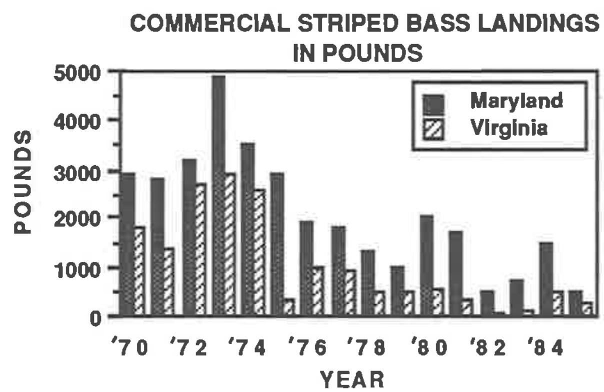


(plankton), reduce water clarity. The stippled area is an average zone for this time of year. Despite well-below average rainfall in March, most of the Bay had only average water clarity. Water clarity at the Susquehanna was relatively clear, probably due to decreased sediment load carried by the river's low flow. The spring increase in plankton will further decrease water clarity.



APRIL HIGHLIGHT: THE STRIPED BASS

Striper, rockfish, rock, linesider, roller, squidhound, greenhead--the colloquial names for the striped bass are as numerous as those for the submarine sandwich. Known for its fighting abilities as a game fish and its delicately flavored meat, the striped bass is a prized catch along the Atlantic Coast. This bass supported a large commercial fishery and until recently was caught in numbers that seemed to verge on the infinite. In 1973, the East Coast commercial harvest was 14.7 million pounds. Then, over a period of years, fish numbers dropped precipitously; a catastrophic turn of events for those who depended upon this fish for their livelihood. By 1983, the harvest had plummeted to 1.7 million pounds.



A handsome fish, the striped bass has characteristic dark stripes running the length of its body which contrast with its shimmery silver background. It ranges along most of the East Coast from Canada's St. Lawrence River to northern Florida and into the Gulf of Mexico. After being shipped across the U.S. by railroad in 1879, the fish also became established from British Columbia to Mexico.

The striped bass is a semi-anadromous fish, spawning (laying its eggs) in freshwater but migrating to the ocean or lower estuaries for much of its adult life. The Chesapeake Bay and its tributaries are the primary spawning grounds for the East Coast stock of striped bass. Males return to the fresh or slightly saline waters of the spawning grounds in April with females arriving soon after. Presumably, fish return year after year to the rivers in which they were born, however recent genetic research suggests that migration patterns may be more complex.

Spawning is triggered by a rise in water temperature with the fertilized eggs hatching a mere 29 to 80 hours after fertilization. Although the eggs are semi-buoyant, the water must be running fast enough to keep the eggs suspended. Hatched eggs produce larvae which can swim weakly but are at the mercy of the shifting currents. These currents may carry the eggs out of the spawning reach and into the spawning river or nursery areas shown on the map. Both fragile and appetizing as food for larger prey animals, the larvae struggle for several weeks to reach the juvenile stage. Scientists have determined that the survival rate of these vulnerable larvae is critical in predicting the success of future Bay stocks.

Although not free of danger, the juvenile striped bass has a much better chance of survival than it did as a larva. The young tend to congregate in schools and remain in the river or estuary in which they were born for about 2 years. At 2 or 3 years of age, following instinctual urges, the bass move out of the tributaries toward the Bay mouth. Until they reach sexual maturity, many males and females move into a seasonal Atlantic coast migration. Upon reaching maturity, they migrate back to their natal spawning grounds.

The timing of the annual Bay migration varies to some extent each year. In their 1988 survey, the MD Dept. of Natural Resources, VA Institue of Marine Science and Fish & Wildlife Service have found spawning striped bass in the Nanticoke, Patuxent, Potomac and Choptank rivers in Maryland and the Rappahannock, James and York Rivers in Virginia--a week earlier than last year.

In 1985, recognizing that the long-term success of the striped bass fishery was in peril, Maryland banned both recreational and commercial harvests of these fish. Virginia followed suit with a partial ban of its own. The federal Emergency Striped Bass Bill, passed in 1984, supports research on the striped bass. The Studds legislation quickly followed, mandating that Atlantic states must reduce their catch of bass born in or after 1982 which effectively reduces the harvest of striped bass. Both federal, state and private (BG&E) agencies are supplementing protection efforts with the release of hatchery-raised fish.

Although overharvesting is undoubtably a factor in depleting striped bass numbers, many scientists suspect that other factors including natural and man-affected water quality conditions are also to blame. Research has shown that acid rain in the upper tributaries is detrimental to egg and larvae development. Eggs are very sensitive to pH levels under 7. Acidic conditions and high aluminum concentrations in the water from heavy rainfall are increasing larval mortality.

The annual striped bass surveys by Virginia and Maryland yield an average number for each state called the "juvenile index." An index of 8.0 is the historical average, but the last index over 8.0 in Maryland occurred in 1982. When the Maryland index averages 8.0 for 3 years running, recovery of the striped bass population will be on its way. On the positive side, Virginia had an all-time record index of 14.0 in 1987.

Protection efforts in Maryland are geared primarily towards the 1982 year class. Half of the females from this class are now sexually mature and capable of spawning. The recent increase in Virginia and improved fishing in less stringently regulated D.C. waters give us reason for guarded optimism. The next few years will tell us if our efforts to revitalize the striped bass population are on track.

- Nina Fisher, Computer Sciences Corp.

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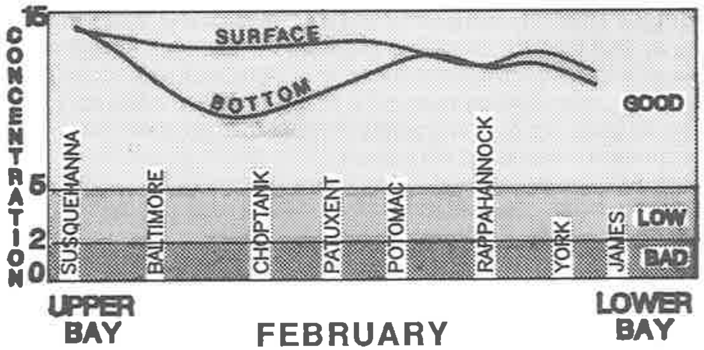
CHESAPEAKE BAY BAROMETER

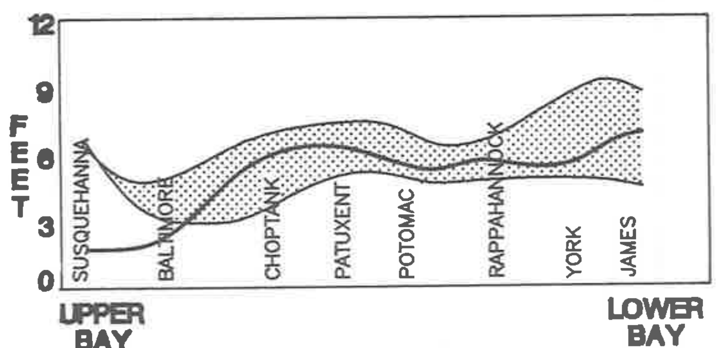
WATER QUALITY CHARACTERISTICS OF THE BAY



FEBRUARY

DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. During winter, the cold water of the Bay is capable of holding more DO. Levels of DO in the bottom and surface waters have remained fairly constant since January. In the next few months, levels should begin to decrease very gradually as the water warms with the advent of spring. For now, there is plenty of oxygen for the Bay's animals.

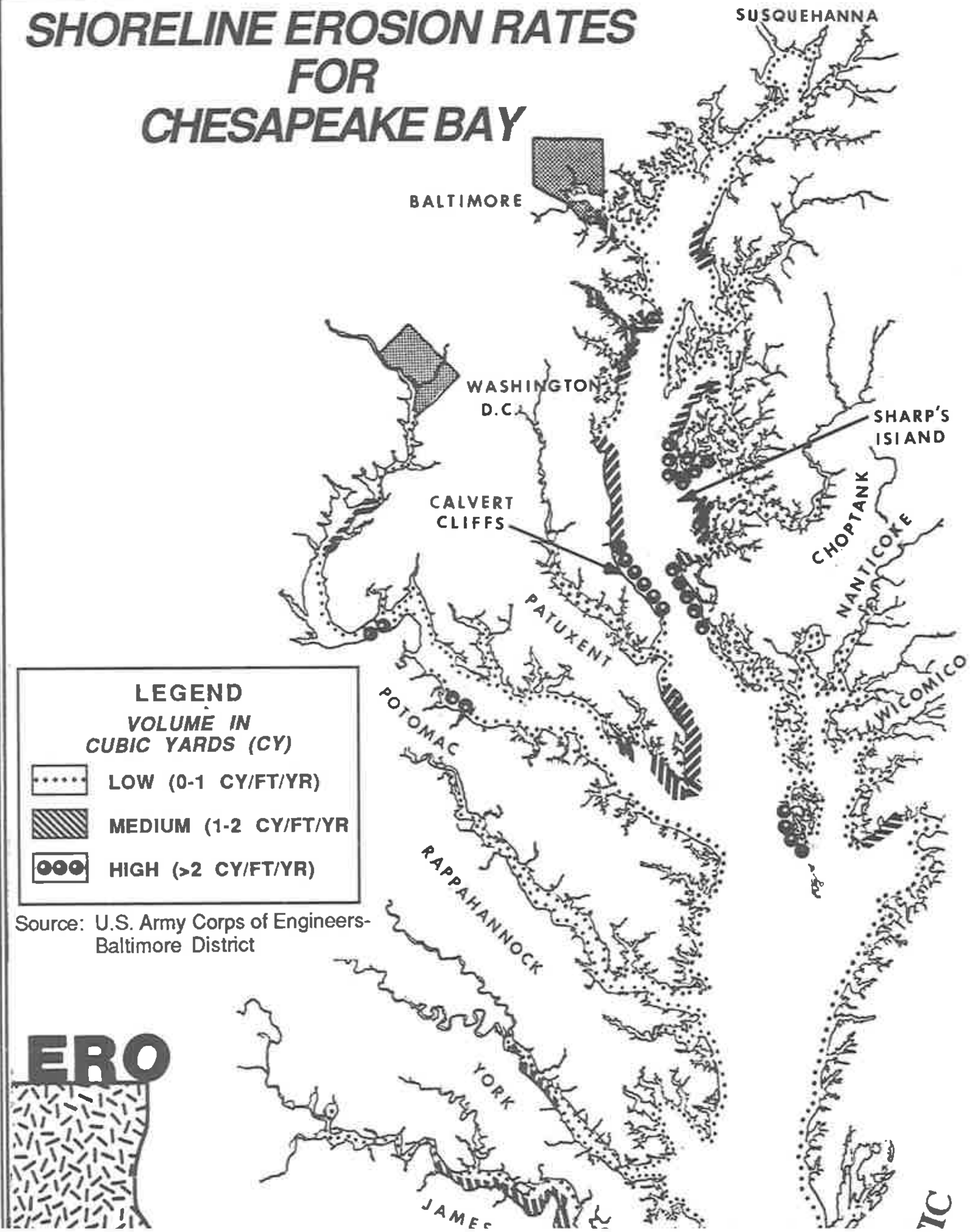


FEBRUARY

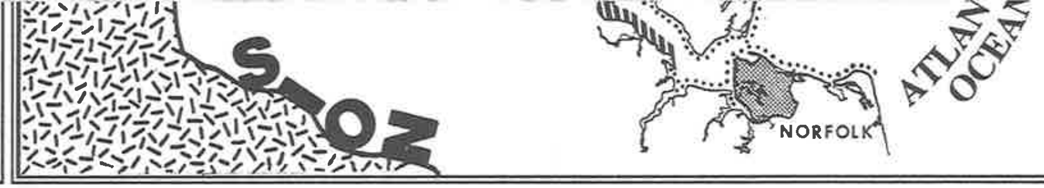
WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material including fine sediment and microscopic organisms

SHORELINE EROSION RATES FOR CHESAPEAKE BAY



Source: U.S. Army Corps of Engineers-Baltimore District normality for this time of year. The clarity of the water in February has dropped considerably in comparison with the extremely high clarity seen in January. This is probably due to the greater than average freshwater flows coming into the Bay from the Susquehanna River carrying large quantities of sediment.



MARCH HIGHLIGHT: SHORELINE EROSION

Sea level has been rising ever since the glaciers of the last ice age peaked and started to recede about 17,000 to 18,000 years ago. Rapidly at first, then slowing several thousand years ago, the sea has crept relentlessly inland claiming the edges of our continent as its own. Although rates vary from place to place, sea level rise along the east coast of the U.S. is currently estimated to be about 1 foot per century.

When the Environmental Protection Agency released a report in 1983 predicting possible sea level rises of up to 17.1 cm (6.7 in.) by the year 2000, scientific debate erupted. One issue, however, remains undisputed: sea level *will* continue to climb. The questions focus on how much and how soon.

Sea level is rising in response to global warming. The ever-increasing use of fossil fuels since the industrial revolution has boosted carbon dioxide (CO_2) levels in the atmosphere, enhancing the so called "greenhouse effect." CO_2 in the atmosphere traps heat radiating from the earth's surface. Warming of the atmosphere accelerates the thaw of polar and alpine glaciers; their meltwaters add to the volume of the oceans. As the atmosphere warms, so too does the ocean water. The warmed water expands, taking up more space in the ocean basins.

Aside from the scientific intrigue of studying an important global process, why should the rest of us care about apparently miniscule changes in the level of the sea? Beaches fortified with rip rap, sand bags and defunct tires, houses poised precariously at cliff's edge, and islands documented in colonial records that no longer exist (such as Sharp's Island), are reasons why changing sea level is of more than passing interest.

On a calm day along the Bay shore, the cliffs and beaches may appear secure. Yet, during a nor'easter or hurricane, the seemingly protected shoreline becomes vulnerable to attack by storm waves. If a storm coincides with a wind direction forcing water against the shore and a spring high tide (the highest tide of the month), the cumulative effect can be devastating. The steep, powerful waves of a storm are especially efficient in combing sand off the beach and biting into the base of rock cliffs. After the larger storms, the evening news shows houses askew on foundations and front porches suspended over badly eroded shore cliffs.

With stable sea level, the shore and water might reach an uneasy equilibrium. Beaches eroded during storms would reclaim sand during periods of calm. Cliff shorelines would remain out of reach of all but the greatest storm waves. With sea level creeping upward, however, new portions of land are exposed to wave attack. Sand and gravel beaches are the fortunate consequence of this erosion process. If we halt erosion of the cliffs, eventually the beaches will become starved of sediment.

The Bay Barometer map shows erosion rates (total volume contribution) for the Chesapeake Bay. Much of the Bay shoreline experiences only low rates of erosion. Yet, even low rates continuing over a period of time can result in substantial retreat of the shoreline. The areas suffering higher rates of erosion, such as Taylor Island on the Eastern Shore and Calvert Cliffs on the western shore, are concentrated in open portions of the Bay where the shore is exposed to unimpeded pounding by the waves. The southern banks of several western shore rivers also are vulnerable to erosion, however. The strong northerly and northeasterly winds of late fall through early spring direct powerful waves at these shores.

Although erosion (and the opposing process--accretion) are natural events, the presence of man around the Bay has accelerated the rate of both processes. Shorelines which we have stripped of vegetation are highly susceptible to erosion. Channels vital to shipping traffic often become plugged with sediment and have to be dredged. Boat wakes create waves that hasten shoreline wasting. All this sediment movement causes major problems for the Bay's animals and plants by settling on their surfaces, blocking essential sunlight, and clouding the water.

Homeowners may be able to slow the erosion rate of the shoreline fronting their properties. Shore protection is an expensive proposition: even "low cost" methods usually require a large initial outlay as well as maintenance over the years. Bulkheads may be used as retaining walls to prevent slumping of a bluff face. Revetments of sand bags, rip-rap, specially designed concrete blocks, or mesh baskets filled with stone are used to armor the beach face. Nourishment of the beach with imported sand, seawalls, and groins are even more costly erosion prevention techniques. None of the methods is guaranteed and, although often partially effective, may cause additional erosion problems on adjacent shore property.

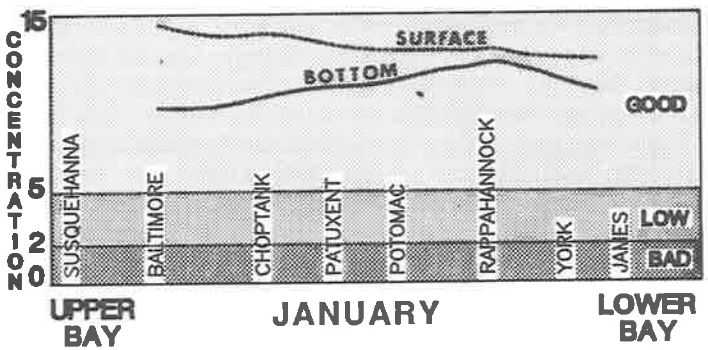
Inevitably, businesses and homeowners with properties along the shore will take measures to protect their investments. But, the Bay is a dynamic entity: people must accept that erosion cannot be halted--only slowed or temporarily stalled. The waves and rising sea level are incessant. Eventually, despite our protests and efforts, the shoreline will position itself as it pleases.

- Nina Fisher, Computer Sciences Corp.

The Barometer is produced by the Monitoring Subcommittee of the federal/state Chesapeake Bay Program. The Subcommittee would like to thank Dr. Robert Byrne, VIMS, for his contribution.

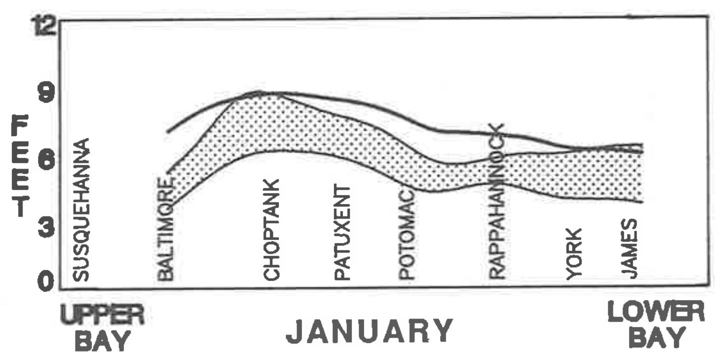
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. During winter, the cold water of the Bay is capable of holding more DO. Although data is missing near the Susquehanna, the rest of the Bay has the greatest amount of DO (in both the surface and bottom waters) observed since last winter. DO will begin to decrease when water temperatures start to increase in early spring.

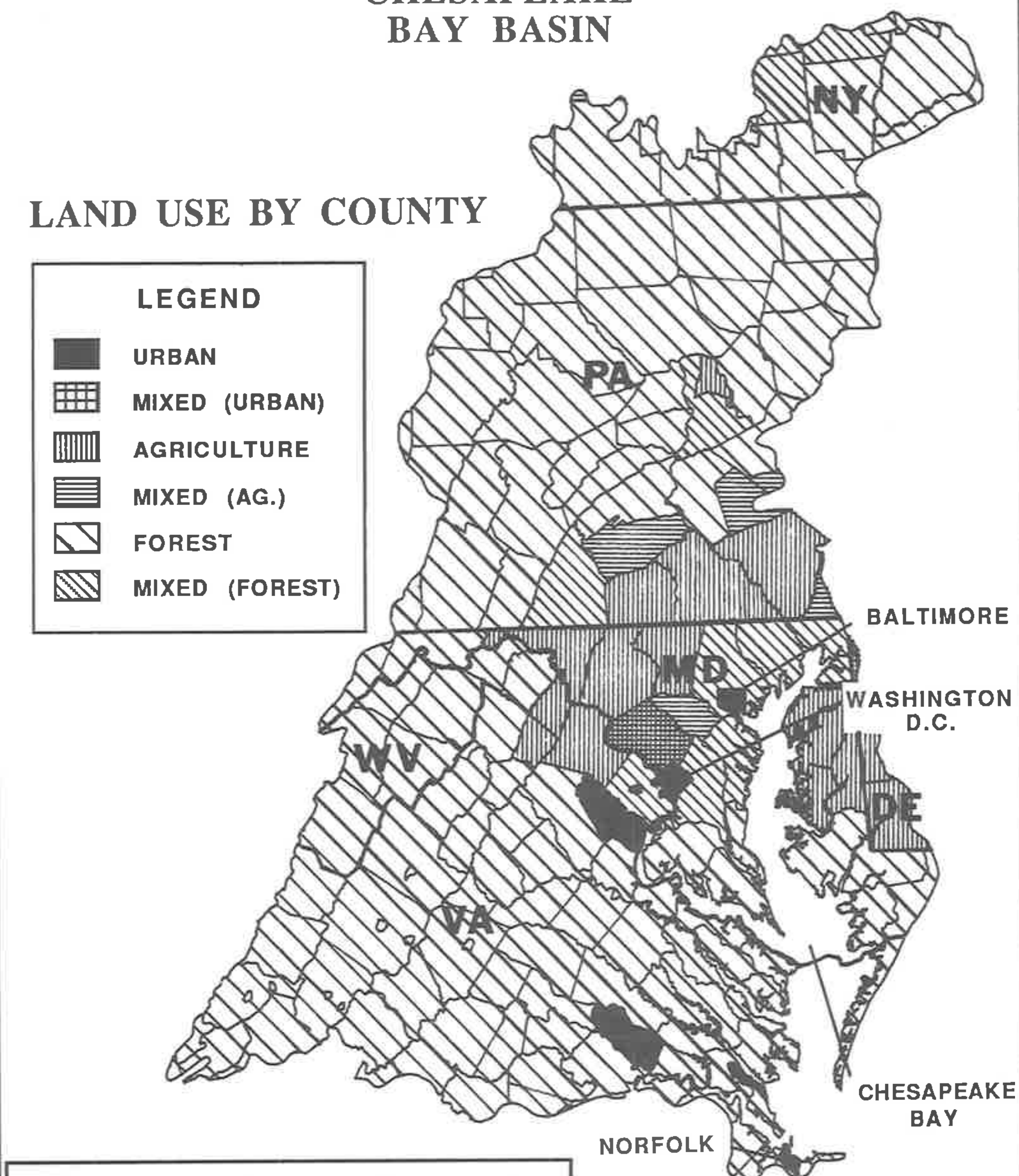


WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

CHESAPEAKE BAY BASIN

LAND USE BY COUNTY



STATE	% AGRICULTURE	% FOREST	% URBAN

normality for this time of year. The clarity of the water in January was higher than average for most of the Bay. Lower than average precipitation in the basin, with this precipitation in the form of snow, may account for the high water clarity. Low precipitation means less sediment will be washed into the water.

NY	28.8	56.5	14.7
PA	28.5	64.9	6.6
VA	22.5	68.2	9.4
WV	25.2	62.6	10.1
TOTAL	27.3	62.6	10.1

FEBRUARY HIGHLIGHT: LAND USE

Traveling back through time to John Smith's arrival in the Chesapeake Bay, a present-day inhabitant probably would have great difficulty recognizing the surrounding lands. In 1608, thick, mature forest flourished to the water's edge, with only occasional breaks in the cover where lightening-caused fires opened short-lived spaces in the forest canopy. With soil tightly bound by tree roots, and nutrients such as nitrogen and phosphorus released slowly to the Bay, the relatively clear waters of the Chesapeake abounded with fish, oysters, crabs, and underwater grasses.

With the diligence so characteristic of the pioneer mentality, land surrounding the Bay and its tributaries was rapidly cleared for farming. Fertile lots next to the water were most desirable in an age where transportation was primarily by boat. Today, no longer reliant on the waterways for transportation, we are still drawn to the waterside for a variety of other reasons.

In the Chesapeake Bay basin, there are currently 3 major land uses including both natural and disturbed types: agricultural (cropland and pastureland), urban (suburbs, cities and industry), and forest (including idle land). The Barometer map shows the predominant land use for each county in the Bay basin based upon 1978 data. Counties that do not have a predominant land use (greater than 50%) are designated "mixed" with the dominant use in parentheses. Most of the urban and agricultural lands cluster close to the Bay and its tributaries with the forests concentrating in the outlying areas. In recent years, a large amount of agricultural land near the Bay has been developed and now is considered urban.

To most people, farming has always seemed to be a "natural" lifestyle--rivaling, perhaps, only life in the deep woods in terms of pure idealism. Yet, from the Bay perspective, land converted to agricultural use is hardly in a natural state. In the past, as farmers sought means to boost crop yields in the face of rising costs and the shrinking size of agricultural plots, they turned to heavy application of nitrogen and phosphorus fertilizers, liberal use of pesticides, and planting of every possible acre of land.

The consequences of these practices soon became apparent. Cleared fields on sloped land were prime targets for destructive soil erosion. Dissolved nitrogen as well as phosphorus bound to soil particles found their way into waterways, fueling the overgrowth of phytoplankton and ultimately depleting summer waters of dissolved oxygen. Sediment clouded the water, destroying submerged plants and smothering immobile shellfish. Rainwater that did infiltrate the ground carried contaminating nitrogen down to the water table.

With the realization in recent years that neither the farmland nor the Bay could indefinitely survive such harsh treatment, lower impact farming techniques were developed and encouraged. Measures such as conservation tillage, contour strip cropping, and nutrient management have helped to reduce soil erosion and the wash of nutrients and pesticides into waterways.

Unlike farming, there is no pretense that urban lands constitute a natural environment. Draped with asphalt and cement, cities, suburbs and industrial areas pose different sorts of problems to the Bay. Rainwaters running off town and city streets accumulate a wide variety of pollutants: toxic substances from car emissions, industries, and buildings; nutrients from home use of fertilizers; bacteria and nutrients from animal feces and faulty septic systems; and sediment from development and other open areas wash into the Bay and its tributaries.

Alleviating water quality problems due to urban land use is difficult--it demands a lot of money, commitment of citizens, improved planning and often unpopular political decisions. Measures to improve water quality include increased use of porous paving materials, improved stormwater managment, proper disposal of toxic compounds, creation of artificial wetlands to remove nutrients, sediment and toxic substances, and planting of land strips bordering waterways.

Although the majority of forests in the basin have felt man's touch at some time, they remain largely in a natural state with regard to Bay concerns. As was true in John Smith's day, the trees of a forest still bind the soil and stabilize slopes, permitting only minimal release of sediment and nutrients to Bay or tributary waters. Forests bordering the spawning streams for Bay fish are critical in maintaining sufficiently good water quality for successful reproduction. In anticipation of continued demand for land development, the maintenance of forests throughout the basin, but especially in the critical zone along the waterways, will help to mitigate problems resulting from this development.

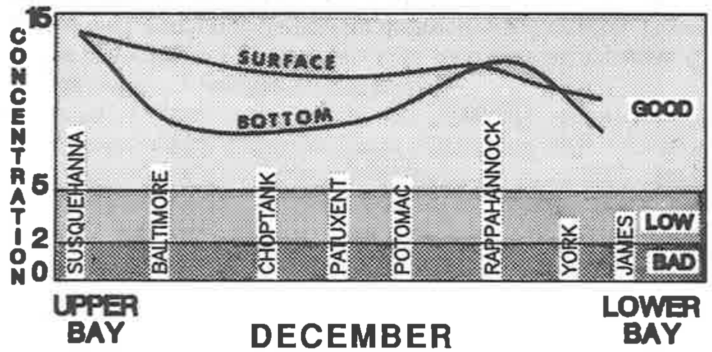
Armed with a copy of a land use map for the Chesapeake Bay basin, developers might point to the high percentage of forested land as justification for a fast pace of continued development. Yet, the percentage of forest may not be as important as the distribution of that forest within the basin. The Maryland Critical Area Act recognizes the significance of vegetation lining the waterways to maintain good water quality. Development acknowledging the importance of different land use types ultimately will pay its reward in a cleaner Bay.

- Nina Fisher, Computer Sciences Corp.

The Bay Barometer is produced by the Monitoring Subcommittee of the federal/state Chesapeake Bay Program. The Subcommittee thanks Mr. James Hannawald (SCS) and Ms. Lynda Liptrap (CSC) for their contributions.

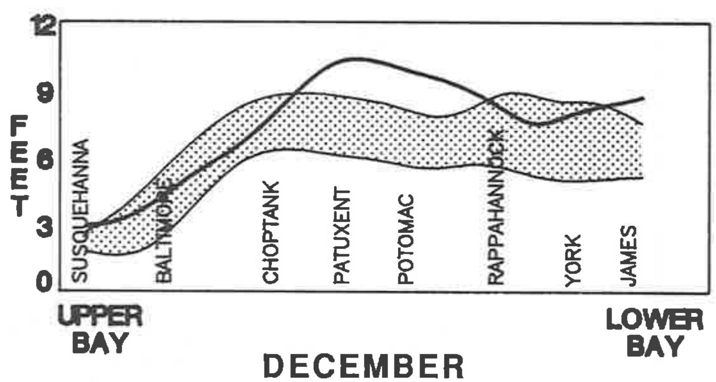
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. During winter, the cold water of the Bay is capable of holding more DO. Both the surface and bottom waters remained in the GOOD zone and there is plenty of oxygen for the Bay animals. Off the Rhappahannock, the bottom water contains more DO than the surface water. This may be due to mixing action bringing oxygen to the Bay bottom.

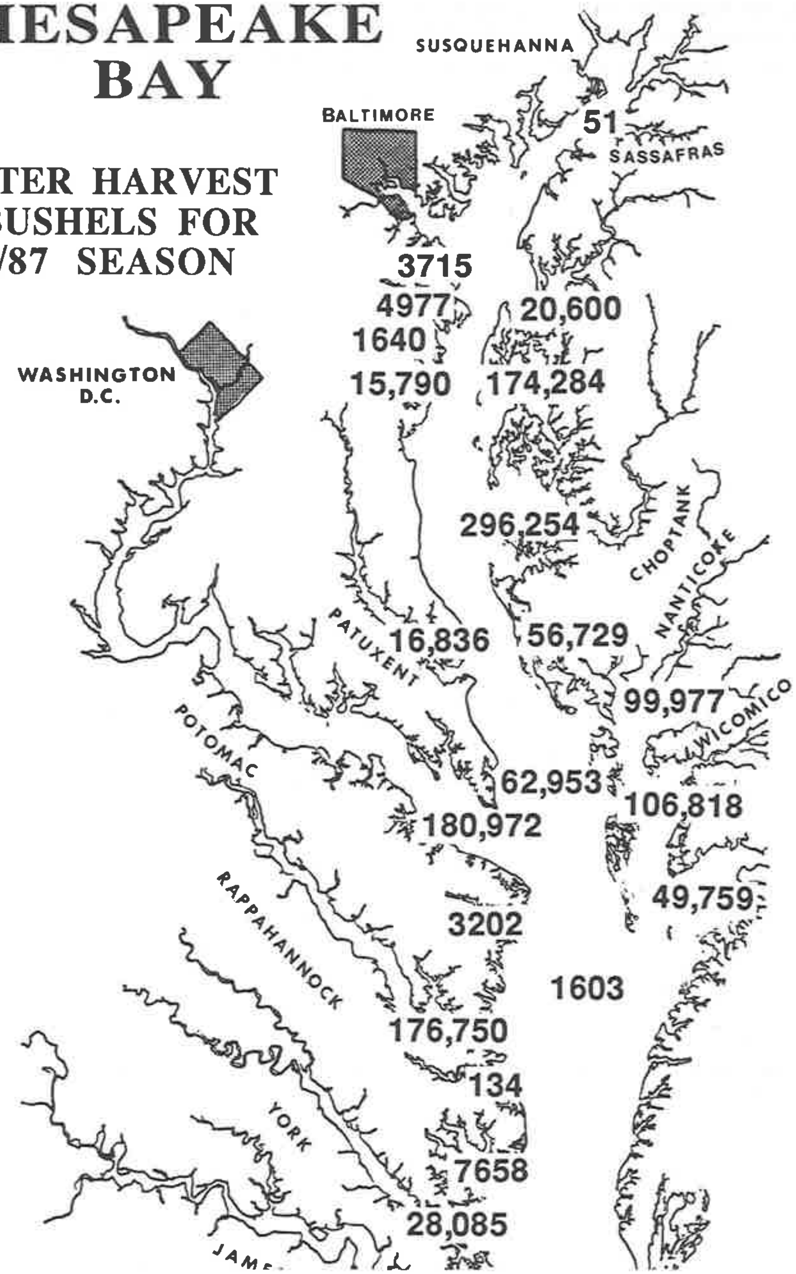


WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

CHESAPEAKE BAY

OYSTER HARVEST IN BUSHELS FOR 1986/87 SEASON



a zone of normality. The water off the mouths of the Potomac and Patuxent was clearer than usual compared to this zone. The rest of the Bay had average clarity. Generally, water clarity has increased from summertime lows due to decreasing amounts of plankton as temperatures have cooled and biological activity has slowed.

JANUARY HIGHLIGHT: THE OYSTER

The first person to taste an oyster must have faced the experience with some trepidation. After all, a raw oyster on the half shell is not the most appealing of foods. Yet, this hesitancy probably was short-lived. As millions of people can attest, the oyster has become one of the most sought after delicacies in the world.

In fact, so many people have feasted on this mollusk that overharvesting, along with pressures from disease and pollution, have resulted in severe depletion of oysters stocks. Nowhere is this more strongly felt than in the Chesapeake Bay -- once the foremost producer of oysters in the country -- where harvests of oysters have steadily declined since the late 1800s.

Aside from its culinary appeal, the oyster's biological life history provides other interesting details. Spawning (the release of eggs or sperm) by adult oysters starts in early summer when water temperatures exceed 20 C° (59° F). Millions of eggs and sperm are released into the water -- a small percentage of the eggs are fertilized and become oyster larvae.

As a larval youngster, the oyster's free-wheeling days are numbered. For 2-3 weeks, the larvae swim weakly through the water. At the end of this stage, they migrate to the Bay bottom in search of hard, clean substrate (especially old oyster shells) on which they may attach or "set." Upon attachment, they become known as spat. Once the oyster has set on the Bay floor, it resides there for the remainder of its life.

Under ideal conditions, oyster larvae locate suitable substrate and the spat grow quickly as they filter and feed on a profusion of plankton and bacteria in the water. The sexual identity of the oyster is a confusing issue for the first few years as oysters can change gender. By the end of the first or second growing season, most young are male. Entering the third season, there are approximately equal numbers of females and males, with females predominating thereafter.

A variety of natural and man-induced factors complicate this life cycle and may play a role in hindering the oyster's ability to reproduce and survive. Although oysters can tolerate a wide range of salinities, they generally fare better in more saline waters (5 - 32 parts per thousand (ppt)). Oyster-afflicting diseases, such as MSX, a parasite, and Dermo, a fungus, also thrive in higher salinity waters (>12-15 ppt). When periodic droughts develop and higher salinity levels move up Bay, which occurred in the mid-1960s and early to mid-1980s, oyster populations may be decimated by these diseases. The oyster drill, a snail that bores into the shells to eat young oysters, also prefers high salinity water.

In addition to naturally occurring fluctuations of salinity, water temperature, and climate, other stresses are imposed on the oyster by human activities. Pollution, especially excessive nutrients, sediments, and toxins, have substantially contributed to the dwindling harvests of the 40 years. An overload of nutrients, such as nitrogen and phosphorus, results in depletion of dissolved oxygen (DO) levels in the bottom water of the Bay. If warm summer conditions cause DO to drop close to zero in tributaries where oysters live, they may be further stressed or perish.

Rainwater washing over city streets and farmland pours large quantities of sediment into the Bay and its tributaries. Not only can sediments smother oysters, but even a few millimeters of sediment on the bottom substrate may be sufficient to prevent larval oysters from setting. Although the effects of toxic substances on oysters are still unclear, it is likely that some of these substances interfere with larval setting and may reduce survival rates.

An entire way of life has developed around the harvest of oysters from the Bay over the past three centuries. Along with pollutants, the annual harvest has severely strained the ability of the oyster to keep pace. Watermen, independent as they are, do not take kindly to restrictions placed upon their catches as was done last year in the James River seed areas, where no limitations previously existed.

The Bay Barometer map shows the harvest in bushels for the 1986-87 season. Harvests from many of the tributaries dropped compared to the 1985/86 season due to the spread of disease. However, the James posted increases in oyster harvests. This may have been a result of salinity shifts in the Bay from the dry weather conditions. Part way through the 1987/88 season, early Baywide indicators suggest that this year will be slightly worse than last year.

The oyster story in the Bay is not a happy one. Biologists tell us that oyster harvests can increase only if overharvesting is prevented and threats from disease and pollutants are considerably lessened. The newly signed Chesapeake Bay Agreement, through Baywide oyster management, points us in the direction to tackle these problems.

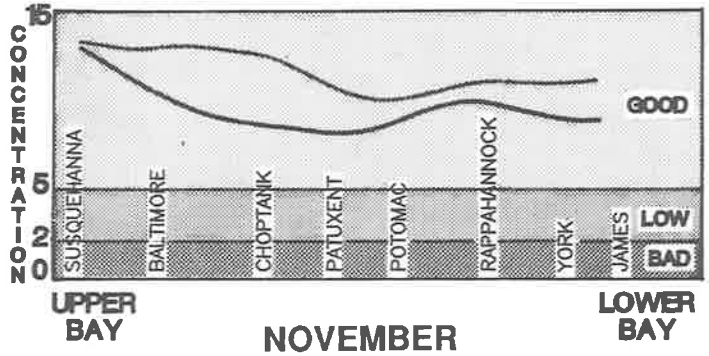
- Nina Fisher, Computer Sciences Corporation

The Barometer is produced by the Monitoring Subcommittee of the federal/state Chesapeake Bay Program. The Subcommittee would like to thank Dr. Victor Kennnedy for his assistance.

APRIL 1987 - DECEMBER 1987

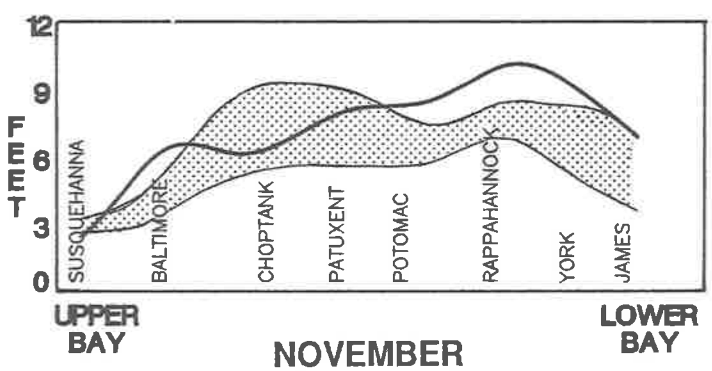
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. As temperatures cool with winter approaching, the water is capable of holding more DO. Both the surface and bottom waters of the Bay have moved into the GOOD zone, which means that plenty of oxygen is available for the Bay's animals. Also, the difference between the amount of DO in surface and bottom waters is now negligible.

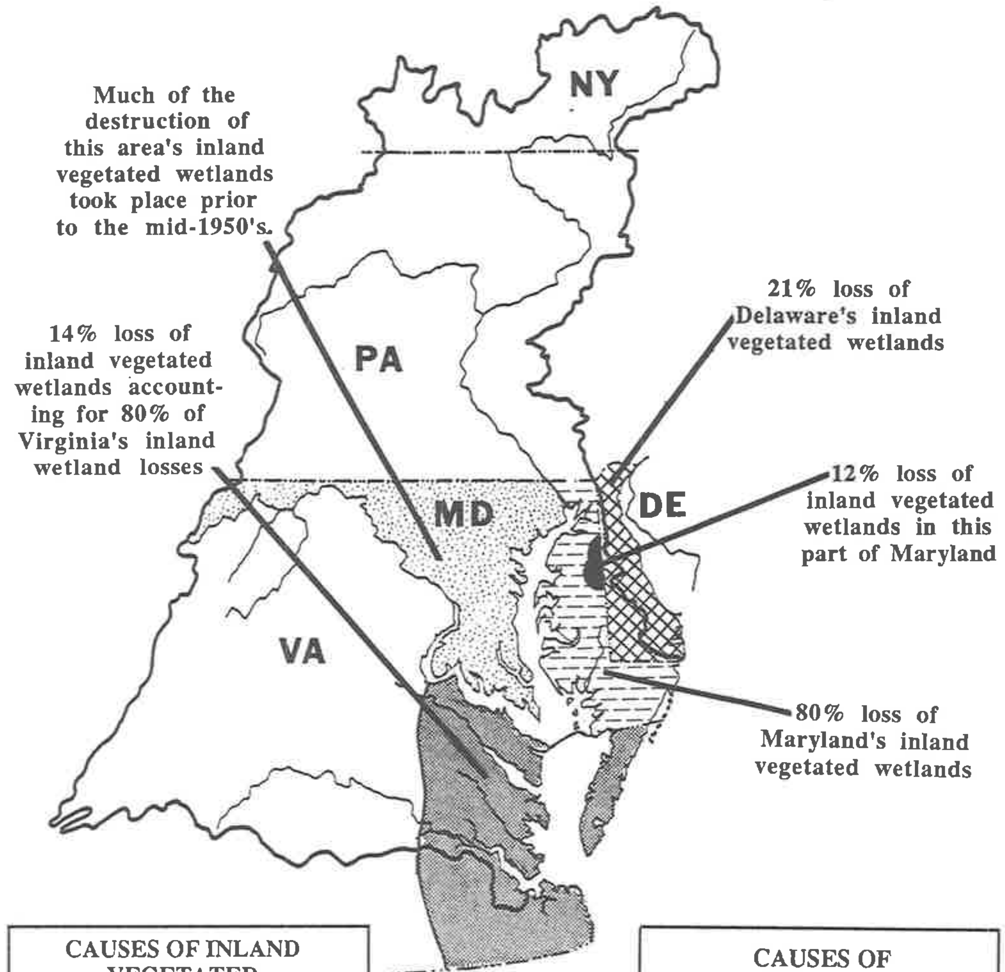


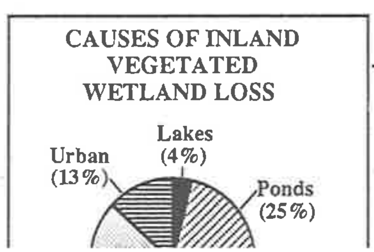
WATER CLARITY

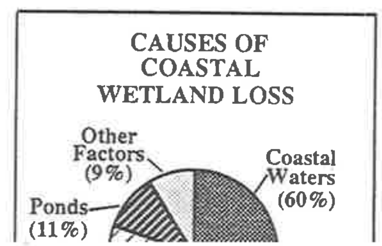
Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

CHESAPEAKE BAY BASIN

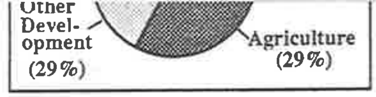
INLAND VEGETATED WETLAND LOSS FROM MID-1950s TO LATE 1980s IN THE BAY AREA*







a zone of normality based on the past few Novembers. The water off the mouth of the Rappahannock is clearer than it has been compared to this zone. Generally, water clarity has increased from summertime lows due to decreasing amounts of plankton in the water as temperatures cool and biological activity slows.



*Information taken from: Mid-Atlantic Wetlands - A Disappearing Natural Treasure (US Fish & Wildlife and Environmental Protection Agency)

DECEMBER HIGHLIGHT: WETLANDS

Wetlands might fare a lot better if we could come up with a name reflecting their real worth. For decades, the name seems to have been used as a synonym for wastelands -- unimportant, saturated ground that can only be made useful to man if filled or drained.

This myopic view led to the destruction of over half the wetlands that existed in the U.S. during colonial times. If the land was too wet to grow crops or build houses, we filled it. If mosquitoes grew too thick, we tried ditching and draining the land. And if we couldn't find a better use for these wetlands, we insulted them with the ultimate indignity: the wastes of our society -- trash, sewage and toxins -- were dumped on them.

Recently, we have begun to appreciate the significance of these lands, but the destruction continues. Along the east coast, demands for housing, urban expansion, and the use of filled wetlands for agriculture have continued to bring about wetland destruction, despite regulations protecting certain types of wetlands.

Wetlands are low-lying lands flooded for some period of time during the growing season. To the casual observer, however, identifying a plot as wetland may prove difficult. Different combinations of factors including salinity, climate, topography, the amount of water and sort of vegetation result in various types of wetlands. A wetland can be a shallow, vegetated pond or a depression saturated with water for part of the year. The vegetation may resemble a thick, grassed field ready for haying or may look like a drowned forest with tall trees.

Wetland types can be simplified by dividing them into two broad categories: coastal and inland. Coastal wetlands consist primarily of tidally flooded marshes and mudflats with salt-tolerant grasses and other non-woody plants. Some of these wetlands occur in the freshwater portion of coastal rivers but are still affected by tidal forces. Inland, beyond the influence of tides, freshwater grass, shrub or forest wetlands with salt-intolerant plants replace their coastal counterparts.

Wetland diversity and productivity are key to the growing concern over wetland loss. Wetlands often form highly productive transition zones between dry uplands and aquatic environments. This characteristic makes them important to a wide range of plants and animals from both environments that depend fully or in part on the wetlands for survival.

Migratory waterfowl rely on wetlands for feeding and cover during their semiannual treks north and south. Coastal marshes provide spawning or nursery grounds for several species of estuarine and ocean fish and shellfish. Inland, freshwater fish comb non-tidal wetlands for food. They also may spawn there, providing their young with productive nursery grounds.

Although the importance of wetlands to animals and plants is obvious, their other values may be less conspicuous. Water that circulates through wetlands prior to entering the Bay is cleansed -- excessive nutrients are taken up, sediments fall from suspension in shallow, vegetated waters, and toxins may be removed. During storms, floodwater is stored, protecting downstream areas from erosion and removing sediment before it can smother oyster beds and choke submerged vegetation. Wetlands can be prime recreational grounds -- if handled carefully -- providing us with fertile hunting and fishing grounds, the opportunity to view wildlife, and pleasant terrain for hiking and boating. Especially around Chesapeake Bay, where the Bay is at once our livelihood, recreation, and a source of food, the wetlands are vital to the future of the Bay, itself.

The Barometer map for this month shows the percentage loss of inland vegetated wetlands in portions of Maryland, Virginia, and Delaware. The majority of these losses was due to draining of the wetlands for agriculture and related channelization from the mid-1950s to the late 1970s. Other causes shown in the pie charts reveal the relative importance of both manmade and natural changes responsible for the loss of inland and coastal wetlands.

Despite protection of some wetlands by the Clean Water Act, state protection of coastal wetlands, and government and private land purchase to preserve inland and coastal wetlands, loopholes legally allow continued destruction of these invaluable lands. Excavation of wetlands may not require a permit. Agricultural lands are exempt from federal regulation although subsidies have been cut off for wetlands converted to agricultural land after December 23, 1985. Even wetlands protected from physical change may suffer from the onslaught of polluted, sediment-laden water from surrounding developed areas.

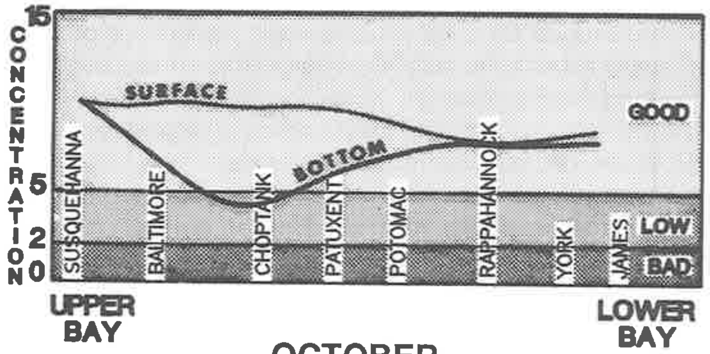
The new Bay Agreement addresses wetland protection, by requiring development of a Baywide policy for the protection of tidal and non-tidal wetlands by December, 1988. With public support, the trend of wetland destruction that has occurred since this area was first settled can be stopped. By doing so, we are ultimately helping to save the Bay.

- Nina Fisher, Computer Sciences Corp.

The Bay Barometer is produced by the Monitoring Subcommittee of the federal/state Chesapeake Bay Program.

CHESAPEAKE BAY BAROMETER

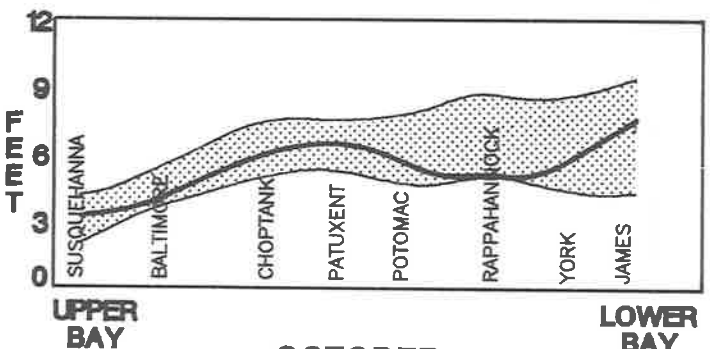
WATER QUALITY CHARACTERISTICS OF THE BAY



OCTOBER

DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by plant photosynthesis. For the first time since last June, the water in the bottom of the Bay has moved out of the bad zone. As temperatures cool with winter approaching, the water is capable of holding greater amounts of DO. Oxygen may be mixed into the water by storm winds and as biological activity slows, less DO is removed from the water.

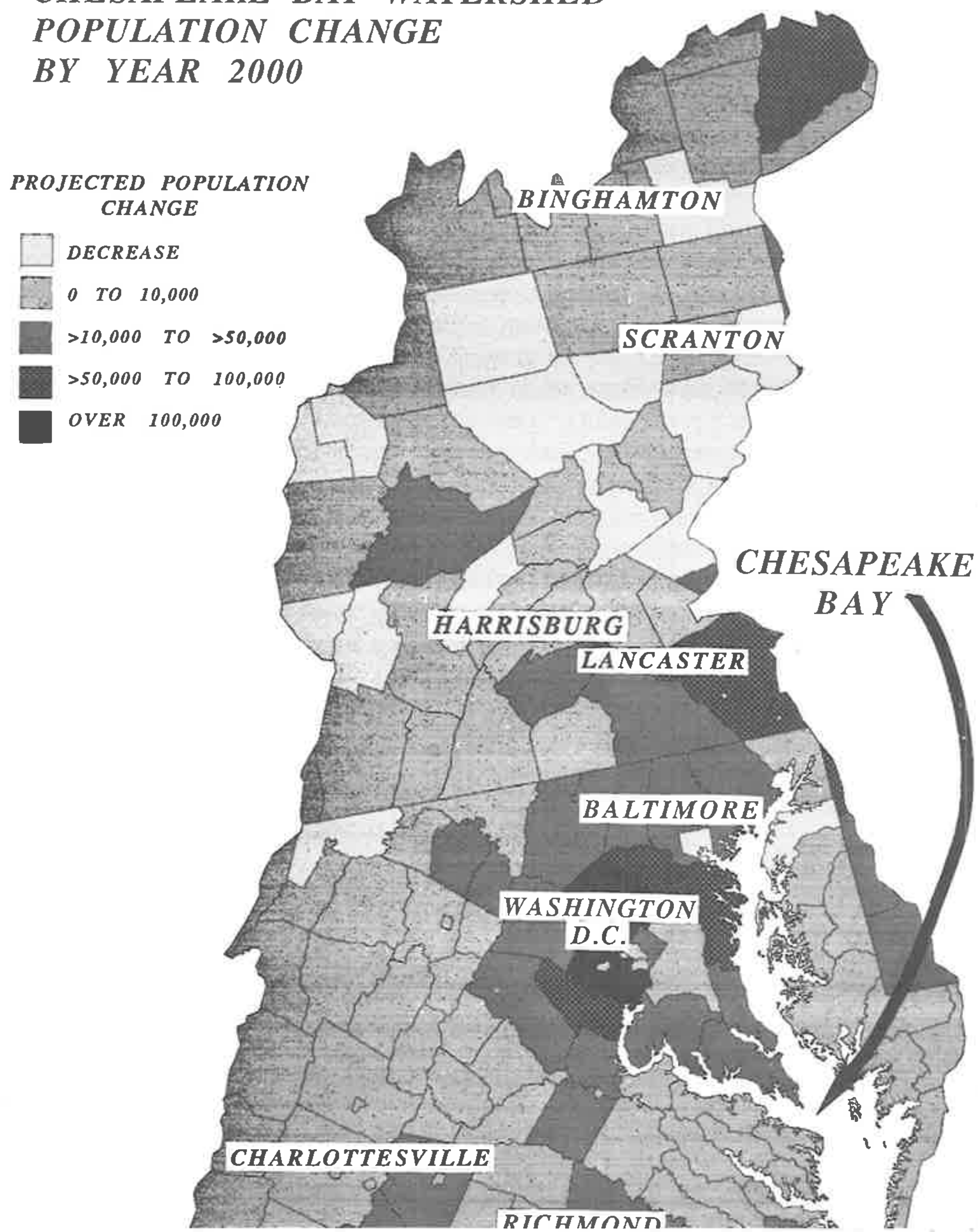


OCTOBER

WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended

CHESAPEAKE BAY WATERSHED POPULATION CHANGE BY YEAR 2000



a zone of normality. The entire main Bay had average water clarity for the month of October. Off the mouth of the Rappahannock River, water clarity was low but still normal. In general, water clarity is increasing from summertime lows due to decreasing amounts of plankton in the water as temperatures cool.

NOVEMBER HIGHLIGHT: POPULATION

The Chesapeake Bay is a victim of its good looks and popularity. Hordes of admirers have flocked to its waters and shores to boat, fish, swim, hunt or explore. Many have chosen to stay - constructing homes not only along its banks, but throughout the watershed that it drains. Even remote areas that seem unrelated to the Bay, attract large numbers of people who want to be within driving distance of the Bay or close to major cities. And, ultimately, the wastes from all these people - tourists and Bay shore and watershed residents - afflict the Chesapeake Bay.

Through the years, large areas of the Chesapeake Bay watershed have been and continue to be altered to meet the needs of thousands more people. Forests are cut to make way for homes and shopping malls, wetlands filled to allow metropolitan areas to creep outward, and large sections of shoreline stabilized to protect property from erosion. To cope with population demands, municipal and industrial treatment plants must process increasingly large quantities of waste, public services must expand, and more land area has to be used for disposal of solid and hazardous wastes. While these and other changes have allowed the Bay area to accommodate more and more people, the cost on the environment has been high.

Several important elements help to shape the development potential of an area. The economic strength of the region forms the foundation for growth; people are drawn to areas that offer jobs. The major cities often form centers with growth occurring in their less populated outskirts. To accommodate expansion, transportation corridors and sufficient sources of both energy and freshwater supplies must be available or created. In the Bay basin, energy is provided by hydroelectric stations, coal and nuclear facilities, while imported oil is brought up the Bay on barges. Freshwater for domestic and industrial purposes is available from the numerous rivers that feed into the Bay. Finally, expansion can occur only if land for development is available.

The growth potential of the Bay watershed remains high based on these factors and the Bay's proximity to other major commerce centers such as New York and Philadelphia. And, growth in recent years attests to the attraction of this area. From 1950 to 1980, population in the Bay region increased about 50%. While some areas grew slowly over this period, areas like the Patuxent River basin had an increase in population of more than 200%. Over the entire Bay watershed, estimates show that by 2020 the population may double that of 1980.

The Barometer map shows projected population change (numbers of people) in the Bay basin by year 2000. Basinwide, population estimates show an increase of 11% from 1985 to 2000. The greater Washington D.C. and Norfolk areas are expected to have the greatest increases. Growth is anticipated not only in environs immediately surrounding D.C., but in several counties well outside the city limits. In general, counties nearest the Bay will grow much more rapidly than distant counties.

Rising numbers of people in the region are stressing the natural resources and the environmental consequences are far-reaching. As more areas become urbanized, runoff containing toxics, wastes and sediment washes into Bay waters. Toxics can cause abnormalities in organisms, reduce reproduction, or be downright lethal. Large quantities of sediment smother oyster and clam beds and reduce water clarity, restricting the growth of beneficial aquatic plants.

Expansion of municipal and industrial treatment plants means more wastes are processed with the effluent ultimately reaching the Bay.

Demand for space may force land use changes such as deforestation for agriculture, fill of wetlands for shoreline development, and increasing quantities of non-porous asphalt and cement. As forest is stripped for agriculture, surface runoff containing sediment and nutrients increases. Nutrients fuel excessive growth of microscopic plants that cloud the water and use up dissolved oxygen when they die and decompose. Ongoing destruction of wetlands has caused the loss of valuable and productive land that helps filter and cleanse Bay waters.

In December, the governors of the Bay states, the mayor of Washington, D.C., the Chesapeake Bay Commission and the federal government will sign an Agreement to reinforce the commitment to save the Bay. The cleanup will be made increasingly difficult by the burgeoning population in the Bay watershed and efforts to restore Bay health will have to be applied at a faster and faster pace just to keep even with the wastes of a growing populace.

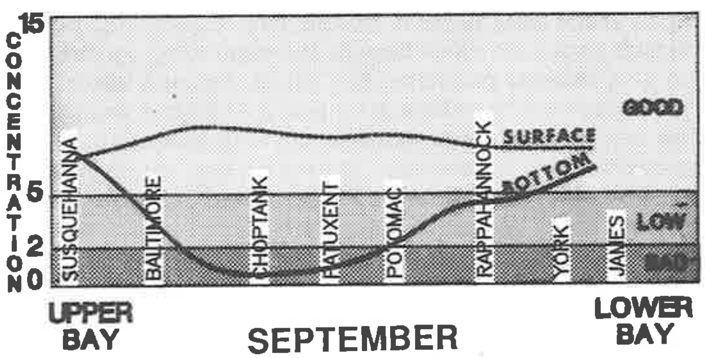
In recognition of the problem posed by increasing population, these officials will agree to substantially reduce nutrients flowing into the Bay by year 2000, adopt guidelines to direct land use and development, and appoint a panel of experts to report on projected population growth and development patterns. Other goals relating to water quality, protection of estuarine life, and land development will also be agreed upon. These measures, acknowledging the changes that come with the Bay area's ever increasing popularity, represent a major renewal of the commitment to save our Bay.

- Nina Fisher

The Bay Barometer is produced by the Monitoring Subcommittee of the state/federal Chesapeake Bay Program.

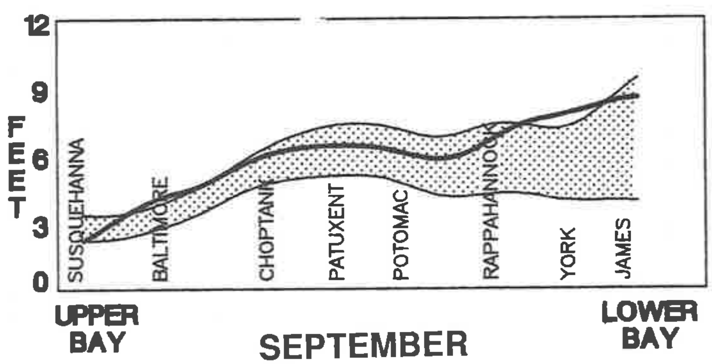
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



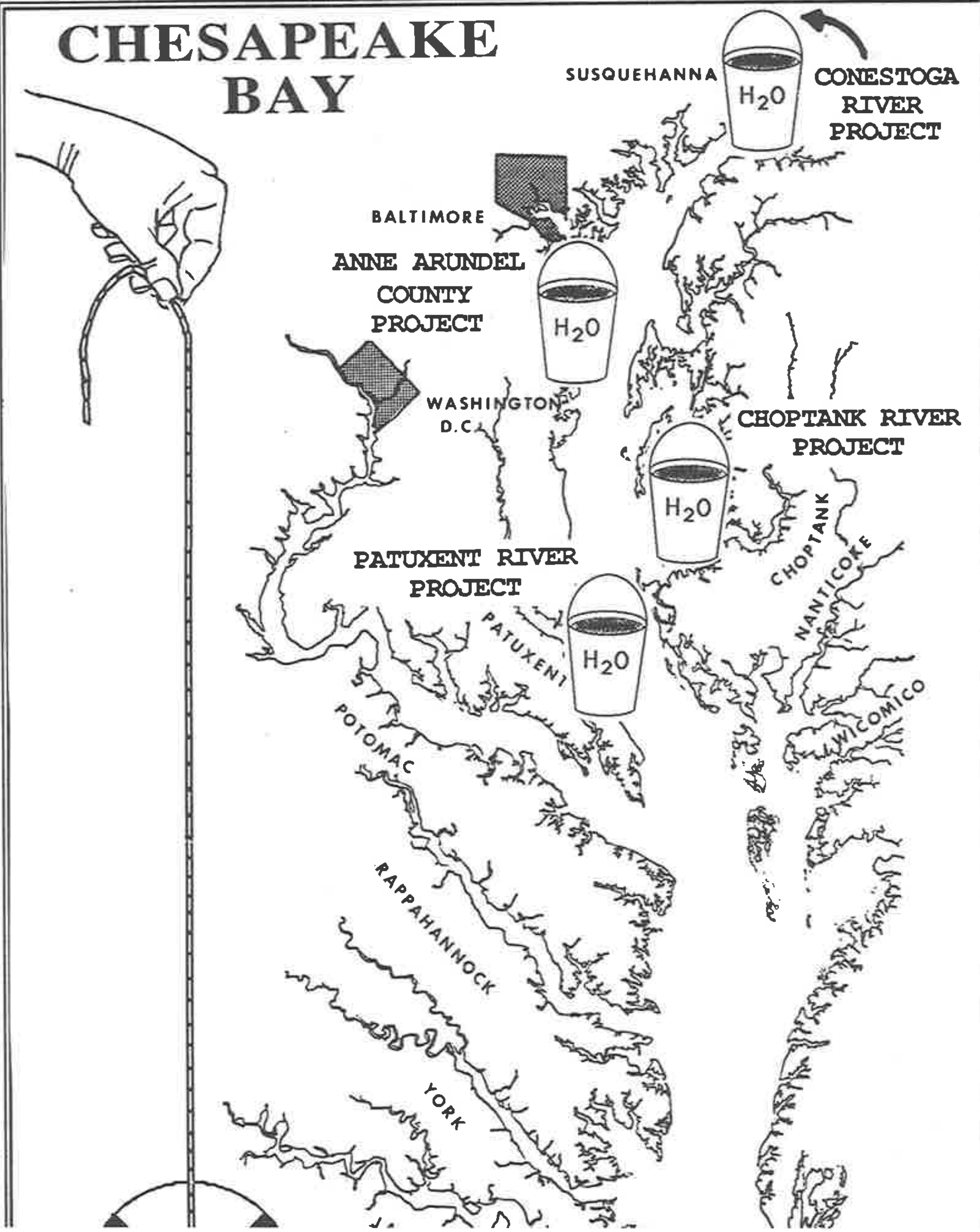
DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by phytoplankton (microscopic plants) photosynthesis. September's values show that the mid-portion of the Bay still has minimal amounts of DO in the bottom waters although the situation has improved since August. Compared to September 1986, the DO is not only lower in the mid-portion of the Bay but the area affected by low DO is larger.



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate



(plankton), reduce water clarity. The stippled area on the graph is a zone of normality. Much of the main Bay had average water clarity values despite a lot of rainfall in September. The data used for this graph were gathered before and several days after the major rainfall event of the month; therefore, the sediment associated with that storm are not reflected in the graph.

OCTOBER HIGHLIGHT: CITIZEN MONITORS

The Chesapeake Bay may be ailing, but there is no lack of people willing to play a role in trying to nurse this legendary "protein factory" back to health. Growing numbers of citizens are volunteering to maintain a careful, ongoing record of the water quality of the Bay and its tributaries.

The citizen monitoring project was launched in the summer of 1985 by the Citizens Program for the Chesapeake Bay (CPCB), a private organization that supports state and federal efforts to protect and restore the Bay. The CPCB chose two river basins where strong support for the welfare of their waters already existed; the James and Patuxent rivers. More than 35 people were trained in the basic techniques required to assess the water quality of the Bay. Sampling sites were set up on each river and the volunteers made a commitment to stay with the program for at least 6 months.

Once a week, each citizen volunteer takes a clean bucket and sampling kit in hand and heads for a designated site along the shores of their river. A sample is scooped from the river water, usually from the end of a dock or pier. The water temperature is measured immediately; the bucket of water is then carried back to the house for further analysis. Filling vials, tubes and bottles, tests are done to measure the pH (acidity or alkalinity), dissolved oxygen content, and salinity of the water.

Along with the water sample, a measure of the water clarity is taken using an instrument called a Secchi disc. The disc, divided into black and white quarters, is lowered into the water from the dock or pier. Just as the disc disappears from view, a reading of the depth is taken. The greater the depth, the clearer the water. Sunlight penetrates further into clear water, promoting the growth of desirable submerged aquatic vegetation. Volunteers also regularly record other observations such as weather, rainfall, and the occurrence of fish kills or algae blooms.

Scientists chose these particular variables to be monitored partially because they are easily measured and the tests are inexpensive. More importantly, these data are good indicators of the water quality of the Bay and its tributaries. Without adequate water quality, the plants and animals of the Bay cannot thrive.

After a year and a half of data collection, the results were compared to the state and federal data collected in the mid-channel of the same rivers. This was done to determine whether the data from the volunteer program were as reliable as the results from government monitoring stations. The data proved to be comparable. As a result, the Chesapeake Bay Program, which coordinates the state/federal cleanup campaign, endorsed the citizen program and recommended further expansion. The citizen program is now viewed both as a feasible method of collecting quality data and an effective means of involving citizens in the Bay cleanup.

The CPCB effort has resulted in the establishment of several other volunteer monitoring programs in the Bay area. The Conestoga River project in Pennsylvania began in fall, 1986. Conestoga volunteers routinely measure nitrate levels in addition to many of the other variables since nitrogen is a serious problem in the upper Bay. Supported by the CPCB staff, Anne Arundel County, MD has started volunteer monitoring of several creeks that ultimately empty into the Bay. The Department of Natural Resources oversees another project on the Eastern Shore's Choptank River. A different type of citizen program, run by the Fish & Wildlife Service with the support of the Chesapeake Bay Foundation and the CPCB, confirms the presence of submerged aquatic vegetation in the Bay and its tributaries.

Other regions of the U.S., such as the Albemarle/Pamlico estuary in North Carolina and the Puget Sound in Washington, are showing interest in developing similar citizen programs for their estuarine waters.

The volunteer monitors of the Chesapeake Bay include farmers, doctors, housewives, college students and bureaucrats. Many of these people have lived for years on their river and watched its decline with time. Their common concern for the Bay is the major reason why the volunteers choose to dutifully take their bucket down to the rivers not only in sun, but also in rain or snow. This commitment is important because volunteers can collect data rapidly during and after storms, often days before the government monitors are able to reach the rivers.

The weekly routine of river sampling has not only provided invaluable data, but has brought about an equally important result: the people involved in the program now speak of their river and the Bay with a renewed outlook. Sampling despite a 4" deluge of rain, one monitor wrote "Sheesh - nearly drowned in the rain last week, then almost blown overboard a couple of times today - starting to feel like a real scientist here! (But its fun!)."

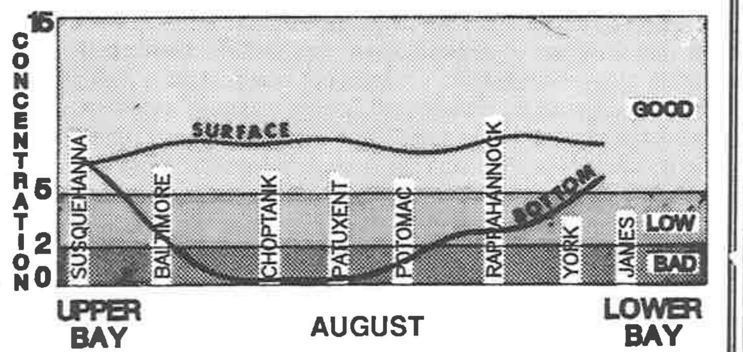
Hauling up buckets of water, jotting down observational notes, and standing out in the rain to stare at a disc lowered in the water has forced these volunteers to become critical observers of the Bay. They have learned how the Bay works and in doing so, have developed an appreciation of the complex interrelationships of this great system.

- by Nina Fisher

The Bay Barometer is produced by the Monitoring Subcommittee of the federal/state Chesapeake Bay Program. The Subcommittee would like to thank Ms. Kathy Ellett and Mr. Paul Schuette for their contributions.

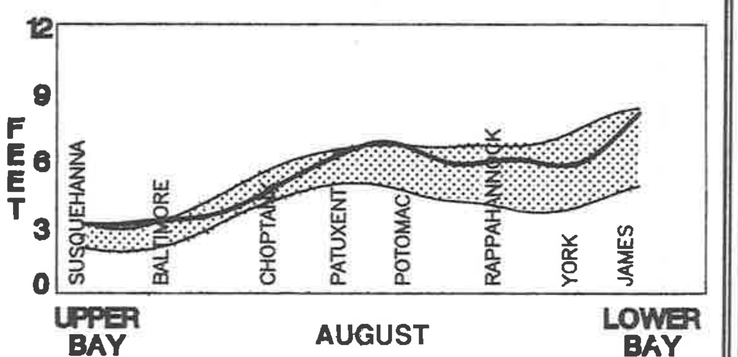
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

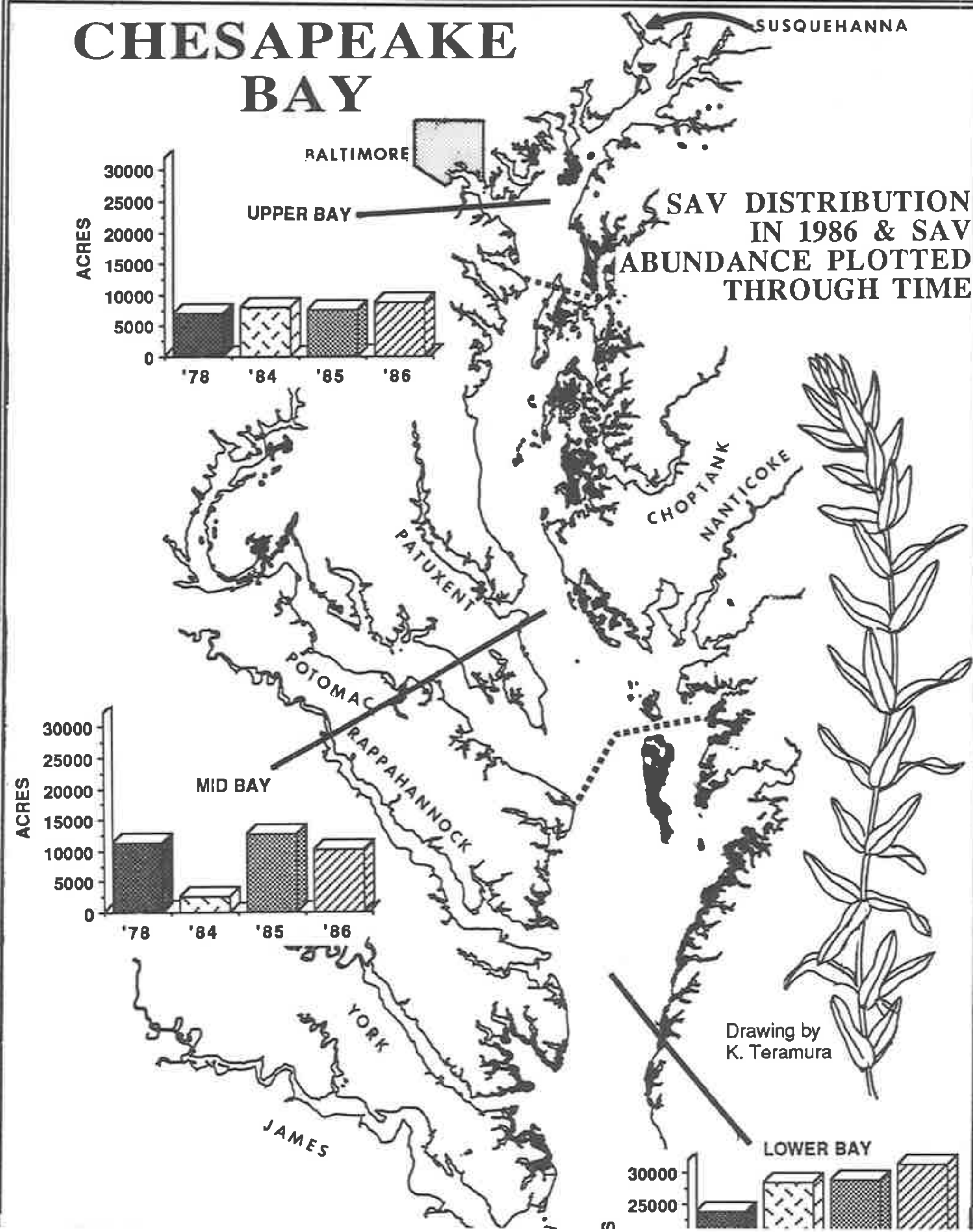
Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by phytoplankton (microscopic plants) photosynthesis. DO values have shown little change since June with almost no DO in the bottom waters of the mid-portion of the Bay, forcing animals to migrate to shallow water where DO is higher. Surface water DO levels are slightly lower than they were in July. As temperatures start to cool and biological productivity decreases during September, DO levels will begin to rise.



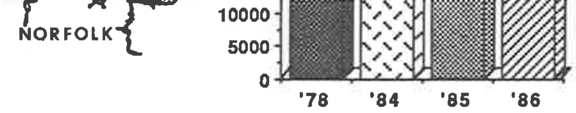
WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material, including

CHESAPEAKE BAY



Bay had water clarity values in August which were average for this time of year despite low levels of precipitation. (Runoff from precipitation carries sediment into the water, making the water more turbid.) Generally, Bay water tends to be less clear during the summer months due to the large numbers of plankton.



SAV BEDS IN 1986

SEPTEMBER HIGHLIGHT: SAV

Motoring through the shallows in parts of Chesapeake Bay, one's progress may be impeded by dense beds of submerged aquatic vegetation (SAV). As headway is slowed, the profusion of life sheltered by these beds becomes apparent. Commonly called "sea grasses," SAV is much more biologically productive that its landbound equivalent, grass meadows. While providing food and cover for many organisms, SAV also recycles nutrients and aerates the water, functioning as a critical link between the physical environment and the Bay's organisms. It is this linkage that makes SAV, more than any other single group of plants or animals, a prime biological indicator of the "health" of the Bay.

SAV, unlike other wetland plants, must be entirely submerged in water in order to thrive. SAV species can generally grow from the limit of low tide to a depth of approximately 9 feet in clear water. Below this, light levels are generally too diminished for adequate photosynthesis to take place.

Although to the casual observer, SAV may appear only to be a mass of weeds growing in the water, its importance in maintaining the ecological balance of the Bay ecosystem cannot be overstressed. Not only is SAV the primary food source for several species of waterfowl, but also provides habitat for many other organisms. Some species use SAV as substrate, either growing on its leaves or depositing eggs on leaf surfaces. The abundance of a variety of lower level organisms within the SAV beds attracts higher level predators such as crabs, cow-nosed rays, and several types of fish to forage for food. Loss of SAV, in recent years, may be partially responsible for decreases of some fish species.

In addition to providing habitat, SAV interacts with the physical environment in ways which assist in the cleansing of Bay waters. Nutrients are taken up during the spring and summer growing season and slowly released by decomposition for use by other organisms in the fall when there are lesser quantities of nutrients in the water. SAV aerates the water through the release of oxygen as a by-product of photosynthesis. Plant roots bind and stabilize the bottom sediment while the leaves buffer the energy of incoming waves, reducing shoreline erosion. Sediment suspended in the water is able to fall to the bottom in this reduced wave energy environment, resulting in clearer water.

There are 10 species of SAV commonly found throughout the Chesapeake Bay and its tributaries with another 10 found less frequently. The distribution of these species is related to several variables including salinity, water clarity, composition of the bottom substrate, temperature, pH, and the availability of nutrients. In the lower zone of the Bay where salinity levels are high, eelgrass and widgeongrass are the two dominant species, forming critical feeding grounds for waterfowl. The less saline mid Bay is dominated by a greater variety of plants including redhead grass, sago and horned pondweeds along with widgeongrass and an introduced species, Eurasian watermilfoil. The upper Bay with tidal freshwater has an even greater variety of submerged aquatic vegetation.

Along with the natural variables controlling SAV distribution and abundance, a new set of important factors has been superimposed in recent years. These factors are due to changes induced by man: increased nutrient discharges resulting in an overabundance of plankton (microscopic floating organisms) and increased sediment input, causing decreased water clarity. In addition, other potentially important factors include farm chemical runoff and the introduction of foreign plants which may overwhelm native species. Not all changes are necessarily bad - barren areas in the Potomac have been populated with introduced hydrilla and watermilfoil, increasing water clarity and providing fish habitat.

Historically, SAV covered hundreds of thousands of acres throughout the Chesapeake Bay. As recently as 1965, Bay grasses were prolific. By the late 1970s and early 1980s, however, many changes brought on by man in addition to natural stresses like hurricane Agnes overcame the ability of SAV to adapt and SAV acreage plummeted drastically. A 1983 EPA report implicated excessive nutrients and sediment as the two primary causes in the loss of SAV.

Recent information about the abundance of SAV in the Bay has indicated that some recovery of the populations may be occurring. The Bay Barometer map shows graphs of SAV abundance for 1978 and 1984-86. While the upper Bay has shown minor improvement through time, there has been a substantial increase in coverage in the lower Bay. The mid Bay decreased dramatically from 1978 to 1984 but showed remarkable recovery through the next year with an increase in coverage of 389%. SAV beds found in 1986 for all Bay zones are delineated in black on the map. Scientists are still analyzing the data, now being collected on an annual basis, in an effort to decipher how much of the year-to-year change is due to uncontrollable factors such as climate and how much is a function of remedial efforts to clean up the Bay.

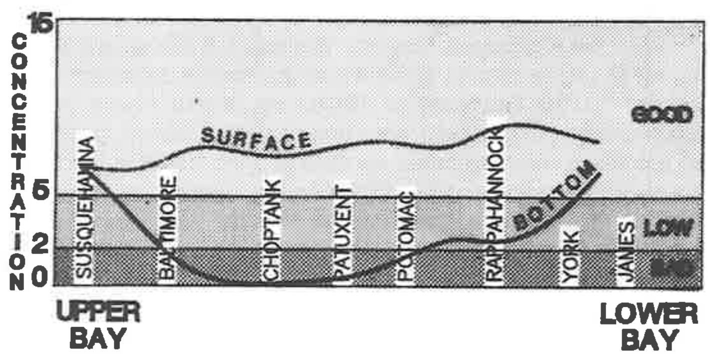
The monitoring of SAV populations along with studies designed to determine the complexities of SAV decline should yield information that will assist in making proper management decisions to nurture the recovery of SAV. At the same time, SAV provides a biological yardstick of the attempts to improve water quality of the Bay. The Bay will be well on its way towards restoration, when, once again, the grasses are gently swaying in the shallow waters.

- By Nina Fisher, Computer Sciences Corp.

The Bay Barometer is produced by the Monitoring Subcommittee of the federal/state Chesapeake Bay Program. The Subcommittee thanks Dr. Robert Orth for his assistance.

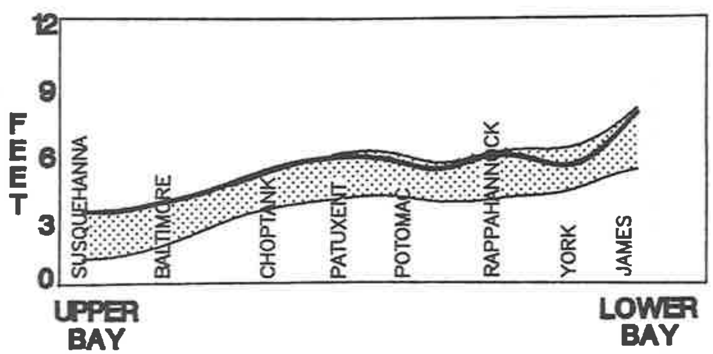
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by phytoplankton (microscopic plants) photosynthesis. July's values show little change from June with almost no DO in the bottom waters of the mid-portion of the Bay. This lack of oxygen should force many Bay animals to leave deep water areas for the shallows where DO is higher. Bottom water DO has increased slightly since June off the mouths of the Potomac and Rappahannock rivers.

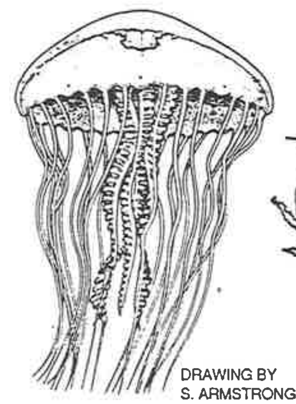


WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material, including

CHESAPEAKE BAY

JELLYFISH CONCENTRATIONS AT SELECTED SITES JUNE 1987



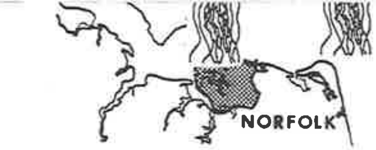
DRAWING BY S. ARMSTRONG

JELLYFISH LEGEND

DENSE

Bay had water clarity values in July which were average for this time of year. Generally, the water tends to be less clear during the summer months due to the large amounts of plankton. Water clarity off the mouths of the Patuxent and Potomac rivers has increased slightly from the low values observed during July.

LIGHT/NONE



AUGUST HIGHLIGHT: JELLYFISH

"More than any other beings, they are true animals of the sea, their frail, diaphanous shapes symbolize the life of the ocean in a way achieved by no other form. Like pale-colored ghosts they roam the waters of the world from the frozen arctic to the warm currents of the tropics and from the shallow bays and creeks to the uttermost regions of the great deeps". - Gilbert Klingel, The Bay

The animals to which Gilbert Klingel is referring are jellyfish. They can bring scorn to the face of even the most hardened naturalist. And, unfortunately for those attracted to local waters, jellyfish thrive in the Chesapeake Bay.

There are 5 common types of jellyfish found in the Bay and its tributaries. Of these, only 3 are considered true jellyfish. The other two, the mermaids purse and the sea walnut, have no or few tentacles and cannot sting. The second group, known as comb jellies, are generally transparent but often tinged green or pink and have bands of seemingly colored cilia striping their bodies. Flapping of the cilia allows the jellies to propel themselves casually through the water. The most distinctive characteristic of the sea walnut is its ability to luminesce, emitting a green glow, when disturbed.

The other 3 types of jellyfish do not have such innocuous traits as the comb jellies. These jellyfish, the lion's mane, moon jellyfish, and sea nettle, all have tentacles loaded with stinging cells. The lion's mane floats through Bay waters only during the winter and early spring and is not a hinderance to normal recreational activities. The moon jelly is the Bay's largest species but its sting is generally mild. It is characterized by fringe-like tentacles and clover-shaped red gonads.

The sea nettle likely receives the dubious distinction as the least welcome creature inhabiting Bay waters. It's peak in abundance corresponds precisely with the period of greatest recreational use of the Bay. Once sea nettles have spread throughout the tributaries and into the Bay, swimming generally slows considerably or ceases for the remainder of the season. For those who do venture into the water, the nettle's sting is usually painful and can cause reactions varying from localized discomfort to intense itching, burning, nausea, and cramping. In rare cases, highly sensitive people suffer shock and convulsions. Anyone allergic to other stinging organisms should take special care to avoid being stung as cross-sensitivity is common.

The bell of the sea nettle is milky white frequently with deep red radiating bands. The bells may reach 8 inches in diameter and have up to 40 trailing tentacles as great as 4-5 feet in length. Clustered within the tentacles are four frilly arms coming from an opening under the bell. This opening functions both as a mouth and anus. Internally, the stomach and gonads are the sole organs while rudimentary eyes and balance organs are located on the perimeter of the bell.

The medusa captures food by stunning its prey with toxins emitted from the stinging cells in its tentacles. The stinging cells operate like small poisonous darts. Tightly coiled within their sheath, they spring free when contact is made with prey or a human. Secured in the victim's flesh by barbs, toxins flow through the cell's tube into the prey. The stunned prey is then transported by the tentacles to the mouth and into the central portion of the bell. Partially digested food may be visible through the translucent bell.

Despite our perception of sea nettles as worthless creatures, their sheer numbers force us to recognize them as important links in the Bay's food web. Nettles consume large quantities of comb jellies and zooplankton (small floating aquatic animals). Their consumption of zooplankton in the summer helps to control the numbers of these organisms in surface waters which increases water clarity. In turn, nettles are preyed upon by crabs and some fish. Nettles are 95% water and do not constitute a highly nutritious meal for the animals feeding upon them.

Small sea nettles first appear in the Bay and tributaries in May or June as temperatures warm. Although the nettle can swim by contraction of the bell, its distribution is largely controlled by the whims of the tide and wind. Its distribution is also limited by salinity and nettles are most commonly found in regions with salinity ranges of 7-20 parts per thousand (ppt). (Ocean water is about 35 ppt and freshwater is 0 ppt.) Nettles cannot survive in conditions with salinities under about 5 ppt. Thus, the upper reaches of the main Bay and tributaries are generally free of these organisms.

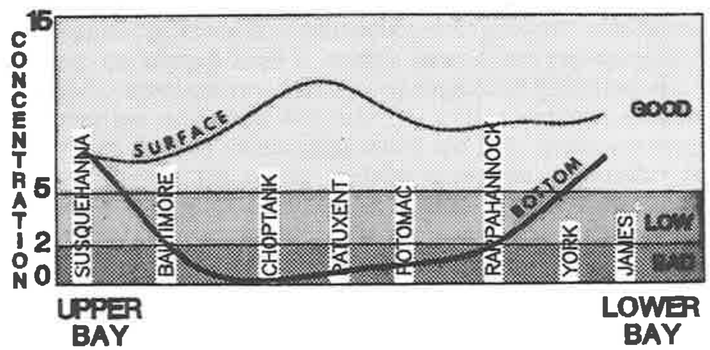
The Barometer map shows the distribution of both true jellyfish and comb jellies throughout the Bay region in June, 1987. Although these data represent the overall distribution of jellies within the Bay, they are only a snapshot in time. There are large amounts of variation in numbers through the summer season, from day to day, and even from hour to hour.

As the self-appointed proprietors of the Chesapeake Bay, we tend to take offense at having to share "our Bay" with animals as unpleasant as the sea nettle and its relatives. Yet, it is important to realize that they, like the Bay's many other inhabitants, are critical in maintaining the balance and unity of the system. Somehow, seeing beauty in the integrity of the whole, makes the task of sharing the Bay with the jellyfish seem just a bit more agreeable.

The Monitoring Subcommittee of the federal/state Chesapeake Bay Program produces the Bay Barometer and would like to thank Dr. David Cargo, Mr. William Burton, and Dr. Ray Birdsong for their contributions.

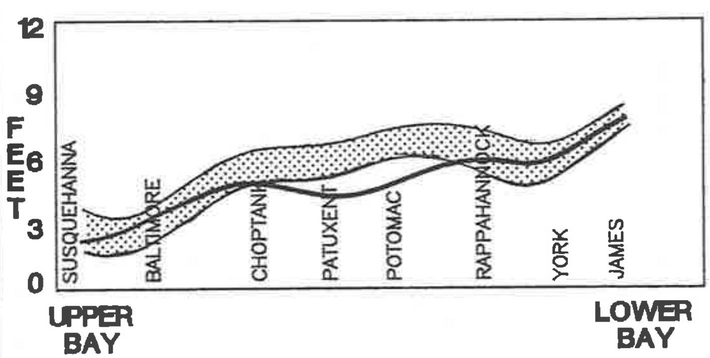
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in water. Surface water usually has a greater amount of DO than water near the bottom due to its interaction with the atmosphere and production of oxygen by phytoplankton (microscopic plants) photosynthesis. June's values show that the mid-portion of the Bay has almost no DO in the bottom waters. This lack of oxygen should force many Bay animals to leave deep water areas for the shallows where DO is higher. The higher DO off the Patuxent and Potomac is due to greater phytoplankton numbers (decreasing water clarity).

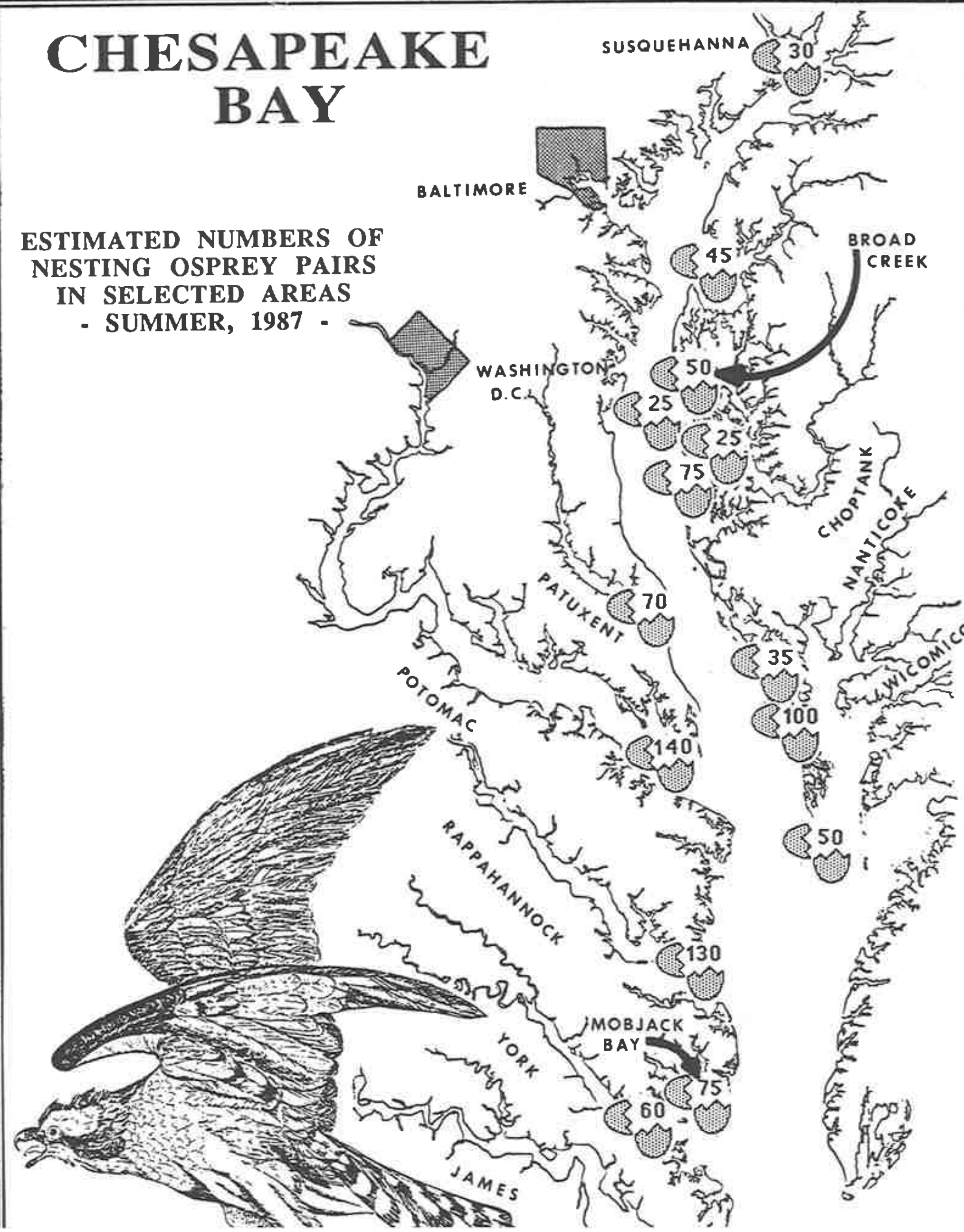


WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended material, including

CHESAPEAKE BAY

ESTIMATED NUMBERS OF NESTING OSPREY PAIRS IN SELECTED AREAS
- SUMMER, 1987 -



Bay had water clarity values in June which were average for this time of year. This is partially related to precipitation which was just under average. Waters were slightly murkier off the mouths of the Patuxent and Potomac rivers. In general, the water tends to be less clear during the summer months due to the large amounts of plankton.

Drawing by Linda Lee

JULY HIGHLIGHT: THE OSPREY

The osprey: at once, a symbol of the plight of the Chesapeake Bay and the potential for its recovery. In the 1960s, osprey numbers decreased dramatically as a result of the widespread application of persistent pesticides such as DDT which caused thinning of eggshells resulting in lowered hatch rates. With the U.S. ban on DDT use in 1972, along with a reversal of the Coast Guard's policy of dismantling osprey nests on channel markers, osprey numbers began to rebound. Now, ospreys are a common sight, and it is estimated that well over 1500 pairs currently nest throughout the Bay area.

The osprey is a large bird with a body 2 feet in length and a wingspread of 5 feet. Its back and long, arched wings are brown with white plumage covering its chest and upper legs. The characteristic crook in its wings, wrist patches and dark bands on the underside of the tail identify an osprey in flight. Its distinctive shrill cry wards invaders away from its nest.

As the weather warms, ospreys migrate as far north as Alaska and Canada for the summer breeding period after wintering in Central or South America. The osprey makes its seasonal appearance in the Bay in March. It often returns to the river of its birth, re-establishes the bond with its mate, and together they begin the task of creating or rebuilding a nest. The nests are bulky affairs composed of carefully interwoven branches. They are unconcealed and situated high in trees, on channel markers, duck blinds, and specially constructed nesting platforms: in short, the osprey will locate a nest near or on the water where a suitable base is available and predators (such as racoons) are uncommon.

When nest-building chores are complete, the female will generally lay 2-4 mottled eggs with a period of 2-3 days between each egg. If food is scarce after the young have hatched, this time gap ensures that the oldest and largest young will likely survive while the younger, smaller chicks will perish. The female incubates the eggs for 5 weeks while the male forages for food in the surrounding waters. After the eggs hatch, the female continues to guard the nest while the nestlings grow in size and strength.

As the young birds mature, they gradually lose their downy fuzz and acquire the feathers needed for flight. Approximately 8 weeks after they hatch, the nestlings are ready to fly. At first they test their wings in ungainly trial flights, however, they quickly become proficient flyers, preparing for the long migration to the tropics.

The osprey is a member of the hawk family; it hunts for its prey which is taken alive, clasped firmly in its talons. Searching for food, the osprey hovers 50-150 feet over the water. When food is spotted, the bird makes a spectacular aerial dive, crashing into the water and grasping the fish in its talons. Although the osprey may be completely submerged by its dive, it quickly regains flight, pausing a moment to shake the water from its oily body. The fish is usually carried back to the nest; it is not uncommon for the bird to display its food to other ospreys in the area on its way to the nest.

In the Chesapeake Bay, menhaden are the primary source of nourishment for the osprey. Large schools of these fish make their way up the Bay in spring. The distribution of the menhaden is not homogeneous throughout the Bay and while some areas may have abundant supplies of older, larger fish, others may be impoverished. Ospreys in the food-rich area tend to have more surviving young due to less starvation. The age of the fish in the schools is also important, with 2-year old menhaden providing much more food per fish than the 1-year olds.

The Barometer map shows estimated numbers of nesting osprey pairs in summer 1987 in selected areas. The actual number of ospreys around the Bay is much higher as these numbers represent only major groupings: there are many smaller groupings as well as numerous non-nesting birds. The numbers do not indicate whether the young will survive. Dr. Paul Spitzer of the University of Maryland's Horn Point Biological Lab, studying ospreys on the Eastern Shore, thinks that the success rate of nests in Maryland's Broad Creek area will be the best of the past five years. In the Mobjack Bay area on the lower western shore, however, Dr. Mitchell Byrd of the College of William and Mary has found development of abnormal young and high rates of nestling mortality. He is investigating contamination by toxics as a possible cause. Alarmingly, the number of young surviving per nest in this area is similar to that prior to the DDT ban.

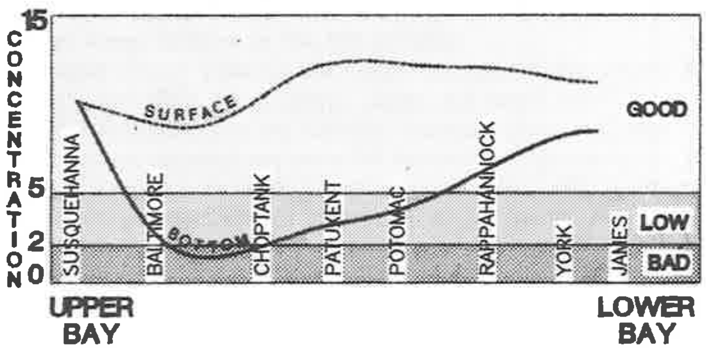
Generally, however, osprey numbers have rebounded and in some cases probably exceed numbers during the colonial period due to the large number of artifical structures serving as potential nest sites. Currently, both the number of suitable nest sites and food availability limit the level of the population. As more artificial nest platforms are built, food may become an increasingly important limitation.

The osprey has become a visible symbol of the Bay's ability to recover. The Chesapeake Bay has indeed regained its status as the "osprey garden."

The Barometer is produced by the Monitoring Subcommittee of the Chesapeake Bay Program. The Subcomittee would like to thank Dr. Paul Spitzer and Dr. Mitchell Byrd for their contributions.

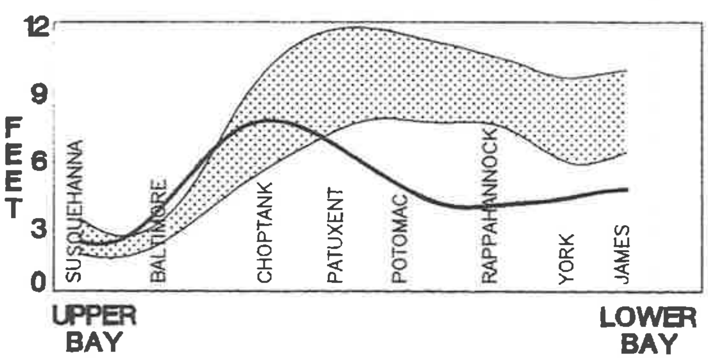
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

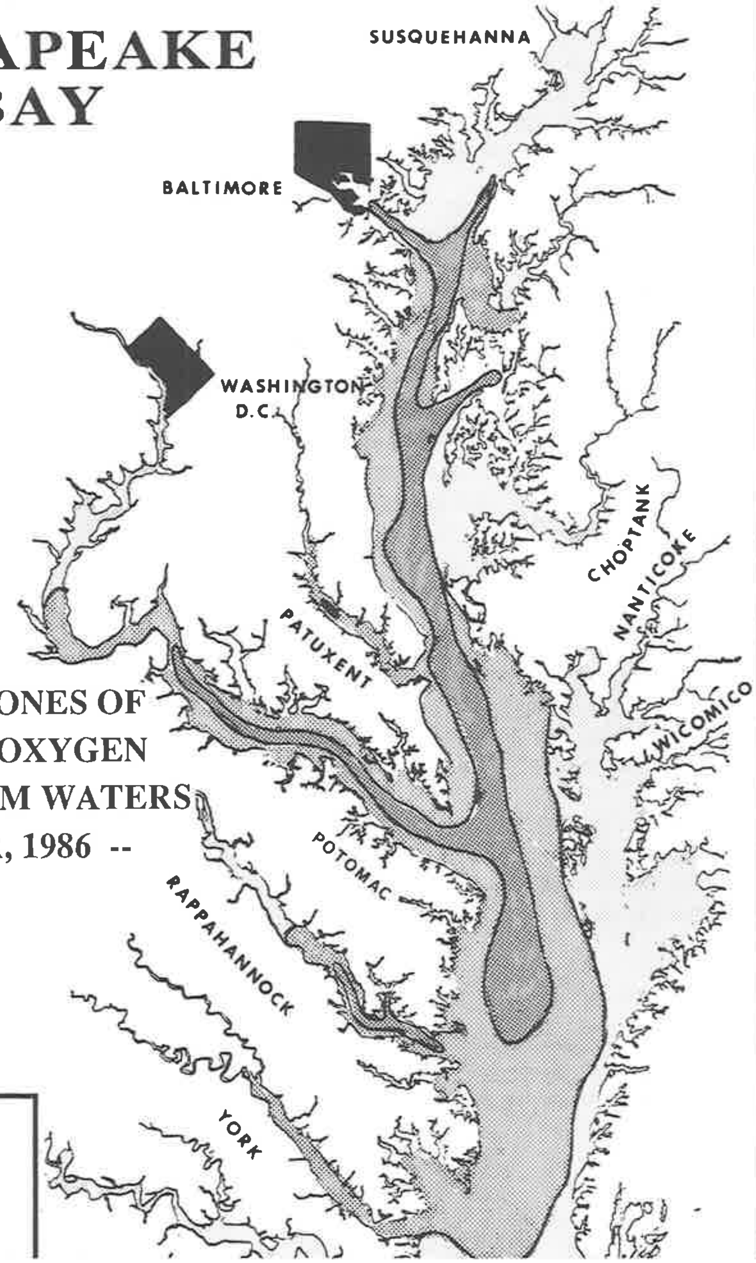
Dissolved oxygen (DO) is the amount of oxygen contained in the water. It is critical for DO to be present in the water for animals and plants to survive. Water on the surface of the Bay usually has a greater amount of DO than the water near the bottom due to its interaction with the atmosphere. Bottom water DO in the mid-portion of the Bay has dropped into the BAD zone for the first time this season. The presence of such oxygen-depleted water is found earlier this year (compared to 1986) because of the large amount of rain this spring (see text below).



WATER CLARITY

Water clarity is a measure of the depth to which light can penetrate water. The greater the value, the clearer the water. Suspended ma-

CHESAPEAKE BAY



GENERAL ZONES OF DISSOLVED OXYGEN IN BAY BOTTOM WATERS

-- SUMMER, 1986 --

LEGEND

0 – 2

of normality. May's values, like April's, show that much of the Bay had lower than average water clarity. This may be due to more phytoplankton in surface waters as temperatures rose. The amount of sediment in the water was probably below average since much of the Bay had less than normal rainfall in May.

above 5

(in milligrams/liter)

JUNE HIGHLIGHT: DISSOLVED OXYGEN

Consider oxygen in the atmosphere: its necessity for survival is readily apparent. A glance at a mountain climber gasping in the thin air as he reaches for the summit of Mt. Everest or the struggles of a newborn baby who cannot take in sufficient oxygen confirm our reliance on oxygen. However, few of us are aware that oxygen is equally critical for animal and plant life in the water.

Oxygen is found in dissolved form in the water and is introduced by two major processes. First, the surface waters of the Bay are enriched with oxygen by the aerating action of the wind as it blows over the water. Second, aquatic plants and phytoplankton (floating microscopic plants) produce oxygen in the upper water layer as they photosynthesize during the day. However, like animals, plants also require some oxygen for their survival.

The amount of dissolved oxygen (DO) in the water is dependent not only on the activity of the wind and plants, but also on the quantity of oxygen which can be held by the water. As temperature (and salinity) increase, less oxygen can remain dissolved in the water. As a result, during the late fall, winter, and early spring when the water is cold and there are numerous storms with winds, both the upper and bottom waters are well-mixed and well-oxygenated. As the temperatures warm in late spring, the physical processes which aerate the water slow, and biological activity accelerates, levels begin to decrease.

The bottom waters show the largest summertime decline in oxygen since they are largely cut off from both aeration by the wind and photosynthesis by the plants due to the layering of water in the Bay. Freshwater is less dense than seawater and forms a lighter layer which floats on the denser saltwater coming in from the ocean. During those spring seasons in which rainfall is above average, large quantities of freshwater flow to the Bay and the problem of low bottom DO worsens. The layering is intensified and mixing between the bottom and surface waters is further inhibited. This means that little oxygen contained above is transferred down through the water. Animals living in the lower water and bacterial decay of dead plants and animals also cause bottom waters of the Bay to become more depleted of oxygen as the summer progresses.

The Barometer map shows DO conditions for the Bay's bottom waters during July and August of 1986 based on monitoring data. It indicates that the central spine of the Bay's mid-portion shows greater seasonal decreases in DO than do the east and west flanks or the northern and southern areas. The increased depth of this central axis causes greater isolation of these deep bottom waters. When the wind blows, it may push surface waters to one of the Bay's sides. The low DO water is tilted in the opposite direction, causing it to move up temporarily into the shallows.

Much of the variation in DO concentrations is due to natural, seasonal changes. However, human activities have introduced additional oxygen-consuming materials and nutrients (phosphorus and nitrogen) magnifying the seasonal decrease in oxygen levels. These nutrients, largely from sewage treatment plants and agricultural runoff, overenrich the water and allow an overabundance of phytoplankton to grow. Many of these remain uneaten, die, and sink so that much of the available DO in the lower waters is used in their bacterial decay. This process amplifies the seasonal decrease in DO; causing it to drop even lower and to remain low for a longer period of time. Although oxygen depletion of the bottom waters occurred in the past, it was probably less frequent and affected a smaller area of the Bay. By 1980, low DO first appeared in early May and continued into late September. In addition, a number of deep areas now suffer from a complete lack of oxygen, a condition known as anoxia, for prolonged period each summer.

Very few organisms can tolerate sustained periods of anoxia or hypoxia (water with low levels of DO). These conditions force organisms that can swim to seek water with sufficient DO for survival. Finfish are excluded from many of the deeper portions of the Bay where they formerly swam and fed. Oysters could survive to depths of 10 meters (31 feet), but are now hard hit by anoxia even in the 5-10 meter range. The "crab jubilee," during which crabs crawl to the shallows and even onshore, may be a boon for crab feasters, but is a signal that the crabs are fleeing the low DO water moving into their habitat.

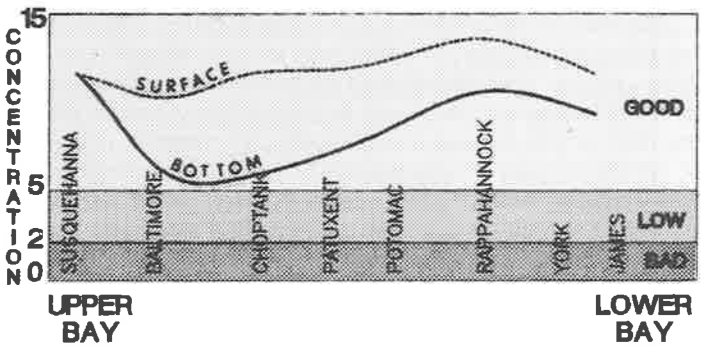
In 1983, the Chesapeake Bay Program officially targeted a reduction in nutrient loads as a primary objective in the restoration and protection of the Chesapeake Bay. The goal is to reduce nutrients to the level needed to attain DO levels which ultimately can support the plants and animals of the Bay. Reductions in nutrient loads should have a measurable effect on DO levels and, along with other actions, should also result in a more balanced ecosystem.

It is expected that in the long-term, higher DO levels will be seen in the main Bay as well as the tributaries once point and nonpoint nutrient sources are adequately controlled. The steady increase in population surrounding the Bay area, however, means that there will be an ever increasing load of nutrient wastes that must be managed. The return of suitable DO levels to Bay waters will require the continued efforts of many organizations as well as those of individual citizens living in the Chesapeake Bay basin.

The Bay Barometer is produced by the Monitoring Subcommittee of the federal/state Chesapeake Bay Program.

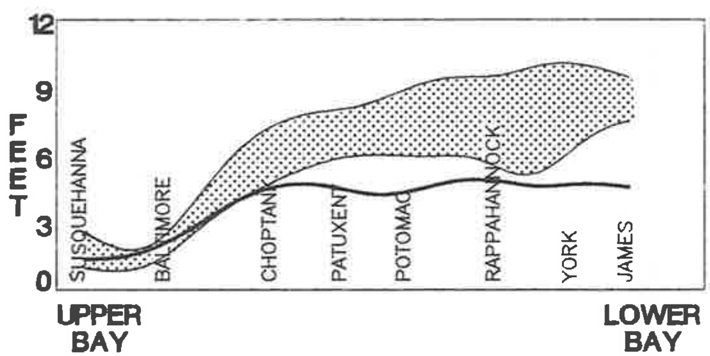
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in the water. It is critical for DO to be present in the water for animals and plants to survive. If DO drops below 2 milligrams/liter, very few organisms can survive. Water on the surface of the Bay usually has a greater amount of DO than the water near the bottom due to its interaction with the atmosphere. The bottom water DO has decreased considerably since March, although surface water DO shows minimal change. The largest decrease is seen between Baltimore and the Patuxent River, the deepest portion of the Bay.



WATER CLARITY

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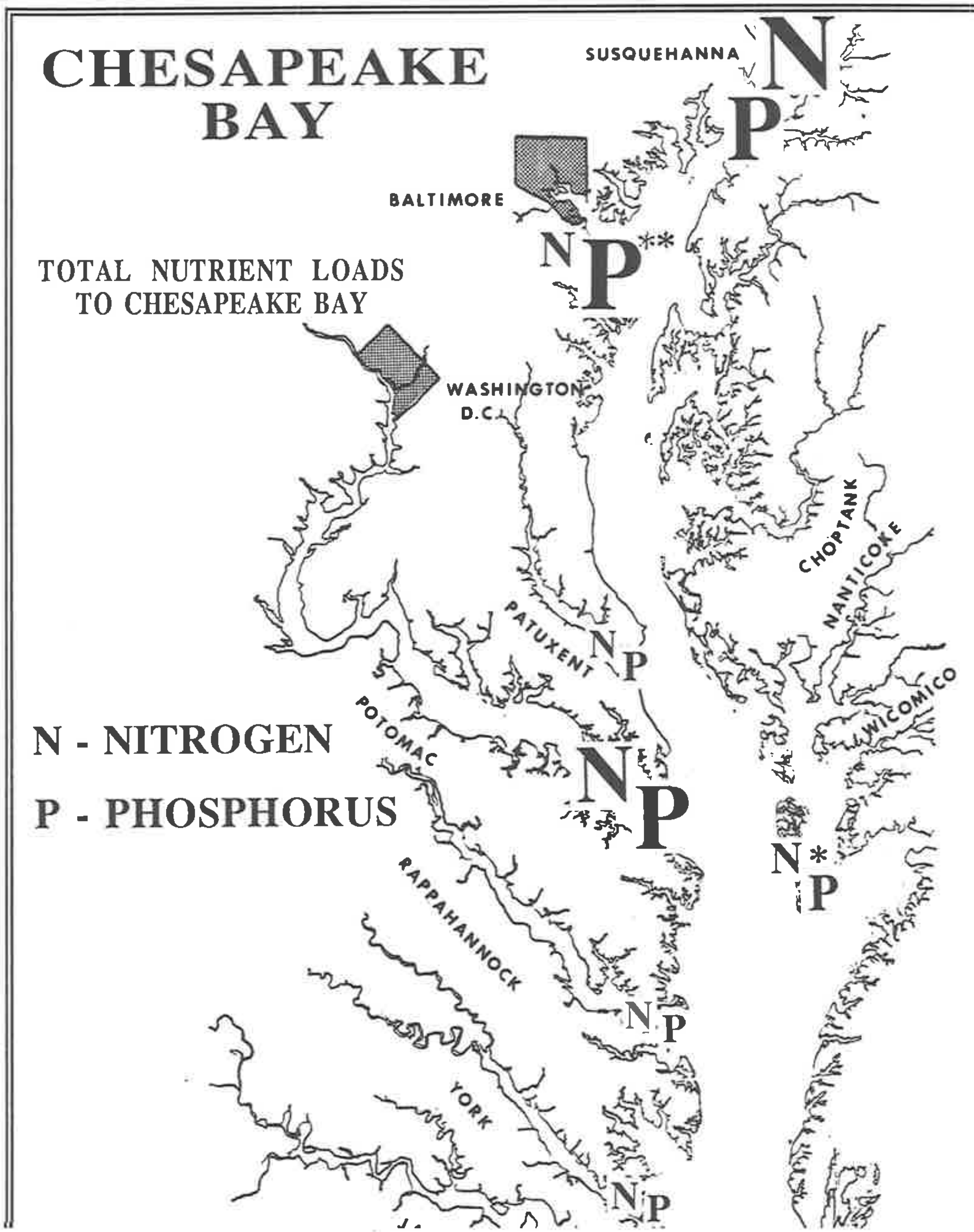

zone of normality. April's values show that most of the Bay had lower water clarity than normal for this time of year. This is due to the greater-than-average rainfall which caused large quantities of sediment to be carried into the Bay, clouding the water. For example, the James received over 2 1/2 times normal rainfall.

** Loadings from south of the Susquehanna to north of the Patuxent.

NOTE: The sizes of N & P are proportional to loadings into the Bay.

MAY HIGHLIGHT: NUTRIENTS IN THE BAY

Nutrients are the raw materials necessary for plant life. In fact, all organisms living in the Chesapeake Bay require specific nutrients in sufficient quantities to grow and reproduce. Without them, the Bay would be void of life. Yet, too much of a good thing can be harmful to Bay plants and animals.

When the colonists first settled the Bay area, extensive forests covered the drainage basin and trapped nutrients instead of allowing them to enter the Bay. As land was cleared for agricultural and development purposes, increasing quantities of nutrients were washed into the Bay.

Scientists and managers are concerned about present nutrient levels in the Bay because excess amounts of some nutrients allow too many phytoplankton to grow. Phytoplankton are tiny floating plants that form the foundation for the food web of organisms found in the Bay. A certain number of the right types of phytoplankton are needed to serve as food for the animals in this web. When there is an overabundance of phytoplankton, many remain uneaten, die off, sink, and are decomposed by bacteria. This can create major problems in the Bay. As decomposition takes place, the bacteria can use up much or all of the dissolved oxygen in the water making it uninhabitable for animals that require oxygen to live. During decay, the nutrients bound in the plankton tissue are released, which may help to fuel a new round of phytoplankton growth.

Can one nutrient be identified as that which limits the growth of phytoplankton in the Bay? Although many different nutrients are required for plant life, only nitrogen (N) and phosphorus (P) are usually important in limiting the total number of plants that can survive. The general scientific consensus is that in freshwater, N is relatively abundant and the availability of P is the limiting factor; in saltwater, the reverse is true and N is limiting. The Chesapeake Bay is a transitional zone between salt- and freshwater which means that either nutrient may be limiting at different times and in different areas.

There are both natural and manmade sources of nutrients to the Bay. These inputs include: atmosphere, ocean, bottom sediments, point source (discharge from pipes), and nonpoint source, (such as runoff containing fertilizer, soil, and street wash from urban areas). Currently, the atmospheric and oceanic sources of nutrients are not controllable. The bottom sediment source may only indirectly be controlled through the reduction of point and nonpoint source nutrient loads. The bottom sediments are a complex source to manage because the nutrients (especially phosphorus) adhere to mud particles on the Bay bottom and are released when water temperature increases and dissolved oxygen decreases in the summer. The point and nonpoint source inputs are primarily introduced by man and are directly controllable. As such, they have been the focus of most management efforts to reduce nutrient inputs to the Bay.

The Barometer map shows relative loadings (total input for a nutrient) from tributaries of the Bay between March and October for a year with average precipitation. These loadings are taken from a 1983 EPA report - when new data are available, they will be presented in a future Highlight. The larger the letters, N & P, the greater the input. The loadings include both point source and nonpoint source inputs. Larger volume rivers like the Susquehanna will necessarily contribute more N & P to the Bay than smaller tributaries. During wetter years, the nutrient loads to the Bay may be 2 times larger than an average year, while loads are lessened during drier years.

Scientists and managers have long recognized that excess nutrients have a detrimental effect on the plants and animals of the Bay. With passage of the Clean Water Act in 1972, there was a federal/state mandate to reduce the level of nutrients flowing into the nation's waters. Phosphorus was targeted as the primary focus for management action in the Chesapeake Bay basin. Scientists and managers are now considering whether nitrogen should be targeted as well.

A variety of remedial actions have been implemented. These include: effluent limits for sewage treatment plants; upgrading of systems in older cities where sanitary and stormwaters are combined in one pipe; the banning of phosphorus-containing detergents in Maryland, D.C., and Virginia; establishment of critical areas around the Maryland shoreline portion of the Bay to trap nutrients; and, use of best management practices (BMPs) on agricultural lands to minimize runoff. The overall strategy has been successful in decreasing phosphorus loads to the Bay system. In the upper Potomac, there has been a 98% decrease of loadings from sewage treatment plant dischargers since 1970.

In addition to government sponsored actions, there are many things that citizens can do around their homes to reduce nutrient loads carried to the Bay in runoff from their land*. Landscaping and tree planting both lessen runoff as do water-permeable walkways and driveways. Lawns should not be overwatered and fertilizers should be used carefully, according to specifications, so that no excess is applied.

* For more information on what you can do around your home, a publication, The Baybook, is available from: Citizens Program for the Chesapeake Bay, Inc., 6600 York Rd., Baltimore, MD 21212 (301-377-6270).

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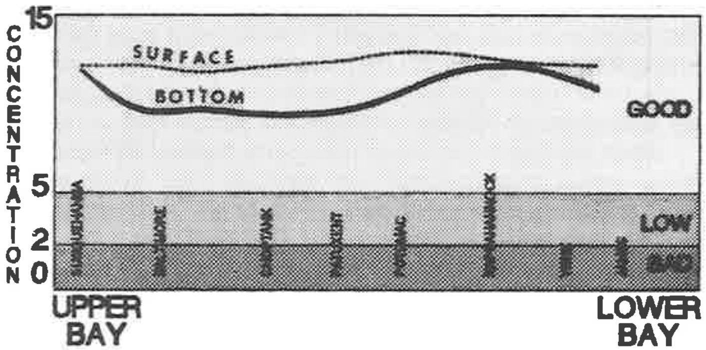
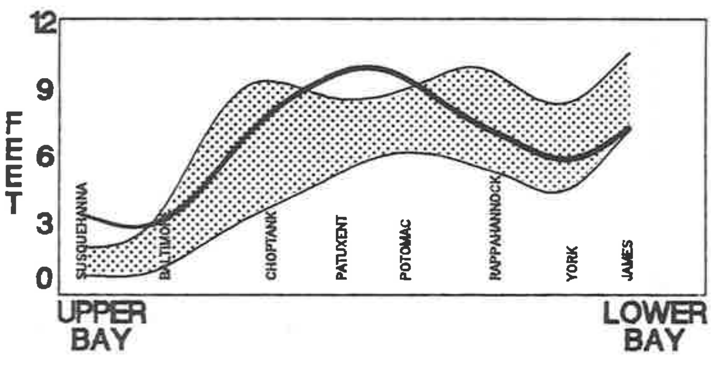
CHESAPEAKE BAY BAROMETER

WATER QUALITY CHARACTERISTICS OF THE BAY



DISSOLVED OXYGEN

Dissolved oxygen (DO) is the amount of oxygen contained in the water. It is critical for DO to be present in the water for animals and plants to survive. DO naturally decreases as the water warms in late spring; if it decreases below 2 milligrams/liter, very few organisms can survive. Water on the surface of the Bay usually has a greater amount of DO than the water near the bottom due to its interaction with the atmosphere. In March 1987, the Bay water was still cold enough to contain a considerable amount of DO. DO levels will begin to decrease for the season in April or May.



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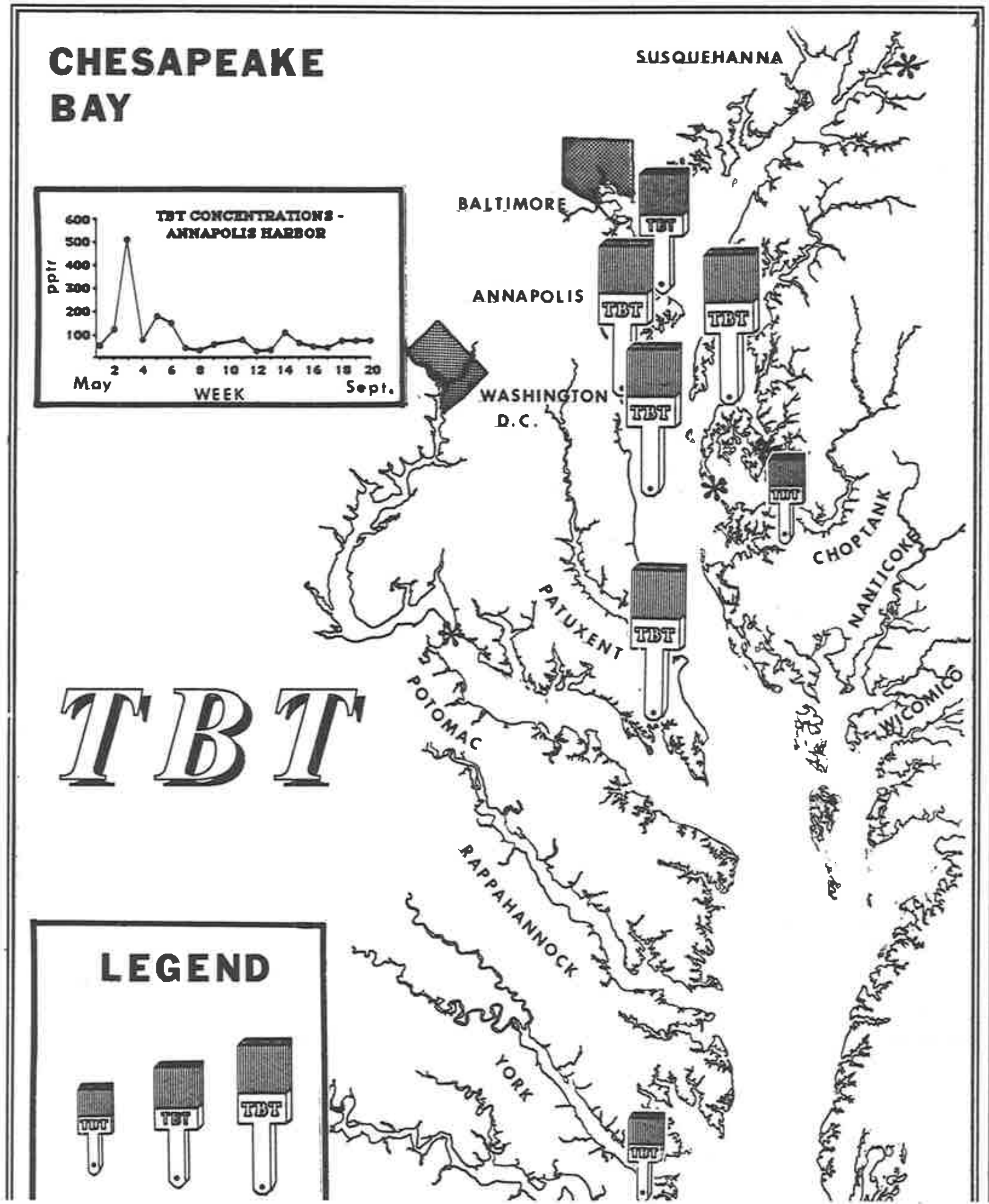

zone of normality. The water clarity values for March 1987 show the effect of lower than average March precipitation around the Bay basin, especially near the Patuxent and Potomac rivers. Lower river flows import less suspended material to the Bay, making the water clearer.

APRIL HIGHLIGHT: TBT

With summer fast approaching, boat owners are considering how to protect their boat hulls from fouling organisms. Until recently, they often turned to TBT (tributyltin)-based antifouling paints as an effective means of preventing barnacle and algae growth on their hulls; without knowledge of the paint's potential impact on the Bay. However, it is exactly TBT's effectiveness as an antifouling agent that has recently caused concern among scientists and managers around the Bay.

TBT leaches from the painted boat bottoms into the surrounding water. Laboratory tests have found it to be toxic to shellfish and phytoplankton (microscopic plants) at concentrations of less than 1 part TBT to 1 billion parts water (ppb).

Even lower concentrations, in the parts per trillion (pptr), can affect organisms. One pptr is equivalent to adding a spoonful of TBT to a water-filled Houston Astrodome.

At TBT concentrations of 20-30 pptr (2000-3000 ppb), nonlethal, chronic effects such as abnormal growth or disruption in reproduction may begin to occur.

Frequently, it is the larval stages of marine organisms that are most greatly affected by exposure to TBT. Although the larval organisms often survive to adulthood, they may not be able to reproduce to maintain the population. Mature organisms may not die directly from TBT exposure, but it puts additional stress on their ability to survive. Areas where TBT concentrations are high for sustained periods of time may pose a potential lethal threat to the larvae of phytoplankton and shellfish.

In response to questions of the impact of TBT on marine organisms, the Environmental Protection Agency (EPA) initiated a special pesticide review of TBT-based anti-foulant paints in January, 1986. As part of the review, a study was conducted to analyze concentrations of TBT in four harbors around Chesapeake Bay. The harbors represent different levels of boating and marina activity.

Other studies were funded by Maryland, Virginia, and the Navy and carried out by scientists at Johns Hopkins University (JHU), the Virginia Institute of Marine Science (VIMS), and the Navy. Results draw a picture of seasonal TBT concentrations at selected sites around the Bay.

The Bay Barometer map shows the results of the studies by EPA, VIMS, and JHU from late May and early June 1986. This time is concurrent with the period when most boat owners are returning their freshly painted crafts to the water.

The paintbrushes on the map correspond to TBT concentrations. An asterisk indicates that the water had no detectable quantity of TBT. Areas with the largest paintbrushes have higher amounts of TBT probably due to the density of recreational and commercial boats and marinas using TBT products.

One might expect the Hampton Roads/Norfolk area to have high concentrations of TBT due to the large number of boats in this area. However, many of these boats are naval vessels. The Navy has postponed fleetwide painting of its ships with TBT until after the conclusion of the EPA special review.

The high initial leaching rate of TBT into the water, as well as the large number of painted boats put into the Bay simultaneously, explain the peak of TBT concentrations in boating/-marina areas early in the season.

The graph on the map shows the initial peak in Annapolis Harbor just prior to Memorial Day. (In Back Creek near Annapolis, the JHU study found 998 pptr late in May.) TBT is found in the water after this date, but in lesser concentrations.

It is thought that the initial higher concentrations found in the Annapolis area were probably sufficient to cause both lethal and chronic effects on some species of larval shellfish and plankton.

Few substances being deliberately introduced into natural waters today are as highly toxic as TBT. To minimize their impact on Bay organisms, recreational and commercial boaters can use alternative bottom paints. Copper-based antifouling paints may be used on any boats with the exception of those with aluminum hulls. Although more frequent application of these paints is necessary, they are approximately 50 times less toxic to marine organisms than TBT.

A more recent addition to the market is an antibiotic, antifouling additive which can be mixed with oil-based bottom paints and used on any type of hull. This compound is completely biodegradable in the water.