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ABSTRACT

This environmental education teaching guide for middle school teachers features information on the National Estuarine Reserve System in Maryland. Pre-trip field activities, field trip activities, and post-trip activities are discussed, and a list of useful resources and organizations is provided. Reproducible handouts are included throughout the guide. (Contains 47 references.) (YDS)

Ecology of an Estuary: Chesapeake Bay

A GUIDE FOR MIDDLE SCHOOL TEACHERS

Chesapeake Bay National Estuarine Research Reserve in Maryland

Coastal Zone Management Division, Coastal and Chesapeake Watershed Service
Maryland Department of Natural Resources
580 Taylor Avenue, E-2, Annapolis, Maryland 21401, 410-260-8730

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Silver Spring, Maryland 20910

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By Cris Fleming and Christopher Swarth

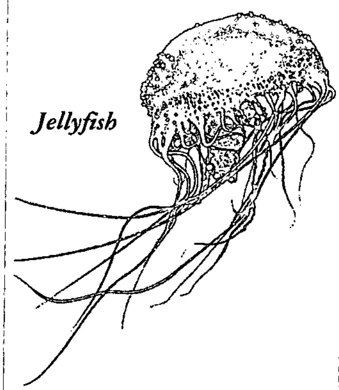
Acknowledgements

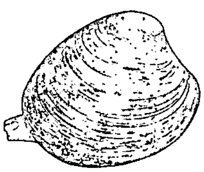
This guide was written for the Maryland Department of Natural Resources through a contract with the Friends of Jug Bay, Inc. Funding was provided by NOAA's Sanctuaries and Reserve Division. Activities for the guide were developed during five teacher workshops offered in the spring of 1992 in the three Chesapeake Bay National Estuarine Research Reserve components. Piloting and evaluation of the original activities took place during the 1992-1993 academic year.

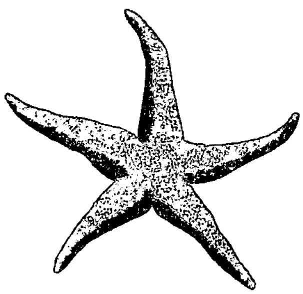
Cris Fleming, main author of Ecology of an Estuary, is an environmental educator and former Education Director of the Audubon Naturalist Society. Co-author, Christopher Swarth, is Director of the Jug Bay Wetlands Sanctuary (JBWS) and co-Site Manager of the Jug Bay Component.

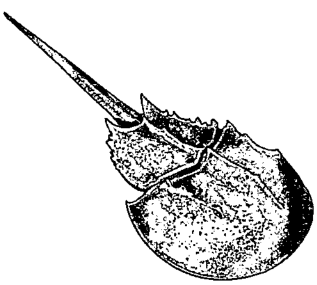
Appreciation is given to Chesapeake Bay National Estuarine Research Reserve-Maryland staff: Kathleen Ellett, Kathleen Buppert, Mary Ellen Dore, and Laura Callahan. Kathleen Buppert revised the guide. Appreciation is also extended to Bill McInturff, Maryland DNR State Forest and Park Service and Site Manager of Monie Bay Component; Mary Kilbourne of Patuxent River Park; Shannon Smithberger and Doris Peters of Jug Bay Wetlands Sanctuary; Bob Chance and Dennis Kirkwood of Harford Glen Environmental Education Center, Dr. Maurice Lynch and Bland Crowder of the Chesapeake Bay NERR - Virginia, Maureen Wilmot of NOAA, and Tom Cassidy and Jim Harle of Friends of Jug Bay. Also many thanks to the following teachers who gave valuable comments and suggestions on the activities: M. Dianne Antonalli, Pat Murphy, Shauneen Guidice, Elaine Joyce, Patricia Driz, Jeff Webb, and Jane Thoman.

PREFACE


Jellyfish


Clam


Starfish


Horseshoe Crab

"Wet, wild, and wonderful!" These words describe estuaries, those unique places where rivers meet the sea, mixing fresh water flowing off the land with salt water from the ocean to create intricate, productive ecosystems.

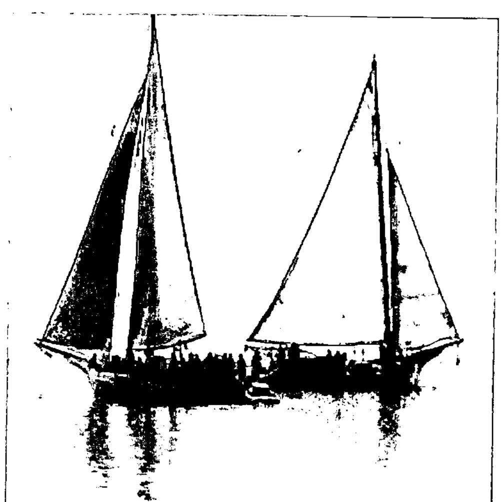
Maryland teachers have wonderful resources for estuarine education both in the Chesapeake Bay and in the many rivers and streams comprising the Chesapeake Bay watershed. In fact, creeks and rivers from every county in Maryland, including one stream in Garrett County, flow directly or indirectly into the estuary. Each in its own way impacts the health of the Chesapeake Bay.

Ecology of an Estuary: Chesapeake Bay is an activity guide written to help middle school teachers incorporate estuarine activities into their curriculum. Although the guide focuses on field experiences in the Chesapeake Bay National Estuarine Research Reserve in Maryland, it may also be used to explore many other estuarine environments.

The guide is divided into seven parts. Part I introduces the reader to the National Estuarine Research Reserve system, established in twenty-three locations throughout the country, and to the Chesapeake Bay National Estuarine Research Reserve in Maryland (Chesapeake Bay NERR-MD). Part II provides background information on estuaries in general and the Chesapeake Bay in particular. Parts III through VI consist of classroom and field activities for middle school students focusing on Chesapeake Bay and its watershed.

Part III presents suggestions for pre-field trip activities. Part IV presents planning and preparation suggestions for an estuarine field trip. Part V consists of field activities, and Part VI suggests post-field trip activities. Part VII provides useful resources and references for estuarine activities, including a list of plant and animal species found in the Chesapeake Bay NERR-Maryland.

Each activity contains a statement of purpose, setting for the activity, an estimated time frame, vocabulary list, materials list, background information, preparation hints, procedure, conclusion, related activities, and worksheets. Field studies focus on the Chesapeake Bay watershed although they may be adapted to other estuarine ecosystems. Classroom investigations are tailored for use in the Chesapeake Bay Reserve Components but are also applicable in other areas of the Bay. Through use of both field and classroom activities, educators will find it easy to include estuarine education as an integral part of the middle school curriculum.



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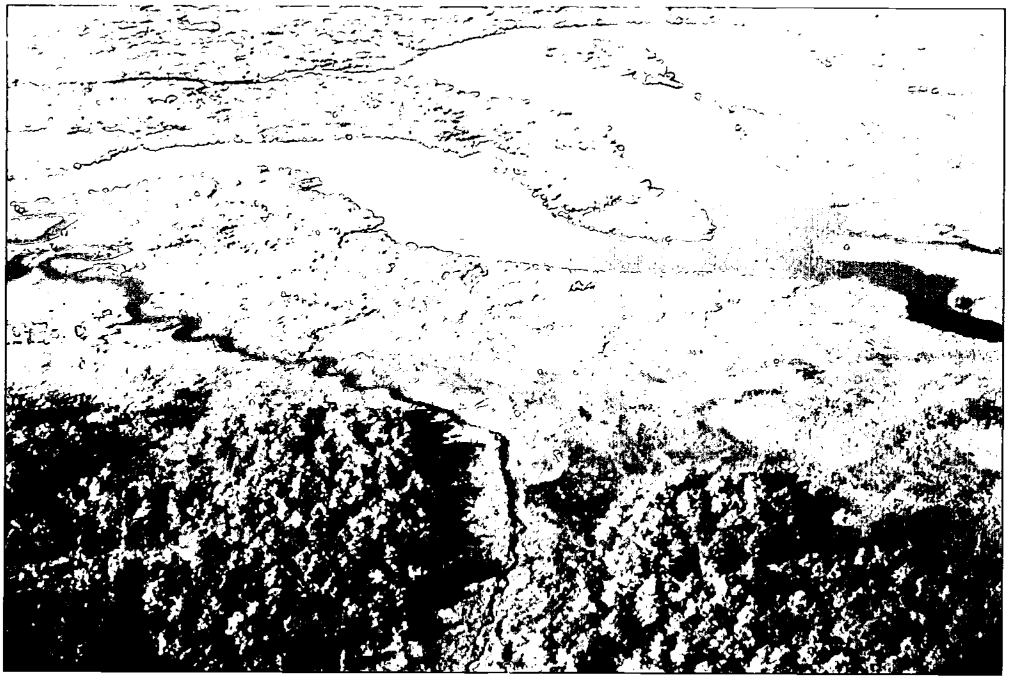
Part I



Introduction
Ecology of an Estuary

The National Estuarine Research Reserve System

Chesapeake Bay
NERR-MD

In 1972, recognizing the value and vital importance of estuaries, the United States Congress established the National Estuarine Research Reserve System. The purpose of this system is "to protect representative estuarine systems, including valuable wetland habitat, for use as natural field laboratories" and to "promote public awareness, understanding, appreciation, and stewardship of estuarine ecosystems and their relationship to the environment as a whole." {Management Plan Chesapeake Bay NERR-MD, July 1990, p.1}

Laura Callahan

The National Estuarine Research Reserve System (NERRS) currently includes 425,000 acres in 18 states and Puerto Rico. With the assistance of federal, state, and local agencies, the Reserve System protects these coastal estuarine environments for research and education.

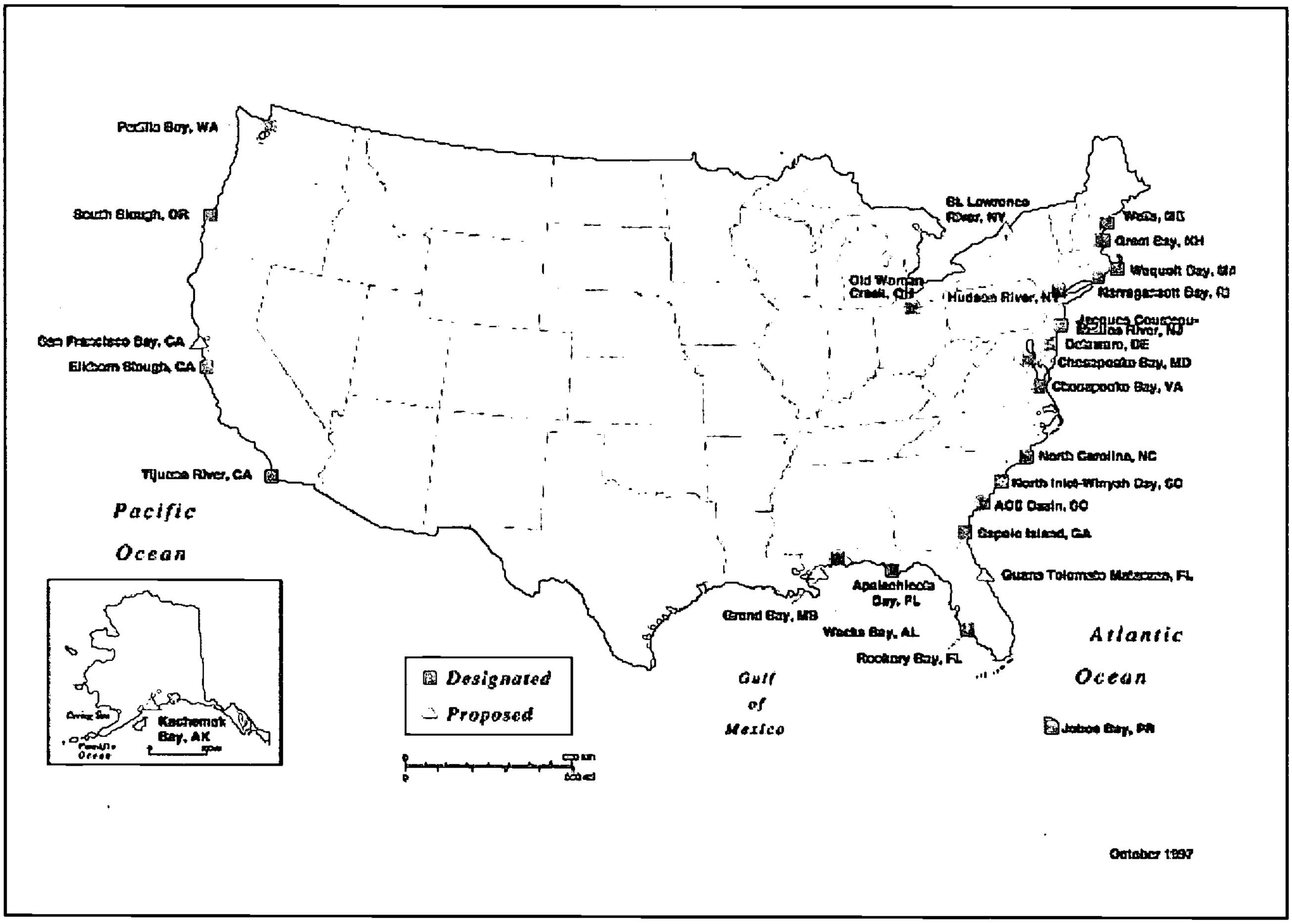
The Reserves serve as living laboratories in which scientists from universities and research organizations throughout the country study the natural processes occurring in estuaries and monitor the impact of human activity on these ecosystems. Reserve staff work with research scientists not only to develop and implement long-term research goals but also to interpret the research results for interested groups. To effectively accomplish this task, National Estuarine Research Reserves offer an array of educational programs to audiences ranging in scope from policy makers, environmental professionals, educators, and government officials to students and families. For each audience the program goals remain the same: to promote an understanding and appreciation of estuarine resources among all visitors and to provide a forum for informed coastal decision making among natural resource planners, environmental professionals, and public officials.

The Chesapeake Bay NERR sites provide protection for Maryland's natural resources while serving as natural field laboratories for estuarine research, monitoring, and education.

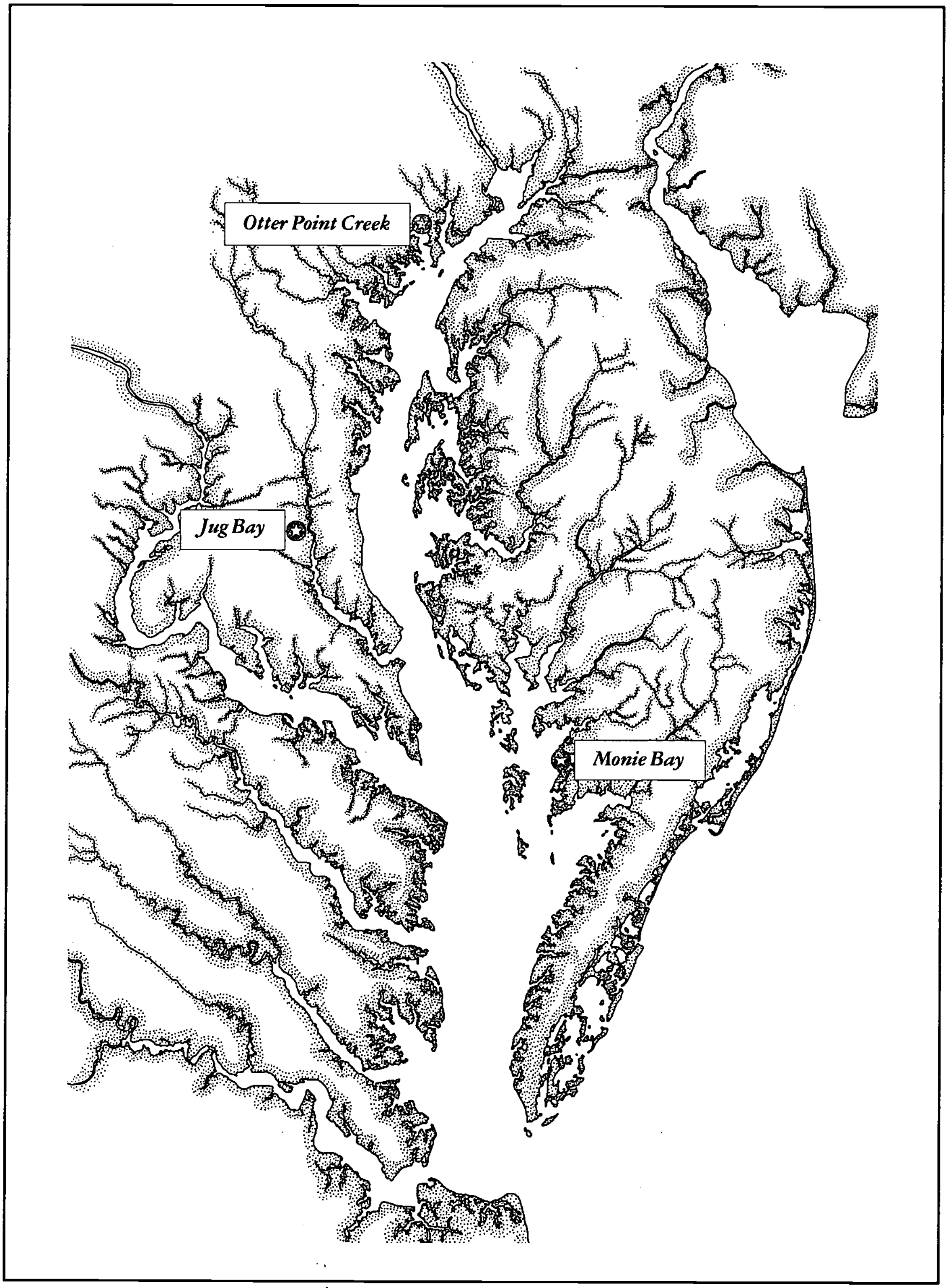
Chesapeake Bay National Estuarine Research Reserve in Maryland

The Chesapeake Bay became part of the National Estuarine Research Reserve System in 1985. Finding no one site typical of the Chesapeake estuary, the State of Maryland entered into partnerships with three local governments and a private, non-profit organization to form a three-component Reserve. The Components include environmentally diverse portions of the Bay from the flooded hardwood forests and marshes of Otter Point Creek in the Upper Bay, to the freshwater tidal wetlands of the Patuxent River at Jug Bay, to the expansive salt marsh habitats of Monie Bay on the lower Eastern Shore. These areas provide protection for Maryland's natural resources while serving as natural field laboratories for estuarine research, monitoring, and education.

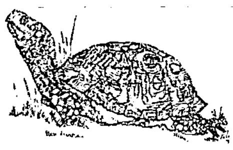
THE NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM ENCOMPASSES MORE THAN 425,000 ACRES IN EIGHTEEN STATES AND PUERTO RICO. THE PROGRAM PROTECTS ESTUARINE HABITAT AS NATURAL FIELD LABORATORIES FOR RESEARCH AND RESEARCH-RELATED EDUCATION.



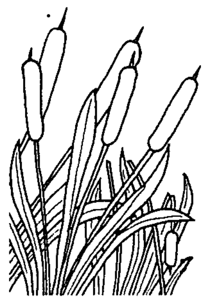
The Chesapeake Bay National Estuarine Research Reserve in Maryland includes three distinct portions of the Bay: Otter Point Creek in the Upper Bay, Jug Bay on the Patuxent River, and Monie Bay on the lower Eastern Shore.



Otter Point Creek Component



Box turtle



Broadleaf cattail

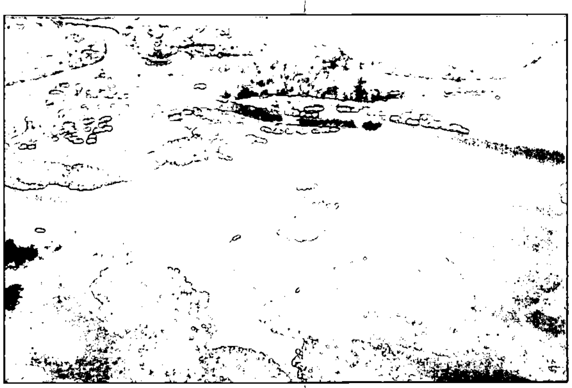
Cardinal Flower

Amid major highways, highly developed residential areas, and commercial-industrial development lies the secluded estuarine environment of the Otter Point Creek Component in Harford County, Maryland. Situated eighteen miles north of Baltimore just east of the Interstate 95 corridor, the Component comprises one of the last remaining expanses of freshwater tidal marsh in the Upper Bay. By virtue of agreements with the Izaak Walton League of America and Harford County Parks and Recreation, the component encompasses 672 acres of open water, tidal marshes, forested wetlands, and upland hardwood forests.

Habitat

Otter Point Creek is a freshwater tidal creek flowing into the Bush River on the upper western shore of the Chesapeake Bay. Its shallow waters range in salinity from 0 to 3 parts per thousand, creating a distinctive freshwater environment with a tidal range of 0.6 meters (approximately 2 feet).

The bottom land forest surrounding the marsh and winding waterways of the Melvin G. Bosely Wildlife Conservancy reflects the quiet beauty of a place overgrown with huge sycamore, river birch, and black willow. Understory shrubs such as elderberry and sassafras, tall stands of jewelweed, and occasional clumps of cardinal flower line the trails. In the low marsh, sweet flag and cattails edge the lagoons while large expanses of spatterdock float on stretches of open water. In the upland forests of Leight Park, mountain laurel dominates the understory shaded by large oaks, Virginia pine, and red maple that form the canopy overhead.



Otter Point comprises one of the last remaining expanses of freshwater tidal marsh in the Upper Bay.

These protected areas abound with wildlife because of their rich habitat diversity. Osprey and eagles circle above searching for food while great blue herons and egrets wade quietly in shallow waters near the shore. Wood ducks nest and feed at the water's edge. Many reptiles, such as black rat snakes, northern water snakes, and snapping turtles, inhabit the wetlands together with wood frogs, toads, and salamanders. The high-pitched calling of peepers and frogs that fills the marsh in early spring slowly changes to the humming drone of cicadas, mosquitoes, and crickets as summer heat settles on the creek. Crayfish hide beneath rocks and logs as minnows and young herring swim silently through the water.

History

The early inhabitants of the Otter Point Creek area were a native people who lived from the bounty of the land. They ate fish and shellfish, hunted and gathered food from the forest, and traded goods with other tribes who lived along the shores of the Chesapeake. Like their neighbors to the south, they feared the mighty Iroquois tribes in the north who periodically traveled down the Susquehanna River raiding the villages along the Chesapeake Bay.

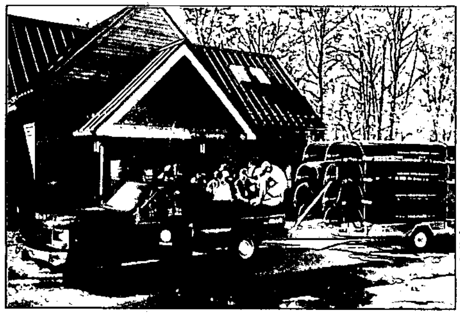
The first Europeans arrived in the region in August of 1608. Captain John Smith with his crew of twelve men set sail from Jamestown, Virginia, on July 24, 1608, on a voyage of discovery to the Upper Bay. Having traveled as far north as the Patapsco River on a previous adventure, Smith's goal on this second expedition was to explore the broad, tidal rivers north of the Patapsco and eventually reach the headwaters of the Bay.

During the exploration Smith and his men sailed into Willowbyes Flue, now known as the Bush River, which was named by Smith in honor of his birth place in England and the home of his honorable friend, Lord Willowby. Smith wrote in his journal that "heaven and earth seemed never to have agreed better to frame a place for man's commodious and delightful habitation." (Preston p. 21)

A tribe of Indians called the Massawomeks inhabited the area of Willowbyes Flue (Bush River) at the time of Smith's arrival. They were a peaceful people who lived in great fear of the warlike Susquehannocks to the north. They must have been subdued by the Susquehannocks in the mid 1600's as no mention of them is made in any future treaties between the early settlers and the Indians living in the region.

By the early 1700's, English settlements dotted the shorelines of Willowbyes Flue. Early colonists engaged in farming, fishing, and trading for a livelihood and transported their goods by boat to other towns on the Chesapeake. Joppa was then a major port and transportation center for the region. Its busy harbor quickly filled with silt, however, as deforestation and agriculture became growing practices in the area. Today the original port of Joppa lies three miles inland, an indication of how rapidly siltation occurred.

Role of the Reserve

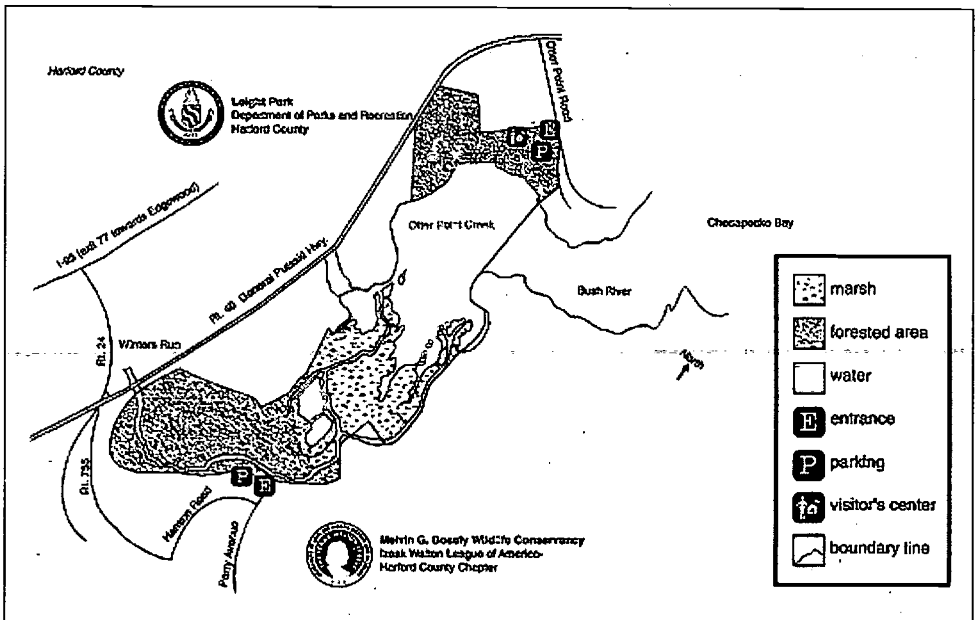


Laura Callahan

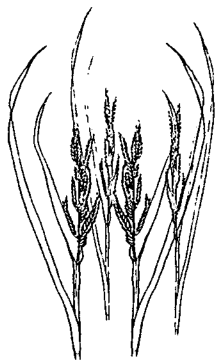
THE ANITA C. LEIGHT ESTUARY CENTER CONTAINS A RESEARCH LABORATORY TO ASSIST SCIENTISTS IN THEIR CONTINUING STUDIES OF THE HISTORY AND ECOLOGY OF THE OTTER POINT CREEK MARSH

Today, Otter Point Creek flows through a densely developed residential, commercial section of the lower eastern end of Harford County. Home building, business development, paving, road construction, deforestation, land disturbance, and sewer line improvement all affect the Winters Run / Otter Point Creek watershed. The location of the Otter Point Creek Component in such a densely populated area not only protects one of the last remaining tidal freshwater marshes in the Upper Bay but also provides ample opportunity for estuarine research and education. With the completion of the Anita C. Leight Estuary Center, facilities are now available for estuarine programs focusing on a wide range of audiences, including land use planners and decision makers. The building also contains a research laboratory to assist scientists in their continuing studies of the history and ecology of the Otter Point Creek Marsh.

Walter W. Preston, History of Harford County Maryland, 1901. Press of Sun Book Office, Baltimore, Md.

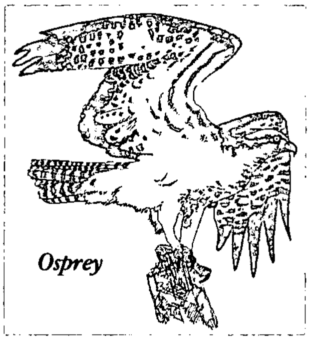


MONIE BAY COMPONENT

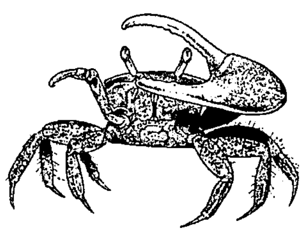


Big Cordgrass

Monie Bay, one of the largest salt marsh habitats in the Chesapeake ecosystem, is located in the northwest corner of Somerset County on Maryland's Lower Eastern Shore. With a salinity range of 12 to 17 parts per thousand, Monie Bay forms a vital link between land and open water in this shallow, salt marsh habitat. The Monie Bay Component encompasses 3,426 acres of water and marshland in the Deal Island Wildlife Management Area.



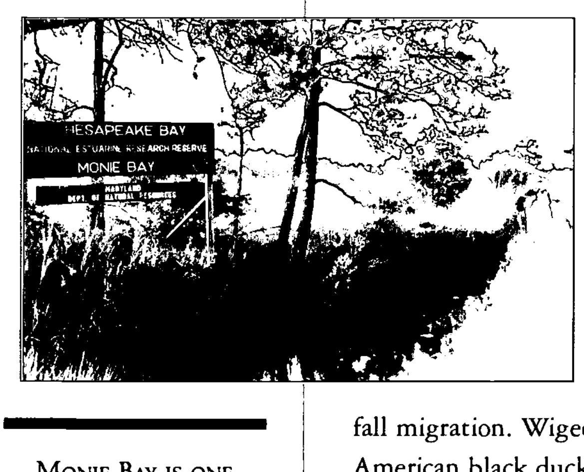
Osprey



Fiddler crab

Habitat

Interlaced with tidal creeks, the brackish marshes of Monie Bay support a wealth of wetland vegetation. Dense beds of widgeon grass, a favorite food for waterfowl, and other submerged aquatic vegetation thrive in the brackish creeks and shallow bay. In the low marsh, saltmarsh cordgrass dominates the landscape while in the slightly drier high marsh, big cordgrass, saltmeadow cordgrass, saltgrass and black needlerush are the dominant species. Loblolly pine, wax myrtle, greenbrier, and poison ivy are the principal species found in the slightly elevated upland areas.



Diverse species of wildlife also abound in the bay and marshlands. Creeks teem with fish while flocks of waterfowl rest quietly in protected expanses of open water during spring and fall migration. Wigeon, canvasback, American black duck, and green-winged teal appear frequently in the marshes together with tundra swan and coots. Bald eagles and osprey circle overhead as northern harriers swoop down over the marsh looking for prey. Black-necked stilt, glossy ibis, semipalmated sandpiper, willet, American bittern, and snowy egret grace the shoreline, expertly plucking fish and small invertebrates from the shallow waters.

Mummichog, white perch, bluefish, Atlantic menhaden and other fish species all flourish here, nourished by plankton, small invertebrates, and large stands of submerged aquatic vegetation (SAV) in which they hide. Fiddler crabs scatter across mudflats and marsh periwinkles crawl up and down stems of cordgrass, scraping off bits of plant as they go. Burrowed beneath the mud lie worms, clams, and mud shrimp, the unseen marsh inhabitants who filter food particles from the water flowing over them. Blue crabs swim along the bay bottom nibbling on decaying plant and animal material, thus completing an important part of the food web in this diverse ecosystem.

MONIE BAY IS ONE OF THE LARGEST SALT MARSH HABITATS IN THE CHESAPEAKE ECOSYSTEM.

History

Somerset County, Maryland's southernmost county, is situated far from the state's major urban centers. The county retains its quiet, rural character with fishing, agriculture, and forestry constituting its major industries. Princess Anne, the historic county seat, and Crisfield, a fishing and seafood packing center, serve as the largest towns in the district.

Artifacts found in the region indicate the presence of Native Americans in Somerset County as early as 13,000 years ago. Of the four major tribes living on the lower Eastern Shore at the time of the Europeans' arrival, the Pocomoke Indians were the principal group occupying the Somerset region. The native people were first described by Captain John Smith in 1608 during his second voyage of exploration. He reported in his journal that the Pocomoke "people at first with great fury seemed to assault us, yet at last with song and daunces and much mirth became very tractable." (Touart 1990) He also commented that the Pocomoke were smaller in stature than Indians on the Eastern Shore of Virginia and spoke a different dialect. Closely associated with the Pocomokes were the Monie Indians who lived to the north along the bay and creeks that now bear their name.

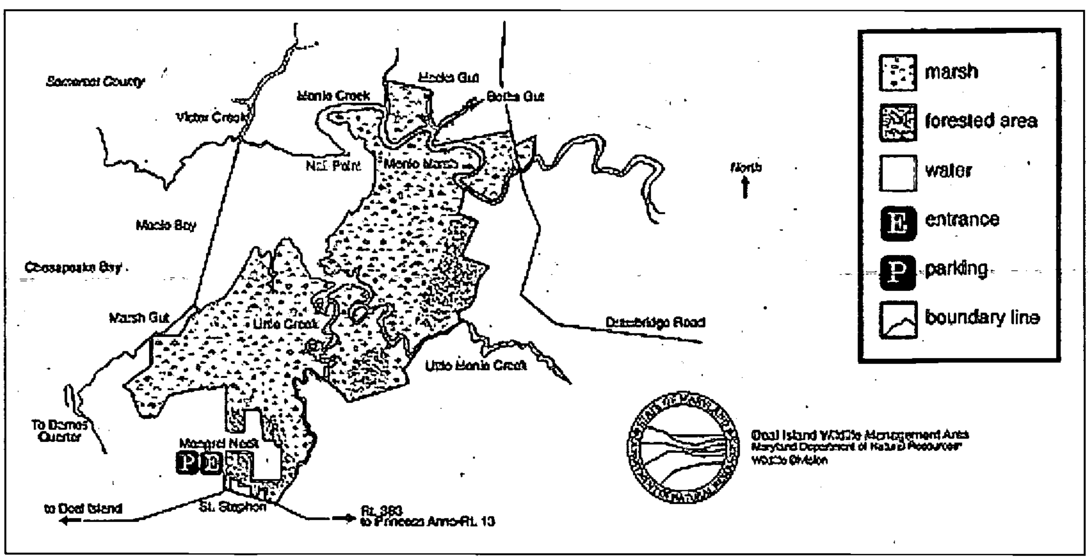
Colonial settlements began in the Monie region in 1665 with the arrival of Quakers from Virginia who came in search of religious freedom. In Maryland they found not only the freedom to worship as they pleased but also flat, fertile lands which lent themselves well to farming. By the early 1700's, families who had settled in the county were engaged in a diversified agriculture that included tobacco, wheat, corn, and livestock production. They exported flour, grain, pork and lumber to England and the West Indies and manufactured cloth, leather, and other marketable goods. Some worked as skilled laborers, growing only the substinence foods needed for their families.

Together with the Quakers came a small group of free black planters who established landholdings in the predominantly white county. Although they owned their own property and provided for themselves and their offspring, they were prevented from rising to any place of importance in plantation society.

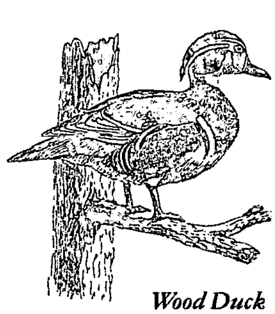
During the 1800's, a change in the economy shifted livelihoods from land to water. Boat building and seafood harvesting became the principal industries supporting the region. Water-related industries remained the chief employers in the county until the mid 1900's when the poultry production began to grow in economic significance. Today the poultry industry represents an important economic base in the Monie region together with seafood and pulpwood harvesting and soybean and corn cultivation.

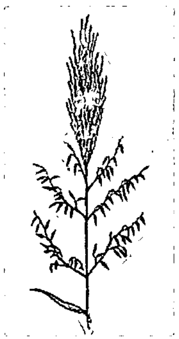
Role of the Reserve

Because of its rich biological diversity and limited accessibility, the Monie Bay Component lends itself well to long-term research and monitoring. Studies conducted in the Reserve by local universities and federal researchers include monitoring of the endangered peregrine falcon, assessment of nutrient loadings from various land use areas, determination of blue crab populations, and measurement of nutrient uptake by marsh plant communities. Programs on duck banding and waterfowl migrations are planned each spring and fall for the general public. Educational programs focusing on estuarine research and ecology are offered both to students and educators on a yearly basis. The purpose of both research and education is to promote understanding, appreciation, and stewardship for this vast, diverse salt marsh ecosystem.



Jug Bay Component


Wood Duck


Wild rice


Salamander

Quietly secluded along the Patuxent River only twenty miles from Washington D.C. lies a tidal freshwater wetland known as Jug Bay. This distinctive estuarine area is bordered by parks on both sides of the river, Patuxent River Park in Prince George's County and Jug Bay Wetlands Sanctuary in Anne Arundel County. Both Jug Bay and portions of its encompassing parkland are protected as part of the Chesapeake Bay National Estuarine Research Reserve. The uniqueness of the estuary resides in its tidal freshwater nature, creating a narrow complement of habitats that exists between brackish marshes and upland freshwater wetlands.

Habitat

The broad, shallow waters of Jug Bay support a great diversity of freshwater plants and animals. Vegetation envelopes the river channel forming a mixture of tidal and non-tidal marshes and forested wetlands surrounded by upland woods and fields. In late summer, the marshes fill with the pale flowers of native wild rice, just one of the many freshwater plant species that thrive in the bay. Spatterdock, arrow arum, swamp rosemallow, pickerelweed, and common reed also bloom in the yearly cycle of seasons.

Jug Bay is a tidal freshwater wetland bordered by parks on both sides of the Patuxent River.

The wetlands provide an important refuge for waterfowl, song birds, and other migratory species as they pass through the Chesapeake region during spring and fall migrations. Throughout the winter months, Jug Bay is home to more than twenty species of geese and ducks, including green-winged teal, wood duck, and American black duck.

Jug Bay marshes also serve as protected feeding grounds and resting areas for wading and shore birds which rely heavily on wetland habitats for their survival. For example, the elusive sora rail, a robin-sized, well-camouflaged game bird that visits the marsh enroute to its southern wintering grounds, feeds in the wild rice stands during August and September before continuing its journey southward. Red-bellied turtles, northern water snakes, green frogs, and dragon flies are also common members of the Jug Bay natural community.

History

As early as 7500 B.C., American Indians were present in the Jug Bay region, finding in the quiet waters an ample supply of fish and on land an abundance of game. Artifacts like axes, spear points, and pottery reveal a relatively continuous and developed community along the shoreline throughout the Bay's early history. By the time the first white settlers arrived, the area was a popular hunting and gathering ground of the Piscataway Indians.

The early colonists who settled along the Patuxent River discovered what Native Americans had learned thousands of years earlier, that the region was a wellspring of natural abundance and beauty. With the colonization of southern Maryland under the Calvert family seal, the fertile lands

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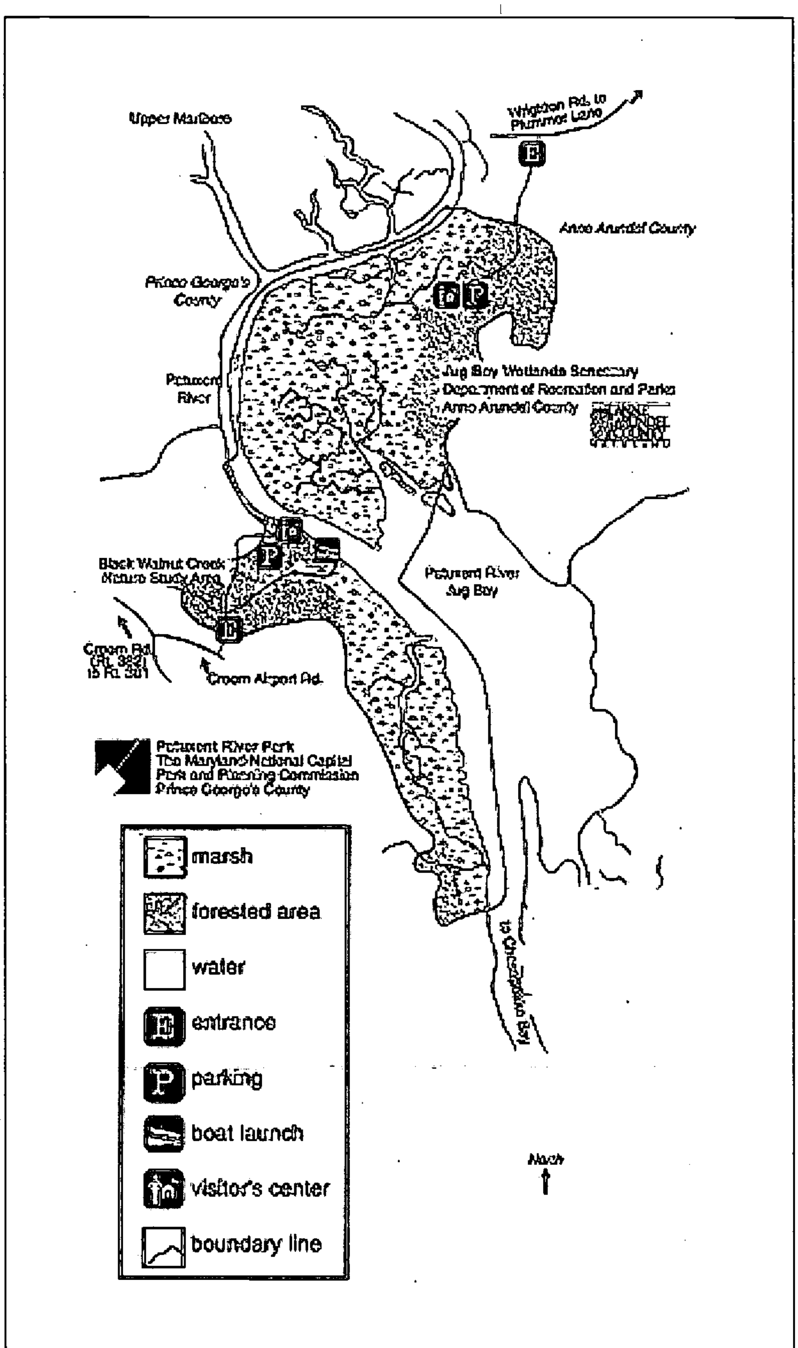
around Jug Bay were soon cleared for agriculture. Tobacco quickly became the dominant crop. Grown on large plantations along the river, tobacco was shipped from Bristol Landing just north of Jug Bay. Ships that sailed up the Patuxent all the way to Bladensburg connected plantations with major cities in the colonies and in Europe. Later, the Chesapeake Beach Railroad crossed the river at Jug Bay, allowing wealthy Washington residents to escape from their noisy urban surroundings to the peaceful shores of the Chesapeake Bay.

Today, Prince George's and Anne Arundel Counties are part of the suburban Washington area, crowded with daily commuters to both Baltimore and the nation's Capital. Yet, despite their proximity to major urban centers, both counties still possess secluded corners of natural beauty reflective of the landscape that once dominated Southern Maryland. Jug Bay is one of these places.

Role of the Reserve

The Jug Bay Component of the Chesapeake Bay National Estuarine Research Reserve in Maryland represents an undisturbed freshwater habitat in the middle reaches of the Chesapeake Bay. The area serves as a natural field laboratory for researchers and scientists to study the dynamic interactions and changes of a wetland community. Equally important, this protected wetlands provides an opportunity for visitors to experience the delight and intrigue of a complex environment. Along scenic board walks, on pontoon or canoe trips, or during interpretive programs along the river, visitors are immersed in wetland habitat and introduced to its importance and beauty.

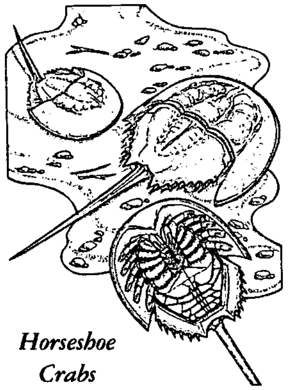
JUG BAY SERVES AS A NATURAL FIELD LABORATORY FOR RESEARCHERS AND SCIENTISTS TO STUDY THE DYNAMIC INTERACTIONS AND CHANGES OF A WETLAND COMMUNITY.



Part II

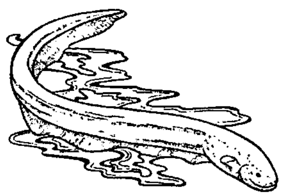
Background Information

WHAT IS AN ESTUARY?

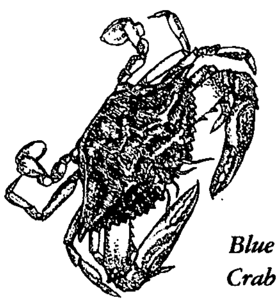


Horseshoe Crabs

An estuary is a complex, dynamic ecosystem that forms where rivers flowing from the land meet the sea. Freshwater draining forests, farms, and urban areas flows into streams and creeks. Creeks flow into rivers. As rivers run toward the sea, they merge with the incoming ocean tide, creating a body of water in which fresh and salt water mix. It is this mixing or churning of fresh and salt water together that gives estuaries their unique characteristics. The name estuary itself comes from the Latin verb "estuare" which means "to surge or be in commotion."



American eel



Blue Crab

The ebb and flow of tidal water allows an exchange of nutrients and detritus between the estuary and the open water. This rhythm of tides, salinity, and nutrients forms unique habitats which generate some of the richest biological productivity in the world. The flow of nutrients and minerals into the estuary stimulates the growth of phytoplankton and submerged aquatic plant life which serve as prime energy sources for the entire estuarine food web.

Estuaries are home to vast numbers of waterfowl and shorebirds. In addition, estuaries are the feeding, resting, and nursery grounds for an abundant array of fish, invertebrates, reptiles, and other aquatic organisms. Many estuarine species are adapted to a wide range of salinity and water levels.

People, too, find the shorelines of estuaries to be wonderful places to live. Estuaries provide safe harbor to ships, easy access to ocean trade routes, and protected coastal habitat for home and industry. Large cities such as Boston, New York and Baltimore, with their vibrant ports, trade and manufacturing centers, packing houses, and industrial complexes, all developed on the edge of estuaries. Commercial fishermen once harvested herring, bass, shad, crabs, oysters, and clams from estaurine waters in numbers too plentiful to count.

Today, however, the very reasons why early populations settled on the shoreline of estuaries now threaten this valuable ecosystem's survival. Population growth together with the accompanying deforestation, altered land use patterns, economic growth and development, industrialization, overharvesting of resources, and pollution all stress the health and viability of estuarine waters. Only through the concerted, cooperative efforts of all citizens will the richness and diversity of estuaries be protected and restored for future generations.

ESTUARIES ARE HOME TO VAST NUMBERS OF WATERFOWL AND SHOREBIRDS. IN ADDITION THEY ARE THE FEEDING, RESTING, AND NURSERY GROUNDS FOR AN ABUNDANT ARRAY OF FISH, INVERTEBRATES, REPTILES, AMPHIBIANS, AND OTHER AQUATIC ORGANISMS.

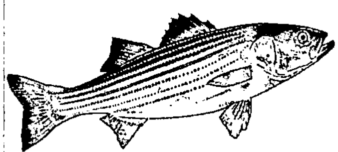
Greg Kearns

THE CHESAPEAKE BAY

Bald eagle

There was a time in recent geological history when the Chesapeake Bay did not exist. It began forming about 10,000 years ago, at the end of the last ice age, when glaciers covering the upper portions of the northern hemisphere began to melt. Before that time, the Bay was only a deep channel in the Susquehanna River which emptied directly into the Atlantic Ocean.

As the climate warmed and glaciers melted, ocean levels began to rise. Along the Atlantic coast, rising seas flooded low-lying coastal areas, including the Susquehanna River Valley. This "drowned" or flooded river valley eventually changed over thousands of years into what we know today as the Chesapeake Bay.

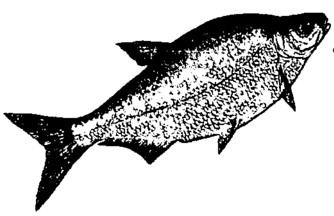


Striped bass

At present, more than fifty percent of the freshwater entering the Bay flows from the Susquehanna River. At least fifty other major river systems also comprise the Chesapeake watershed draining parts of Maryland, Virginia, West Virginia, Delaware, Pennsylvania, New York, and Washington, D.C. The more noted of these rivers include the Patuxent, Potomac, Patapsco, Choptank, and Pocomoke in Maryland and the Rappahannock, York, and James in Virginia.

Oysters

The Chesapeake Bay is 195 miles in length from Havre de Grace, Maryland, to Norfolk, Virginia. It measures between four and thirty miles in width from its narrowest to widest points. Its surface area covers approximately 3,900 square miles, but the entire watershed or drainage basin encompasses 64,000 square miles. The Chesapeake is very shallow, with an average depth of twenty feet. Because it is so shallow, it is especially vulnerable to the impact of human activities and development in its watershed.

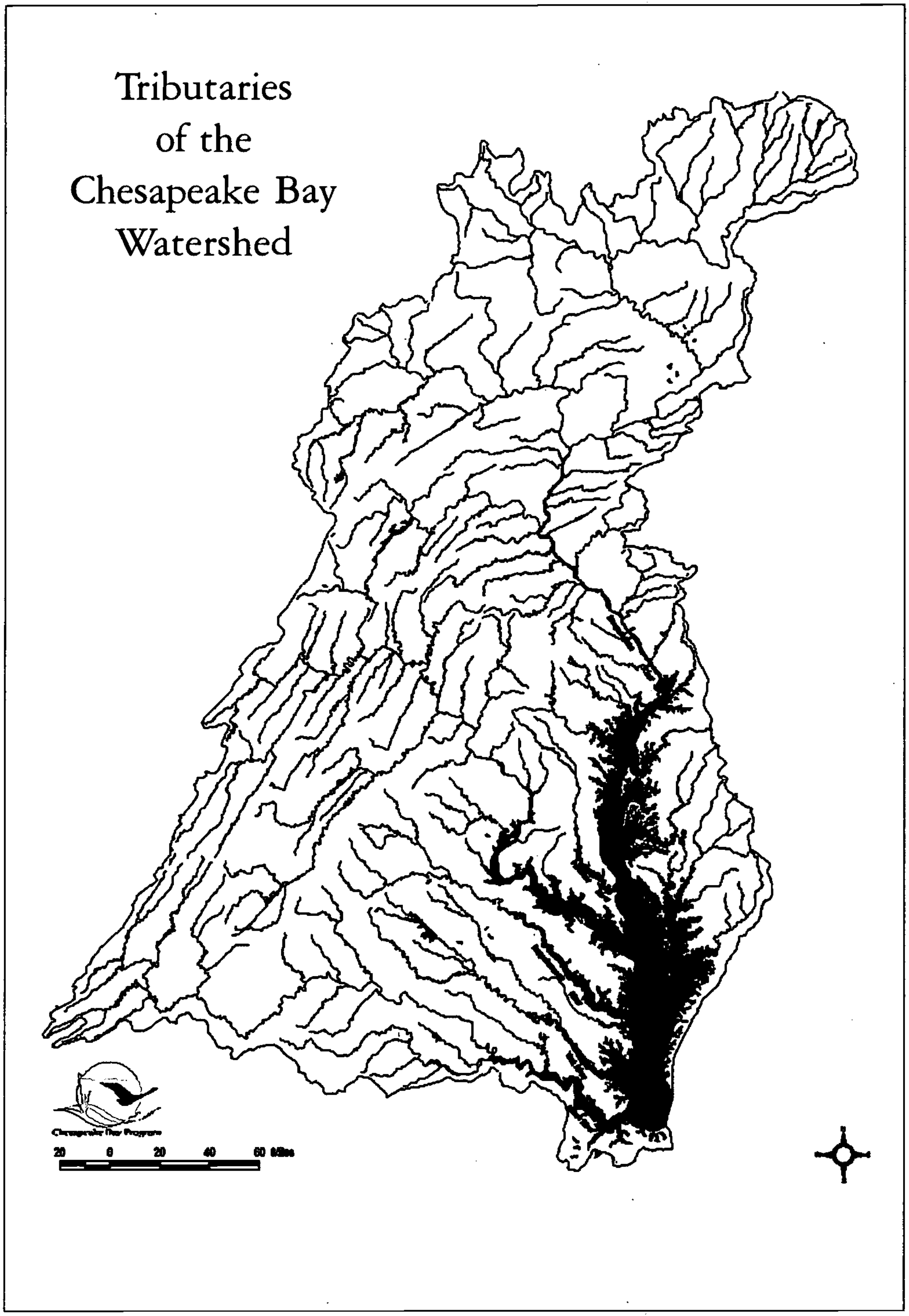


American shad

The Chesapeake Bay is the largest estuary in the United States and one of the most productive estuaries in the world. Its vast reaches include thousands of acres of wetlands, large populations of shellfish and finfish, and fine wintering grounds for migrating waterfowl. It is famous for its excellent harvest of oysters, soft-shelled clams, blue crabs, and striped bass.

However, the productivity of the Chesapeake Bay has declined in recent decades. This decline has been accentuated by startling decreases in oyster, striped bass, shad, and blue crab populations as well as populations of several species of ducks. For example, in 1974 almost three million bushels of oysters were dredged or tonged from the Bay. By 1991 the yield had fallen to less than four thousand bushels per year.

Striped bass harvests on the Chesapeake show similar trends. The commercial catch fell from 14 million pounds in 1973 to less than 2 million pounds in 1983. This drastic reduction in numbers necessitated a temporary moratorium on striped bass harvesting in the Bay from 1985 to 1990. American shad populations suffered as well. When the number of American shad dropped to all-time lows in 1980, the State of Maryland imposed a moratorium on catching this popular fish.



Vast flocks of ducks, such as canvasback, redhead, and American black duck, once darkened the skies over the Chesapeake Bay. However, these species also experienced drastic declines during this century. Reasons for the population decrease include over-hunting, disappearance of food sources such as eelgrass, pondweed, and other submerged aquatic vegetation (SAV), loss of wetland habitats, and the degradation of water quality from increased nutrient and sediment levels, toxic substances, and air pollutants.

In 1976, the Environmental Protection Agency (EPA) reported a link between productivity decline in the Chesapeake estuary and the increase in nutrients, sediment, and toxic substances in its waters. In 1983, Maryland, Virginia, the District of Columbia, Pennsylvania, the Chesapeake Bay Commission, and the EPA signed the first Chesapeake Bay Agreement, pledging cooperative efforts to restore the quality and productivity of the Bay. In 1987, they extended the agreement by promising to take specific actions necessary to reduce pollution, protect wetlands, and restore the living resources of the Bay. Although important efforts such as the upgrading of sewage treatment plants and a temporary ban on striped bass harvesting have contributed significantly to Bay restoration, there is still much to be done to improve and preserve the vitality of the Chesapeake Bay.

Part III

Laura Callahan

Pre-Field Trip Activities

TRACK THAT TRIBUTARY

BACKGROUND

A watershed encompasses the total land area from which rain and melting snow drain into a creek, river, or estuary. Although the Chesapeake Bay itself lies only in Maryland and Virginia, the watershed of the Bay extends over 64,000 square miles and includes land in New York, Pennsylvania, Maryland, Virginia, West Virginia, the District of Columbia, and a small part of Delaware. More than one hundred fifty major tributaries, such as the Susquehanna, Potomac, Rappahannock, York, and James Rivers, flow into the Chesapeake Bay. In fact, the Susquehanna River alone contributes at least 50 % of the fresh water entering the Bay each year.

In a watershed, small creeks and streams flow into rivers which then empty into a bay or ocean. Therefore, whatever chemicals or materials discharge into these tributaries, whether through pipes, off the land, or in the air, eventually find their way into estuaries. Materials such as soil, fertilizers, sewage effluent, and toxic chemicals enter small streams in the upper drainage area and travel down waterways with the current until they finally reach the Bay.

The shallow waters of the Chesapeake are particularly vulnerable to pollutants. Organisms living in the sediment, marshes, and open waters of the Bay tend to trap and filter toxic substances and other chemicals from the water, concentrating them in their tissues and body fat. As a result, activities occurring in the upper reaches of the Chesapeake watershed, such as on a farm in Cooperstown, New York, or in a home in Cumberland, Maryland, influence life in the Chesapeake Bay.

PREPARATION

Copy one Track That Tributary Worksheet per student and one Chesapeake Bay Watershed map per group. Obtain and laminate maps of Maryland or the combined states of Maryland, Virginia, and Delaware.

PROCEDURE

Before the activity, ask students to estimate the number of tributaries flowing into the Chesapeake Bay and identify some of the major river systems (Susquehanna, Potomac, Patuxent etc). Sketch the Chesapeake Bay watershed on the board or show a map of the watershed on an overhead projector. Discuss the term "tributary", tributary components (stream, creek, river), and the relationship of tributaries to the Bay.

Divide the class into groups of four (4) students. Distribute a laminated map, Chesapeake Bay Watershed map, and four worksheets to each group. Allow 30 to 40 minutes for students to study the maps, discuss the answers, and complete the worksheets. At the end of the activity gather the class together to discuss their findings.

PURPOSE:

To develop an understanding of the size and complexity of the Chesapeake Bay watershed and the relationship of the Bay to its tributaries.

SETTING:

In a classroom

TIME REQUIRED:

1 to 2 hours

MATERIALS:

Laminated maps of Maryland, Virginia, and Delaware
(one per group)

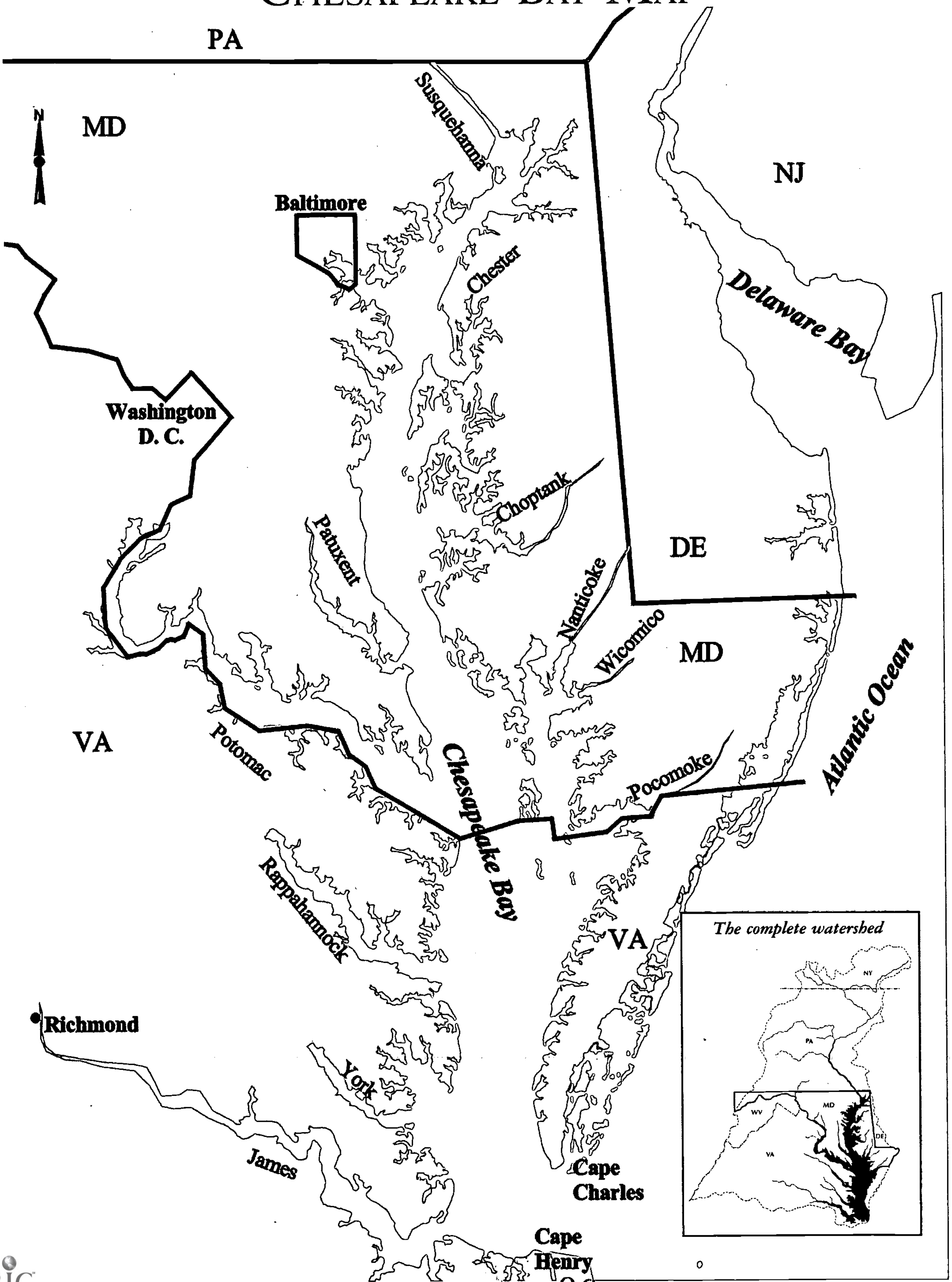
Chesapeake Bay Watershed map
(one per group)

Track That Tributary Worksheet
(one per student)

VOCABULARY:

bay
estuary
tributary
watershed

CHESAPEAKE BAY MAP



TRACK THAT TRIBUTARY WORKSHEET

1. A watershed is the total land area from which water and melting snow drain into a creek, river, or bay. The watershed of the Chesapeake Bay includes not only the land bordering the Bay but also the land drained by rivers and streams that flow into the Bay. The watershed of the Bay is over 64,000 square miles. Name the six states that are part of the Bay watershed.

1. ______________________ *4.* ______________________

2. ______________________ *5.* ______________________

3. ______________________ *6.* ______________________

2. A tributary is a creek or river that flows into a larger river or a bay. Using the Chesapeake Bay Watershed map, name 10 rivers or creeks that are tributaries of the Bay.

1. ______________________ *6.* ______________________

2. ______________________ *7.* ______________________

3. ______________________ *8.* ______________________

4. ______________________ *9.* ______________________

5. ______________________ *10.* ______________________

3. On the laminated map of Maryland, locate and list the river or creek that is nearest to your home. ______________________ Using an erasable or water soluble colored highlighter, trace the flow of this neighborhood stream into the Chesapeake Bay.

4. Now outline the watershed for your neighborhood stream in red on the laminated map. (Depending on where you live, you may need maps for bordering states.) List the streams, creeks, and rivers that are a part of this watershed.

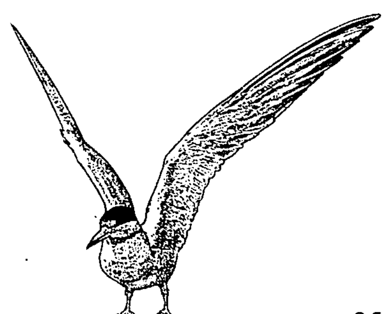
5. Choose one large river in the Chesapeake Bay watershed that does not drain your local area. Locate it on the laminated road map or topographic map and outline its watershed in blue. List all the creeks and streams that flow into it.

6. An estuary is an area in which freshwater from a river mixes with saltwater from the sea. Where is the estuarine portion of the river you chose in #4 located? (Hint: the tidal portion of rivers are usually very wide.)

7. Suppose that a sewer line in Richmond, VA, breaks. Into what bodies of water will the raw sewage flow? What impact will this accident have, if any, on the Chesapeake Bay?

8. A storm washes soil from a construction site in Washington, D.C. onto the neighborhood streets. What effect will this situation have on the Chesapeake Bay?

9. A farmer in Baltimore County is applying pesticides to his fields. Discuss what measures this farmer might take to reduce the possibility of harmful chemicals draining into the Chesapeake watershed and affecting the aquatic organisms living there.



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Related Activities

1. Explore the cultural history of the estuary by tracing land use patterns in the region from the time that Native Americans inhabited the area through the colonial period to present day.

2. Compare current maps of the region to maps of the same location that were drawn twenty-five, fifty, one hundred, and two hundred years ago. Ask students to find and list any changes that may have occurred during this time period. Discuss why these changes most likely took place and what impact, if any, they had on the estuary.

3. You may also wish to obtain aerial photographs of the area taken over several decades and have students look for any visible changes in land use patterns that occurred during that time span. The local Soil Conservation District may have these photos on file.

4. Use U.S. Geological Survey topographic maps for further study of the Chesapeake Bay Watershed. Have students estimate the percentage of land in their local area that is forested, agricultural, industrial, residential, or park land. Ask them to locate certain land features on the maps such as marshes, riverine wetlands, urban and residential areas, industrial sites, and paved surfaces. Research what impact these facilities have on the Bay.

5. During the actual field experience, locate and explore small tributaries in the vicinity. Discuss their relationship to the area under investigation as well as to the Chesapeake Bay.

6. Have students locate the cities of Richmond, Washington D.C., Baltimore, and Philadelphia on the map. Ask them to determine why these population centers were first situated in their particular locations.

7. Contact Maryland Save Our Streams and the U.S. Fish and Wildlife Service for additional watershed activities.

forest

cultivated

suburban

urban

urban/industrial

Mixing Waters

BACKGROUND

An estuary is a semi-enclosed body of water in which freshwater from streams and rivers mixes with saltwater from the sea. As freshwater enters an estuary, it flows downstream on river currents while saltwater from the ocean moves upstream on the tide. The denser, or heavier, saltwater sinks to the bottom of the estuary as a wedge or layer beneath the freshwater.

During storms, high winds, or times of significant temperature changes (spring and fall), the saltwater and freshwater layers begin to mix. The resulting brackish or semi-salty water created by this mixing remains in constant motion, churning and flowing in rhythmic patterns. Winds, tides, temperature, and water density combine with other fluctuating conditions to create a dynamic, changing ecosystem.

It is this constant motion in an estuary which brings nutrients to the surface and stimulates productivity. In the spring and fall of the year, as surface and bottom water temperatures equalize, wind passing across the water's surface stirs and mixes water from beneath. Upwellings of cold, dense saltwater from the bay bottom bring new minerals and nutrients to the surface. This influx of nutrients into warming, sunlit surface waters triggers a rapid increase in phytoplankton populations throughout the estuary. Zooplankton, crustaceans, fish, and many other Bay organisms feast and thrive on this abundant food source. The phenomenal abundance of plant life in estuaries ranks them among the most productive ecosystems in the world.

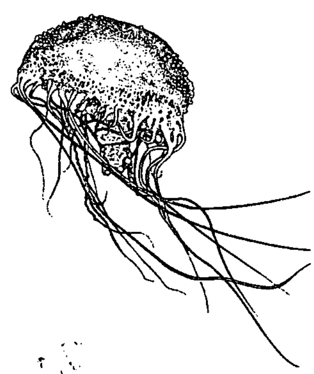
PREPARATION

Gather materials needed for the activity and practice the demonstration before doing it for the class.

PROCEDURE

Introduce the demonstration by defining an estuary as a body of water in which freshwater from rivers meets and mixes with saltwater from the sea. Explain that the Chesapeake Bay as well as the lower portion of many rivers in Maryland are estuaries. It may be helpful to point out these estuarine areas on a map of the state. Then question the students on their understanding of fresh, salt, and brackish water. Discuss how freshwater and saltwater enter the Bay.

After the discussion, demonstrate the formation of a saltwater wedge in an estuary.



PURPOSE:

To demonstrate the mixing of freshwater and saltwater in an estuary and the formation of a saltwater wedge.

SETTING:

In a classroom

TIME REQUIRED:

30 minutes

MATERIALS:

lunch tray
clear glass baking dish or aquarium
pitcher of cold water
pitcher of warm water
red and blue food coloring
2 measuring cups
2 tablespoons salt

VOCABULARY:

brackish water
density
dynamic
estuary
freshwater
phytoplankton
productivity
saltwater
saltwater wedge
salinity

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DEMONSTRATION

Note: Water temperature is very important to the success of this demonstration. Use warm water for freshwater and cold water for salt water.

1. Place the glass baking dish or aquarium on a table in the front or center of the room. Arrange a large, white piece of paper under and behind the dish to increase the visibility of the colored layers. Placing a light behind the dish or tank will also help to distinguish the layers.

2. Pour warm water into a cup, add red food color and mix. The red water represents freshwater in a creek or river.

3. Pour cold water into a second cup, add three to five tablespoons of salt, and stir. Then add blue food coloring and mix. The blue water represents saltwater from the ocean.

4. Pour the red freshwater into the glass baking dish or aquarium. This represents a river or creek flowing into the bay. Then pour the blue saltwater slowly along the side of the baking dish, demonstrating the incoming ocean tide.

5. Saltwater is heavier than fresh water and will form a blue layer beneath the red layer on the bottom of the dish or aquarium. The blue layer represents the saltwater wedge which forms beneath the red freshwater layer on the surface.

Adapted from Project Estuary, "The Physical Properties of Estuaries," and The Chesapeake Bay, It Starts With You, "A Model Estuary."

WORKSHEET AND DISCUSSION

Divide the class into groups of three or four students and assign a leader, recorder, and reporter to each group. Then allow the students fifteen to twenty minutes to discuss and answer the questions on the Mixing Waters Worksheet. At the end of the discussion time, ask each group to report on an answer to one of the questions. Discuss the results.

1. Is it possible that the two layers of water will always remain separate? If not, what factors may cause the layering to disappear and the two layers to mix?

   Wind, currents, rain, and temperature changes will all influence the mixing of estuarine waters.

2. What happens to the layering effect in an estuary when the tide goes out?

   Freshwater continues to flow into the Bay from tidal creeks and rivers. The saltwater layer, however, begins to retreat, somewhat reducing the salinity of the water.

3. Does the mixing of fresh and salt water help or benefit organisms that live in an estuary? Please explain your answer.

   The incoming ocean currents carry minerals and nutrients with them into the estuary. As the salt water begins mixing with freshwater, upwellings carry nutrients from the bottom to the surface. The enriched surface waters then stimulate large phytoplankton blooms, which are a very important food source for many estuarine animals.

4. What adaptations will an organism need in order to survive in a brackish or saltwater environment?

   The organism will need to possess some mechanism for expelling or excluding salt from the water it takes into its system or tissues.

Mixing Waters Worksheet

Please answer the following questions based on what you have learned from the demonstration.

1. Is it possible that the two layers of water will always remain separate? If not, what factors may cause the layering to disappear and the two layers to mix?

2. What happens to the layering effect in an estuary when the tide goes out?

3. Does the mixing of fresh and salt water help or benefit organisms that live in an estuary? Please explain your answer.

4. What adaptations will an organism need in order to survive in a changing brackish or saltwater environment?

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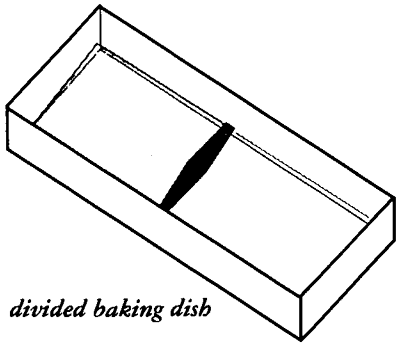
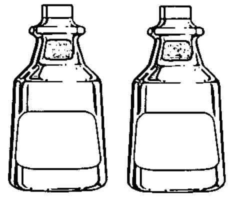
RELATED ACTIVITIES

1. Set up a second baking dish with a wall of clay down the middle. The wall serves as a divider between freshwater and saltwater environments. Now pour warm, red freshwater into one half of the dish and cold, blue saltwater into the other half. Once both sections of the dish are filled, create a small breach in the middle of the clay wall. As the red and blue water flow together, blue saltwater should settle to the bottom of the dish while the red freshwater layer remains on top. A purple color will appear in the area in which the two layers mix.



divided baking dish

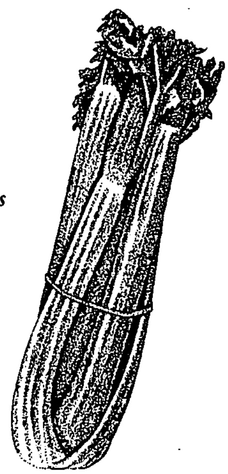


blue and red food coloring

2. Celery stalks and red food coloring may be used to demonstrate the uptake of water by marsh plants. Cut the ends from crisp celery stalks and place them in a glass jar containing a few drops of red food coloring and water. As the stalks absorb water, red coloring rises up the stem, dyeing the leaves and vascular tubes a faint red.

glass jars of salt water

3. Place another stalk of celery in a glass of salt water and observe what changes occur. Ask the students to predict the results and then explain their observations. **(Water moves from the celery cells, areas of high water concentration, to the salt water, an area of lower water concentration.)** As a result of this water loss from its cells, the celery stalk becomes very limp.



celery stalks

Adapted from Project Estuary, "The Physical Properties of Estuaries," and The Chesapeake Bay, It Starts With You, "A Model Estuary."

The Oyster Bar

INTRODUCTION

The American oyster, Crassostrea virginica, that once flourished in Maryland waters, is declining rapidly in the Chesapeake Bay. In fact, the oyster population of the Bay has decreased by 95% in the last century. Disease, overharvesting, pollution, sediment, water quality degradation, and destruction of oyster beds by dredging all contribute to the loss of this valuable resource.

The health of Chesapeake oysters relates directly to the quality of water in which they live. As they filter plankton from their surroundings, oysters take in other chemicals, pollutants, and disease causing organisms present in the Bay. These substances may create a great deal of stress on oyster populations by contaminating their tissue or drastically altering the optimum conditions needed for growth.

An oyster's sensitivity to its environment begins very early in life. As a newly developed larva or veliger, it swims free. It then develops a muscular foot which senses the bottom to find a suitable site to attach itself. When it finds suitable substrate (preferably other oyster shells,) the veliger cements itself and will not move again. It is now known as spat.

An oyster feeds by pumping water through its gills. They filter out and retain planktonic organisms such as diatoms, algae and dinoflagellates. Oysters filter out silt and bind it in mucous. When pumped out of the oyster, the silt settles to the bottom rather than staying in the water column.

Oyster bars once functioned as huge filtering systems in the Bay, cleansing the water as it passed through its gills. Scientists estimate that as recently as one hundred years ago, oysters filtered a volume of water equivalent to the amount in the Bay in about 3-5 days. Today, a reduced number of oysters requires more than a year to filter the same volume of water.

Salinity influences the growth, development, reproduction and feeding activity of oysters. They can tolerate a wide range of salinities, but thrive in the Bay's brackish waters. Brackish water is neither salt water like the ocean at 35 ppt (parts per thousand) nor freshwater at 0 ppt. Oysters become less abundant toward the head of the Bay and in the upper reaches of the Bay's tributaries where the salinity falls below 5 ppt. Please remember that although salinity does have an impact, salinity alone does not determine how well an oyster will grow. For more information on oysters, please refer to the book, Habitat Requirements for Chesapeake Bay Living Resources.

PREPARATION

Fill five plastic gallon jugs with water at room temperature. Number the

PURPOSE:

To mimic an oyster larva's search for the right salinity by tasting several water samples and comparing them to a known solution. The known solution represents the salinity needed by young oysters for growth.

SETTING:

In a classroom

TIME REQUIRED:

1/2 to 1 hour

MATERIALS:

5 plastic gallon jugs
water
table salt
long-handled spoon
measuring cup
paper cups
eye droppers
clean hands!
known salinity sample

VOCABULARY:

degradation	salinity
disease	substrate
dredging	sediment
larva	spat
overharvesting	veliger
oyster bar	water quality
pollution	

jugs 1 through 5 and then rearrange the bottles in the following order: 4, 2, 5, 1, and 3. Pour the specified amount of table salt into each jug.

Jug #4	No salt
Jug #2	1/4 cup salt
Jug #5	1/2 cup salt
Jug #1	3/4 cup salt
Jug #3	1 cup salt

Divide the class into groups of four students. Number five paper cups 1 through 5 and mark the sixth cup "Known Sample." Prepare a set of cups and an eye dropper for each group.

Shake each jug well and pour water from each of the numbered jugs into the corresponding cup for each group. Select Jug #5 as the known salinity sample and pour water from Jug #5 into the Known Sample cup for each group.

PROCEDURE

Discuss oyster growth and development with the students. Current information on oyster populations and disease is available through the Maryland Department of Natural Resources. Read to the class a few paragraphs from Tom Horton's essay, "Short, Important Trips of Oysters," in Bay Country.

Then introduce the students to the oyster tasting activity. They need to determine which bottle contains the brackish water in which oysters will thrive. This brackish water will match the Known Sample in taste.

Have students work in teams of four with one member of each team serving as a recorder. Then assign a set of numbered cups arranged in numerical order (1,2,3,4,5) and a Known Sample to each group.

Next, instruct each team member to use an eye dropper to place a few drops of water from the Known Sample onto his or her hand. Each individual will then taste the water drops to determine the salinity of the Known Sample. Then ask each student to place a few drops of water from cup #1 onto his or her hand and taste it to see if it matches the salinity of the Known Sample. After the team comes to a consensus of opinion about the water's salinity, have the recorder list the results of the test on the Oyster Bar Worksheet. The team will then proceed to test water from each of the remaining cups in the same manner.

After the water in every cup has been sampled, ask each team to arrange the cups in an order of increasing salinity from the least salty water to the most salty. The proper cup order for increasing salinity will be cup #4,2,5,1,3. Then ask each team to choose the water sample which matches the Known Sample, a salinity level in which oysters thrive.

CONCLUSION

Ask each team to report on its findings. Tabulate the results for the class on the overhead, blackboard, or flip chart. Discuss the effect of changing salinity levels on young oysters as well as other organisms living in an estuary.

RELATED ACTIVITIES

Perform the activity "Mixing Waters" for the class to demonstrate the mixing of fresh water with salt water in an estuary.

Research the effect of overharvesting and diseases on the Chesapeake oyster population.

If possible, examine live oysters with the class, studying both the fascinating community of organisms that live on the oyster shell as well as the internal structures of the oyster.

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THE OYSTER BAR WORKSHEET

Determine the saltiness of the water in each cup using the taste test. Check the appropriate box for the level of saltiness you choose for each water sample tested.

SALINITY **CUP NUMBER**

	1	2	3	4	5	Unknown
No Salt						
Fairly Salty						
Lightly Salty						
Medium Salty						
Very Salty						

The cup containing water matching the salinity of the Known Sample is cup number ________.

WHO AM I?

BACKGROUND

While investigating estuarine habitats, students will discover a variety of organisms living in, on, under, or near the water. Many of these species possess intriguing lifestyles or adaptations which enable them to survive and flourish in a changing environment. Through research into life cycles and habitat requirements of estuarine organisms, students will broaden their understanding of species living in the Chesapeake Bay.

PREPARATION

Collect pictures of plants and animals that live in an estuary, particularly in the Chesapeake Bay. Cut photos from nature magazines or copy the Who Am I? pictures. If students research a particular species in preparation for their field studies, they may wish to sketch the organism for this game. Suggested species include the following:

arrow arum	barnacle
muskrat	northern harrier
eelgrass	grass shrimp
beaver	great blue heron
blue crab	Canada goose
osprey	oyster
herring gull	phytoplankton
canvasback	killifish
cattail	cordgrass
raccoon	river otter
leopard frog	mud snail
diatom	eel
sea nettle	shark
mummichog	
diamond-back terrapin	

PROCEDURE

Clip or tape a picture of a Bay organism on each player's back, being careful to keep the picture out of the wearer's view. Only the other players will know what species an individual is wearing.

INSTRUCTIONS

Ask students to stand in a circle with their backs to the outside while instructions are given. Players are to discover the identity of the organism they are wearing by asking questions of their fellow students. However, only questions requiring an answer of "yes", "no", "sometimes", or "I don't know" may be asked. For example, a player may ask broad questions, such as: Am I an animal? Do I have a backbone? Am I warm-blooded? Do I eat freshly killed meat? Am I able to fly? Once the player narrows the possibilities in this way, then he or she may ask more specific questions about particular organisms until he or she determines who they are.

Players may move freely about the room while trying to discover their identity. A player may ask only <u>two questions</u> of each individual at a time. Once a student identifies the species he or she is wearing, that player then moves the picture to his/her front side. If a player requires extra help at the end of the game, each "identified" person may offer a clue until the remaining player guesses his or her correct species.

PURPOSE:

To become familiar with the plants and animals living in an estuary.

SETTING:

In a playground, gym, or large classroom

TIME REQUIRED:

30 minutes

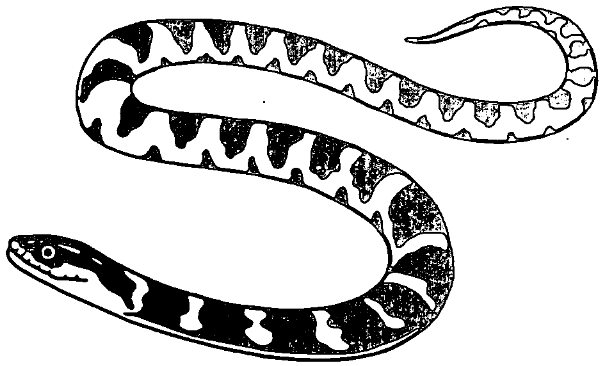
MATERIALS:

pictures of estuarine plants and animals
clothespins or masking tape
Who Am I? pictures

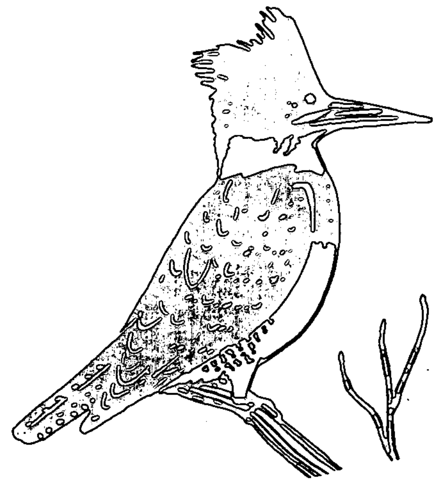
VOCABULARY:

adaptation
estuarine
estuary
habitat

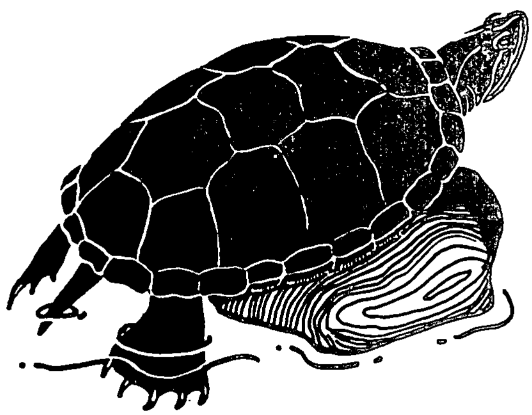
WHO AM I? - PICTURES



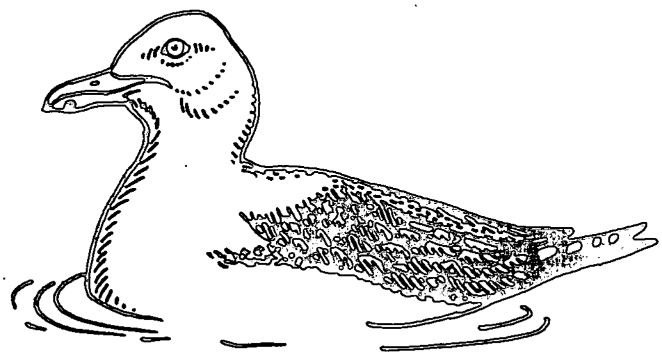
Northern Water Snake



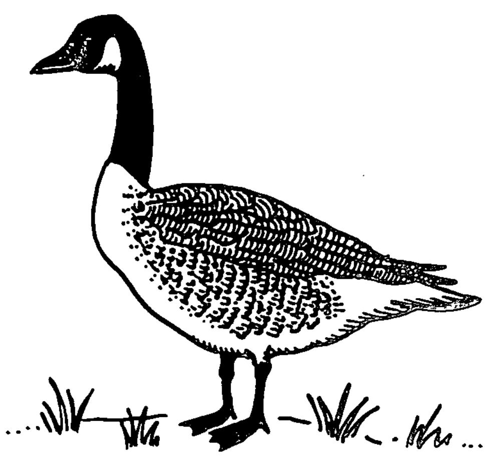
Belted Kingfisher



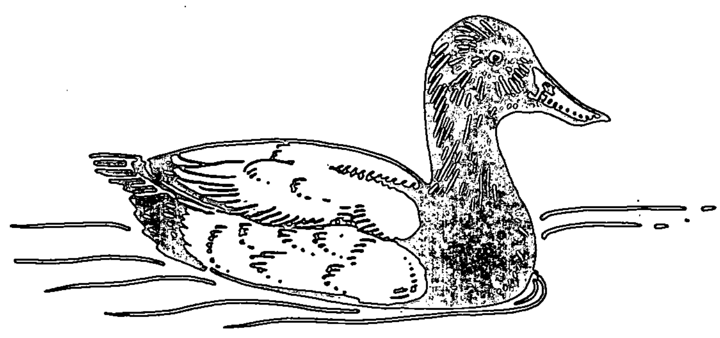
Red-bellied Turtle



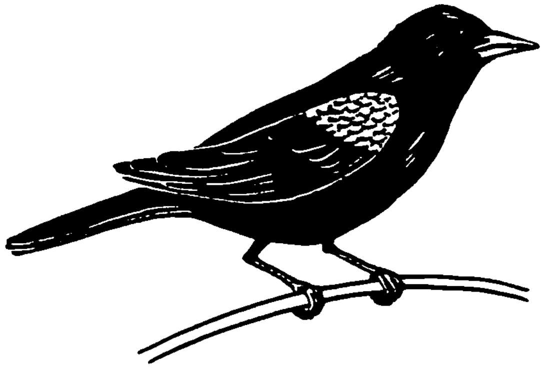
Herring Gull



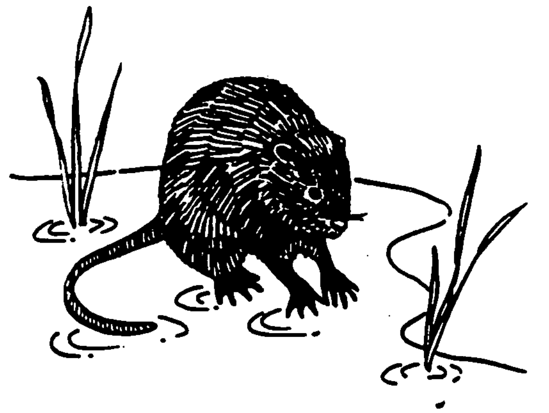
Canada Goose



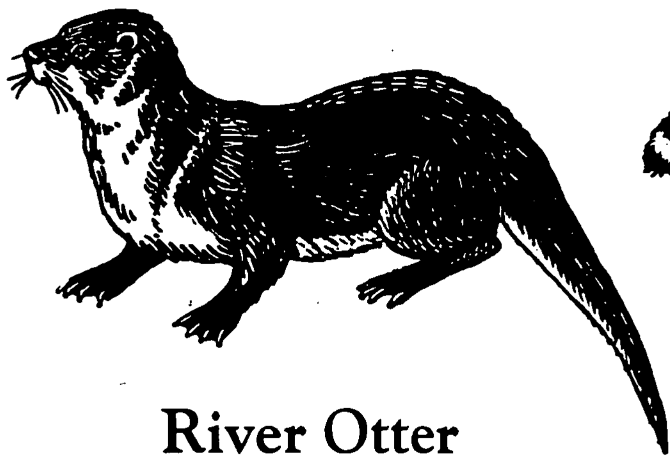
Canvasback Duck



Red-winged Blackbird

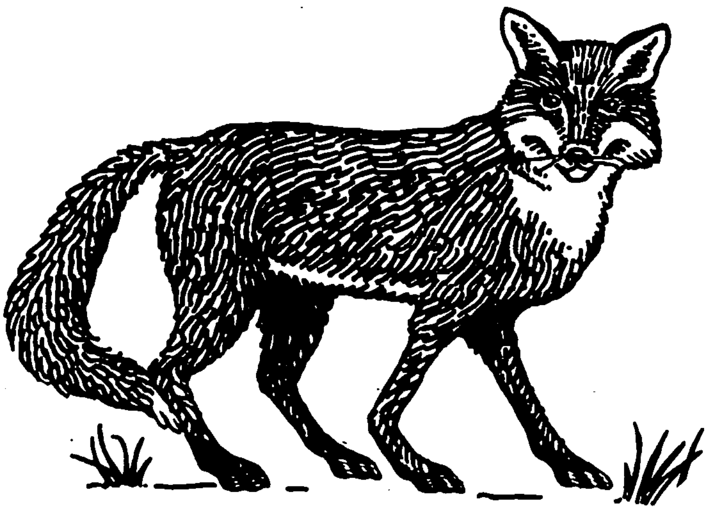


Muskrat



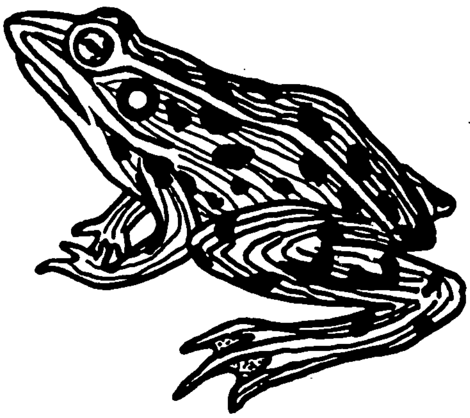
River Otter

Raccoon

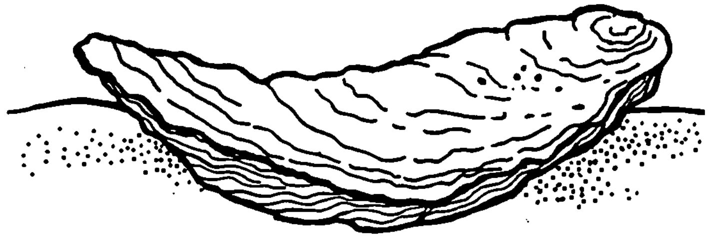


Red Fox

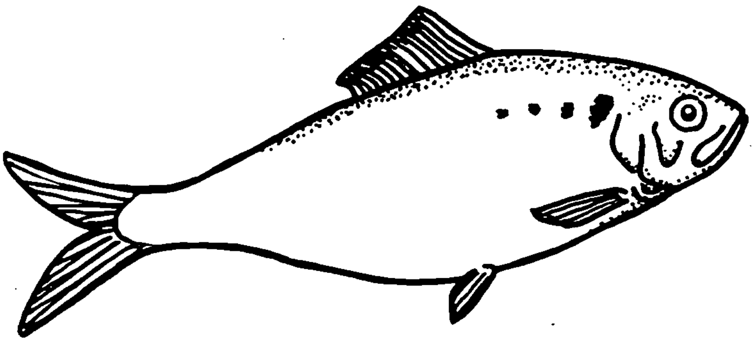
Osprey



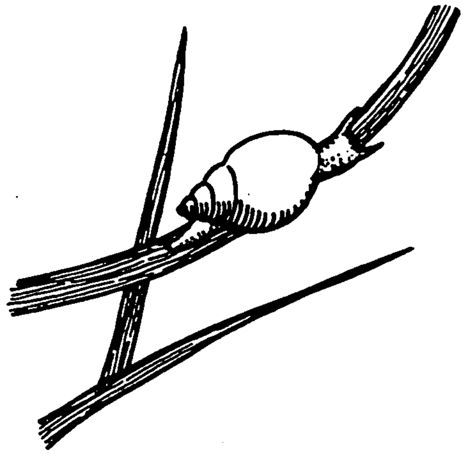
Leopard Frog



American Oyster

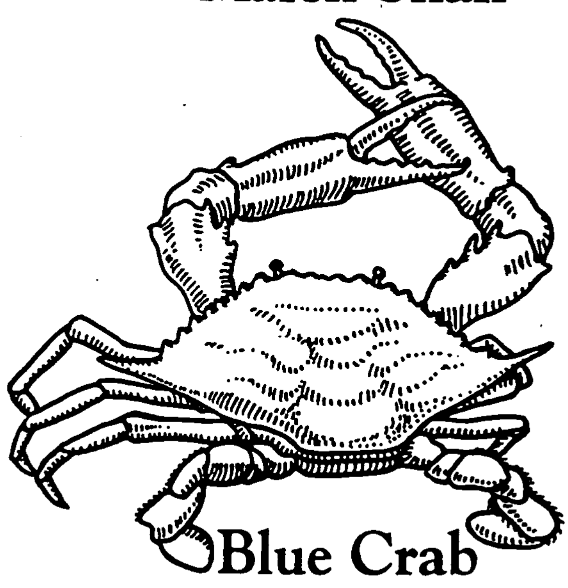


American Shad

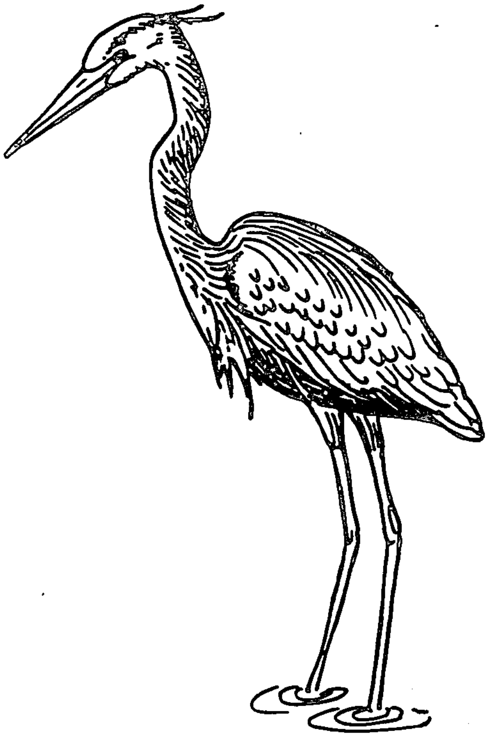


Marsh Snail

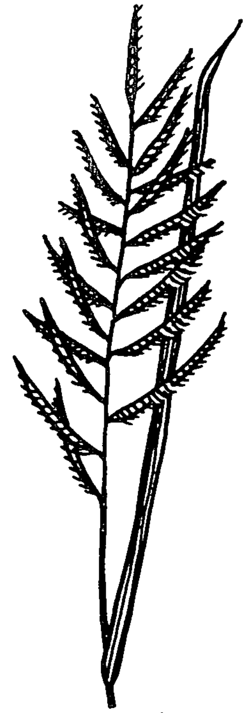
Striped Bass



Blue Crab


Great Blue Heron

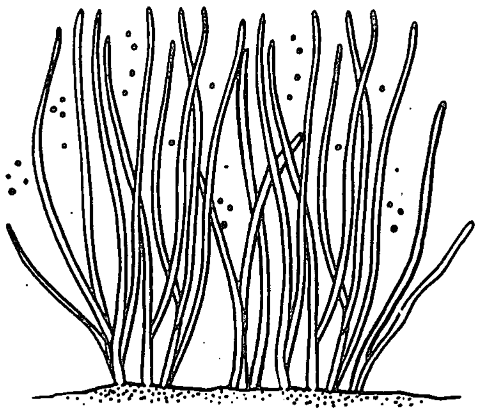

Cattail


Big Cordgrass

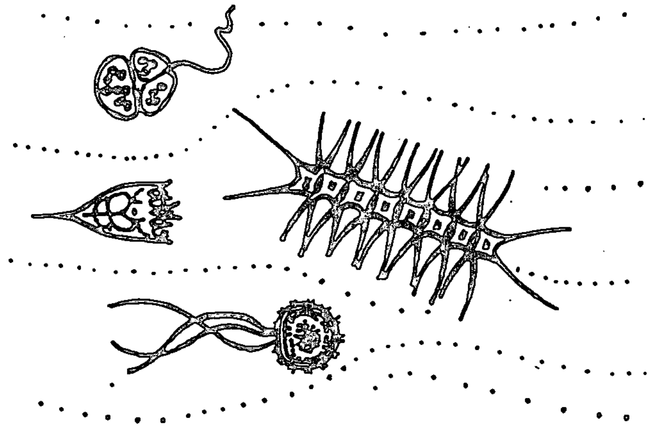

Wild Rice


Corn


Phragmites

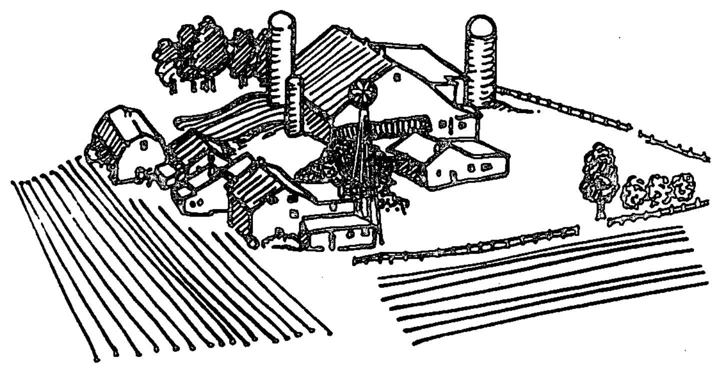


Eelgrass



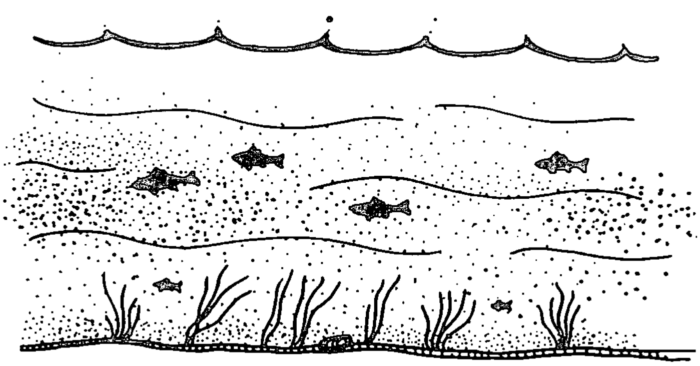
Algae

Swamp Rose



Nutrient Source

Forest



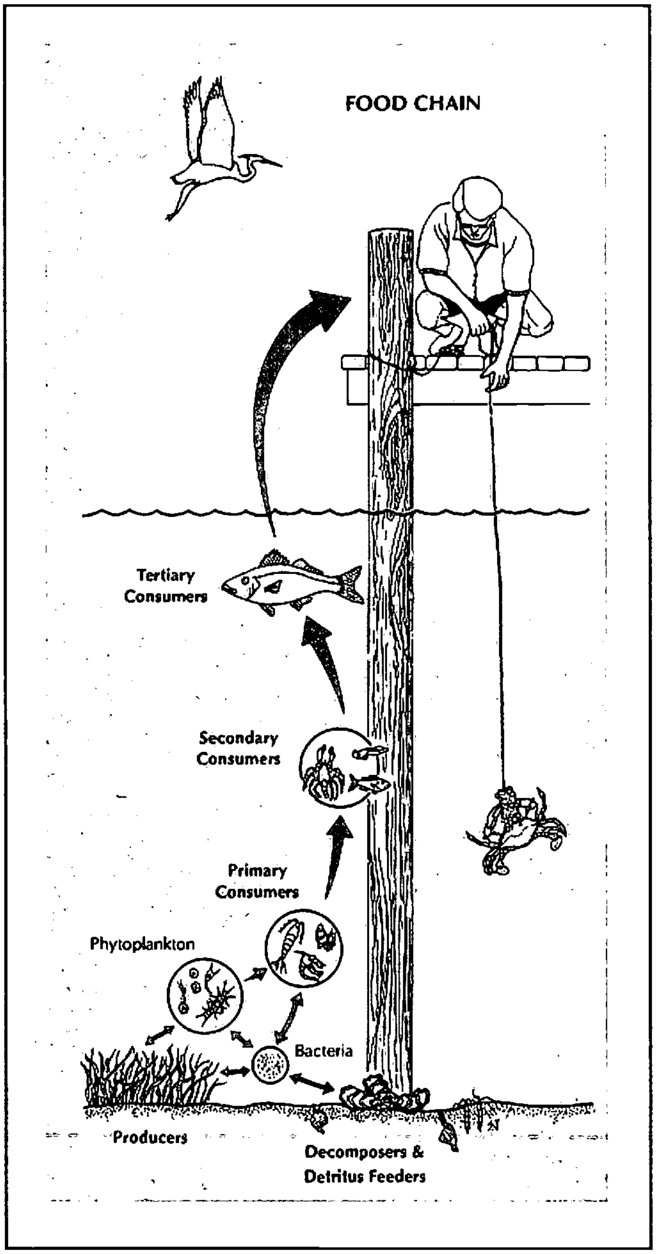
Sediment

39

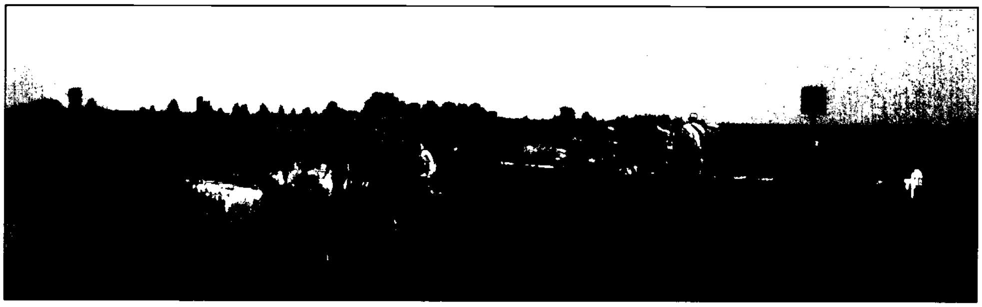
RELATED ACTIVITIES

1. Ask students to construct estuarine food chains using the species pictured in the game. Then challenge the class to form a food web from the food chains. The chains and web may be in writing, in poster form using pictures, or "in person" if students are wearing their pictures.

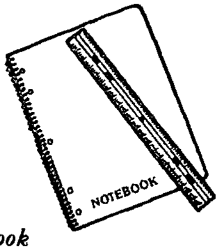
Adapted from "Wild Animal Scramble" Sharing Nature With Children by Joseph Cornell



Part IV



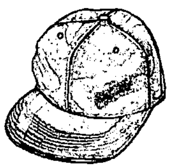
Planning a Field Trip

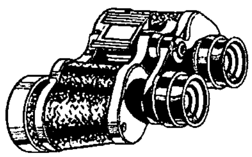


notebook

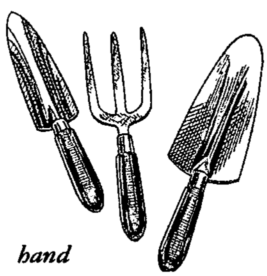
backpack

hat





binoculars



hand tools

a pair of old sneakers

PLANNING A FIELD TRIP

An ideal way to generate interest and enthusiasm among students for wetlands and estuaries is on a field trip. Experiencing tidal flows, marsh grasses bending in the wind, flocks of waterfowl, or throngs of fiddler crabs teaches students more about estuaries than textbook descriptions are able to convey.

Prior to the field trip, talk with the students about where they will be going and what they will be seeing and doing while they are there. Use state, county, and topographic maps plus aerial photographs to locate the site and determine land use patterns in the watershed over a period of years. Describe the type of habitat they will find at the field location in addition to the plant and animal life they will likely discover there. Emphasize that the estuary is a protected natural area in which plants, animals, and other living things are respected and safeguarded. This requires responsible behavior on the students' part, such as walking slowly and quietly so wildlife is not disturbed, being careful not to pick or crush vegetation, and carefully returning any collected specimens to their original habitats.

Be certain to discuss with the class the importance of proper dress for the field study. Depending on the weather and where the field study will take place, conditions may be very wet and muddy. Old clothes, a pair of old sneakers, a towel, a change of shoes and clothing, a plastic bag for dirty items, a hat, sunscreen, insect repellant, and proper outerwear are all important items for the occasion.

In preparation for the field trip, visit the field location to determine necessary logistics. Note travel time, parking accomodations, restroom facilities, picnic areas, possible hazards, trail length, station locations, rotation schedule, and ways to transport students and equipment to and from the field study stations.

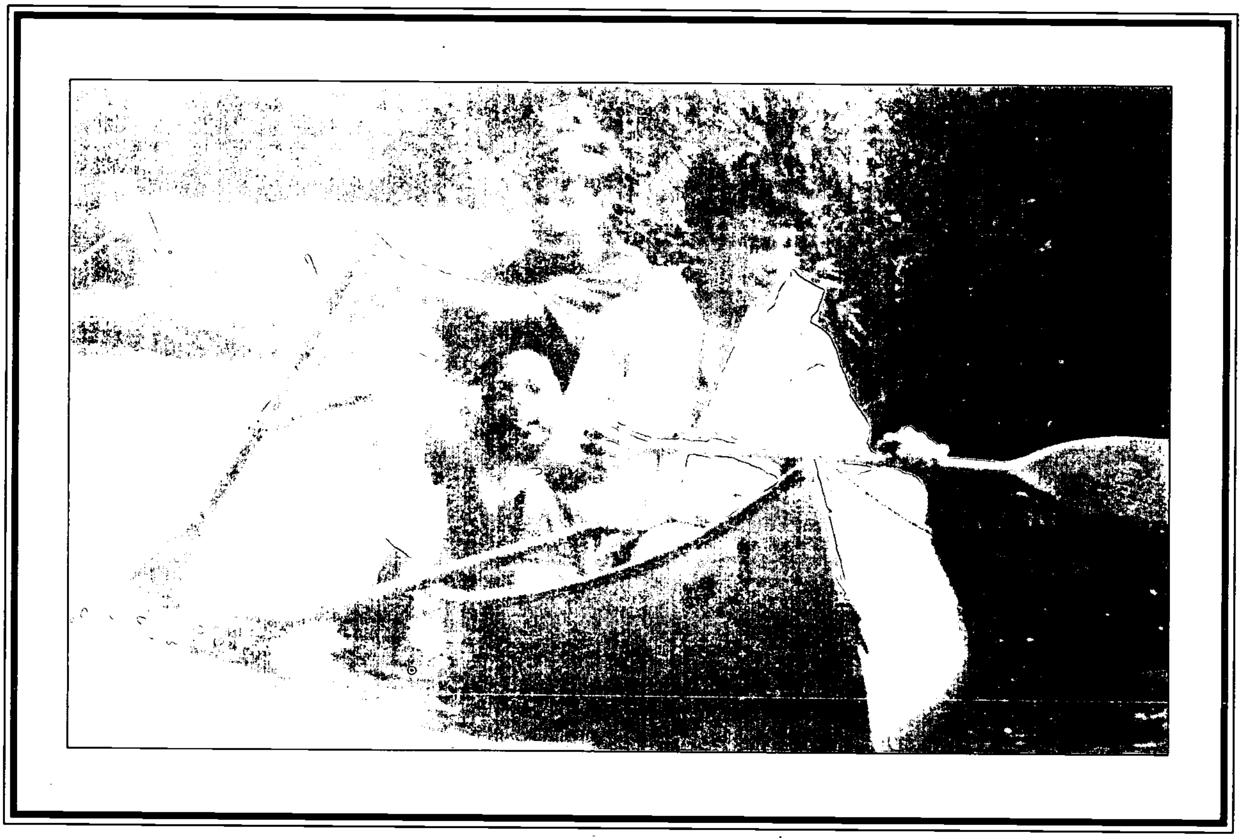
Two weeks before the trip, divide the class into teams of three or four students and assign pre-trip duties and research to each team. Arrange for an adult or high school chaperon to accompany each team during its field investigation.

On the day of the field trip, allow students a few minutes to adjust to their new surroundings before beginning the day's activities. Point out the group meeting area, location of rest rooms, and park office where staff members are available to help. Take a restroom break and then gather all the students together. Introduce the naturalist and other adult leaders who will be assisting the class during their field investigations. Outline the schedule for the day, the location of study stations, expected behavior and conduct, and any other guidelines pertinent to the day.

Laura Callahan

Safety is always of utmost consideration during field studies. Following these simple suggestions will help to make any field trip a safe educational experience.

1. Always have other adults present to assist you.
2. Avoid dangerous areas, such as sharp drop-offs or rising tides.
3. Keep the group together. If small groups are in different locations, arrange to meet at a specified time and place.
4. Have a first aid kit and cellular phone with you throughout the trip.
5. Have students wear shoes at all times, both in the water and on land.
6. Be certain that everyone in a canoe or boat is wearing a life jacket at all times. All boating safety precautions should be followed.



Part V

Field Trip Activities

WHO LIVES HERE?

BACKGROUND

It is sometimes very difficult to observe wildlife, especially in urban and suburban settings. Many wild animals shy away from people or are nocturnal, making them difficult to view even under the best conditions. Considering these circumstances, it is best to focus the field trip on the discovery of animal signs rather than depending on actual wildlife observations. Students find it an adventure to hunt for footprints, bird's nests, feathers, bones, snake skins, animal droppings, deer rubbings, or any other fascinating clue to an animal's presence that they might discover.

PREPARATION

Visit the area chosen for the field study prior to the activity to familiarize yourself with the location. Search for animal signs as well as any logistical or safety considerations. Useful books for this activity are Olaus Murie, Field Guide to Animal Tracks (Peterson Field Guide Series) and Dorcas Miller, Track Finder (Master Finder Series). Copy the Who Lives Here? Worksheets I and II. One set of worksheets is needed per group. Familiarize the class with the animals found in the Otter Point Creek Component (see Appendix) or the estuarine area you will be visiting. One way of doing this is to have students research the habitat preference, diet, and activity patterns of the various species and present their findings to the class.

Explain to the class that they may not actually see many of the animals during the field investigation, but they will definitely discover signs or "clues" indicating an animal's presence. Some clues or signs include tracks, holes in the ground and in trees, nests, animal droppings, deer rubbings, bone fragments, fur, or teeth marks on tree saplings. You may wish to explain the importance of scat or animal droppings as a source of information on the diet and health of certain animal populations. Design a data sheet with the students for recording the wildlife signs they may discover during the field investigation.

Send a note to the parents requesting adult volunteers for each student group. Include a reminder that students will need to wear outdoor attire and old shoes or boots for the field study.

PROCEDURE

Divide the class into small groups, reminding students of the need for quiet during this field adventure. Assign a clip board, pencil, and worksheet to the recorder in each group. Emphasize the need for teamwork among the students in discovering signs of wildlife.

PURPOSE:

To observe animals and/or animal signs along a stream's edge.

SETTING:

Along the edge of Jug Bay, Otter Point Creek or on the banks of a small stream.

TIME REQUIRED:

1 to 2 hours

MATERIALS:

field guides to animal tracks

Who Lives Here? Worksheets I and II
(one set per group)

clipboard and pencil
(one per group)

student data sheets

VOCABULARY:

nocturnal
riparian
rubbing
scat
sign
track

Lead the children on a walk along the creek and in the woods looking, listening, smelling and feeling for any evidence of animal life. Possible discoveries might be tracks in the mud, crayfish chimneys, deer rubbings on trees, fragments of shell, holes in logs, small piles of scat, or turtles basking in the sun.

Carefully turn over rocks in the stream or decaying logs along the path to see what might be hiding beneath them. Look and listen for frogs at the pond's edge. Once you are in the open marsh, be attentive to the sights and sounds of this wonderful wetland. Watch for herons, egrets, ospreys, and small wading birds. Listen for the whir and buzz of insects, croaking frogs, birds calling, and other intriguing marsh sounds. Don't overlook the spiders, sowbugs, and earthworms as well. They play a very important role in this riparian ecosystem.

CONCLUSION

At the end of the field trip, tally the animal sightings, signs, and tracks observed by each group. Discuss the various signs with the students, relating the evidence discovered on the field trip to the diversity of life inhabiting the estuary.

Borderbund

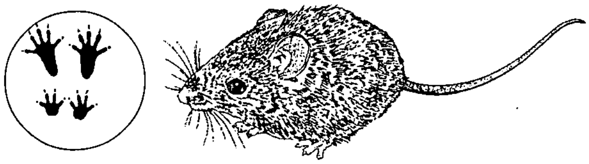
RELATED ACTIVITES

Challenge the teams to research the natural history of various species to determine why these organisms live in an estuary. Play the game "Who Am I?" Develop food chains and webs using the animals observed either directly or indirectly during the field study.

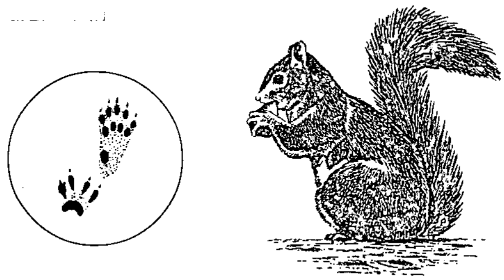
Laura Callahan

WHO LIVES HERE? - WORKSHEET 1

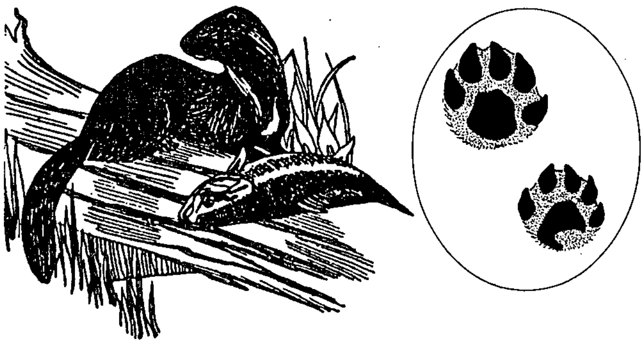
ANIMAL TRACKS



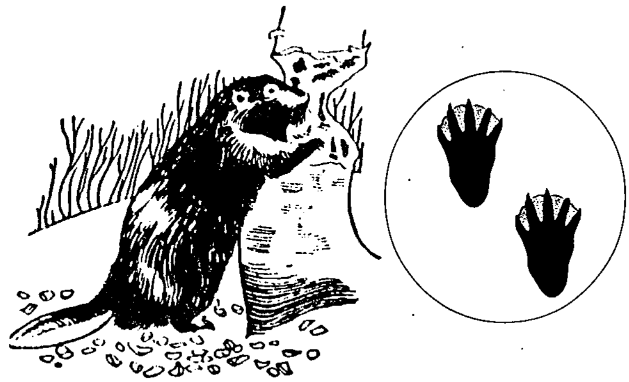
White-footed mouse



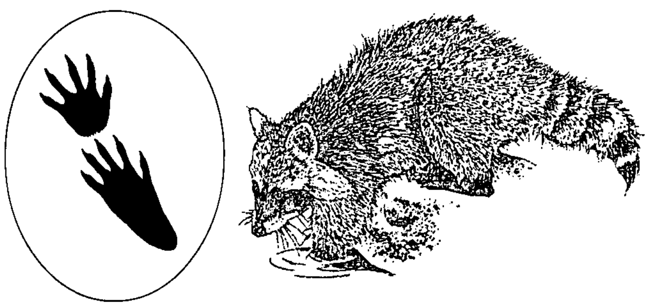
Eastern grey squirrel



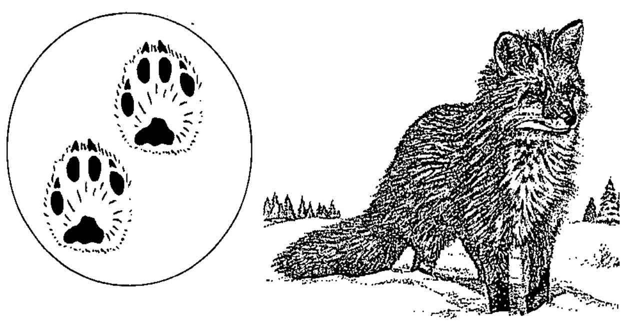
River Otter



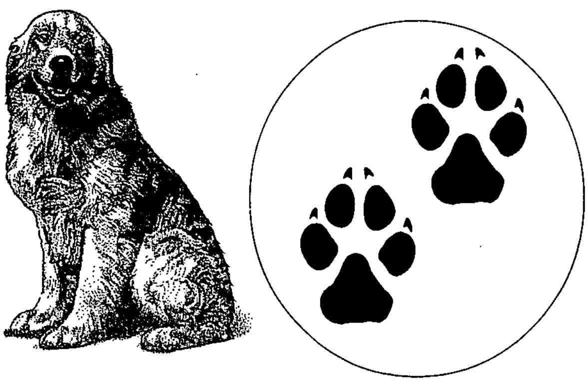
Beaver



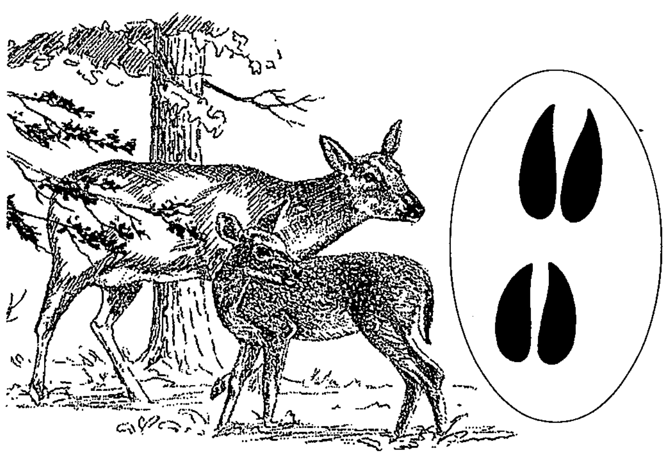
Raccoon



Red fox



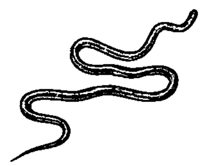
Dog



White-tailed deer

WHO LIVES HERE? - WORKSHEET 2

ANIMAL SIGNS

ANIMAL SIGN	ANIMAL
Scattered feathers	Songbird 
Pile of nutshells on stump or log	Eastern gray squirrel 
Small pile of crayfish shell pieces	River Otter 
Oval pellet of fur and small bones	Owl 
Whitewash on tree or ground below tree	Owl
Snake skin on ground or tree	Black rat snake 
Scat filled with large seeds and berries	Raccoon 
Spiral droppings with small bones and fur	Red fox 
Large (20 - 30 cm) round hole in ground	Woodchuck (Groundhog) 
Small hole at base of tree	Eastern chipmunk 
Dam of sticks across stream	Beaver 
Dome-shaped mound of reeds in marsh	Muskrat 

Patterns of Plants

BACKGROUND

As the primary link in an aquatic food web, plants provide the basis for all life existing in and around the waters of an estuary. They are food for the microscopic zooplankton that swim at the water's surface as well as the fish, muskrats, waterfowl and other animals in the estuary. Even as they die and decompose, plants nourish a myriad community of detritus feeders who feast on them throughout the year. Plants also provide shelter, habitat, and nesting materials for shore birds and migratory waterfowl.

Estuarine plants experience varying conditions in their surroundings because of fluctuating water levels, salinity, turbidity, currents, and pollutants. However, over time, aquatic plants have evolved special adaptations to help them survive in this changing environment. For example, emergent plants such as spatterdock and pickerelweed have air-filled tissue in their stems and leaves to help them remain upright and to increase the availability of carbon dioxide and oxygen to their cells.

Other adaptations found in aquatic plants include:

1. the formation of flowers and seeds on tall stalks to facilitate wind or insect pollination;
2. thick underground stems called rhizomes which anchor the plant in the mud and store food;
3. the elimination of salt through leaf pores;
4. thick, succulent, wax-coated leaves that reduce the evaporation of water from the plant;
5. arrow-shaped leaves that offer little resistance to moving water;
6. stiff, rigid leaves to withstand the movement of flowing water; and
7. long, flexible leaves which bend easily in strong currents.

See Patterns of Plants Worksheet II (Estuarine Plant Adaptations) for examples of plants exhibiting these various adaptations.

PREPARATION

Before the field trip, discuss with students the importance of plants in an estuarine ecosystem as well as the stresses plants experience in this changing environment. You may demonstrate some of these stresses to the class with the use of a house plant such as a geranium. Pour tap water at room temperature on the leaf of a house plant. Ask students to observe the response of the leaf to these conditions. Then pour saltwater at room temperature over the leaf and note the plant's response. What changes occur? Simulate tidal conditions by submerging the plant in freshwater for three hours. How does submersion affect the plant?

PURPOSE:

To recognize various aquatic plant species and to study the adaptations of these plants to an estuarine environment.

SETTING:

On boardwalks through the marsh at Jug Bay Wetlands Sanctuary or Patuxent River Park. On the trail to the open marsh at Otter Point Creek. Along the shoreline at the end of Messick Road (Dame's Quarter Boat Ramp parking lot) at Monie Bay.

TIME REQUIRED:

1 to 2 hours

MATERIALS:

potted geranium; pocket knife;
salt; shovel or trowel;
field study notebooks
or clipboards with stiff paper
(one per student)
plant identification cards *(optional)*
Pattern of Plants Worksheets
I and II *(one per student)*

VOCABULARY:

adaptation	freshwater plant
detritus	rhizome
emergent plant	salt marsh plant

Familiarize students with the concept of adaptation. An adaptation is a genetically determined characteristic of the structure, function, or form of an organism that helps it to survive in its environment. After demonstrating the effects of various stresses on a house plant, ask students to pretend that they are plants living in an estuary. Brainstorm the various adaptations that they, as plants, might develop over time in order to survive the tidal fluctuations and other stresses of an estuarine environment. Record all ideas on the board. Include the adaptations listed above if students do not suggest them.

Visit the field study location prior to the field trip to familiarize yourself with the aquatic plants growing there. Choose a study area in which wetland plants may be closely observed, such as on the boardwalks of the Jug Bay Wetlands Sanctuary or Patuxent River Park. Mark and map observation stations for each team. Also plan a rotation schedule which will move teams to at least three different plant communities.

You may also wish to prepare identification cards for the plants students will be seeing. Using the Patterns of Plants Worksheet I (Typical Estuarine Plants) or other plant references, copy the picture and name of each plant growing in the study area. Mount each picture on a thin piece of cardboard and laminate it. These cards will be helpful in preparing students for the activity as well as in identifying aquatic plants during the actual field investigation.

PROCEDURE

Divide the class into small groups, being sure that each student has a clipboard, card (or a field notebook), and a pencil. Assign each group to a particular station in the study area. Each team is to observe, describe, and sketch three different marsh plants growing in their location. With each drawing they are to include the size, shape and characteristics of the plant as well as any adaptations the plant may possess for surviving in an estuary. Students may use the Estuarine Plant Adaptations Worksheet as a guide.

Allow a fixed amount of time (20 minutes or so) for each team to complete its inventory. At the end of that time period, rotate the teams to a new station. Have students sketch and describe three new plant species during each rotation. Encourage students to identify the marsh plants they find using the Typical Estuarine Plants Worksheet or the identification cards prepared earlier in class.

CONCLUSION

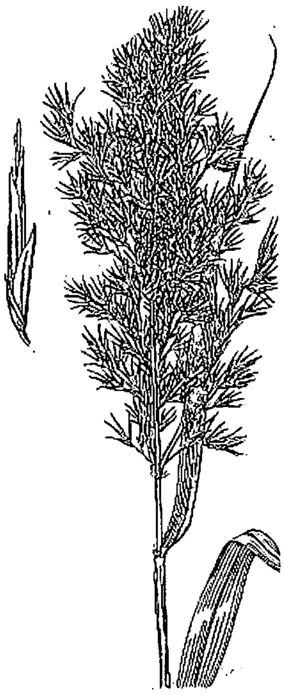
At the end of the activity gather the students into a large circle. Ask one representative from each team to describe a plant discovered in the study area and the adaptations which this plant possesses for surviving in its estuarine environment. When all teams have shared their findings, discuss with the group the similarities and differences of plants growing in a marsh.

Related Activities

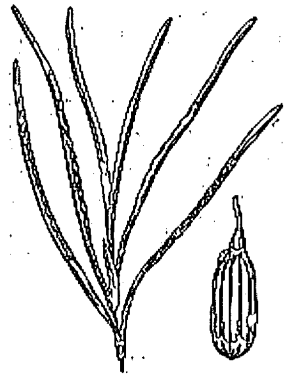
In the classroom, ask students to list all the characteristics they consider vital to aquatic plants based on their field observations. Then, using these vital characteristics as guidelines, challenge each student to "invent" or "create" his or her own unique, three-dimensional aquatic plant. Have a "Marsh Plant Expo" to display the creations for the class and the school.

Patterns Of Plants - Worksheet I

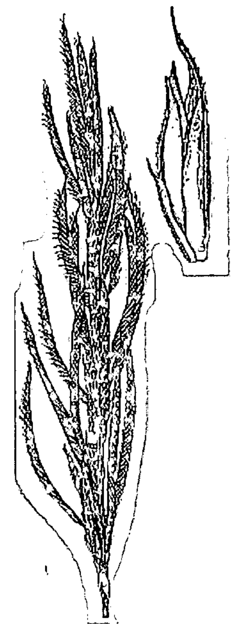
Typical Esturine Plants



Common reed



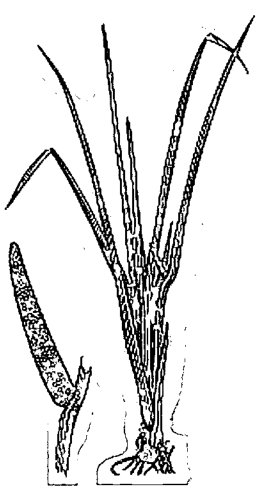
Eel grass



Big cordgrass

Wild rice

Saltmarsh cordgrass



Sweet flag

Swamp rose

PATTERNS OF PLANTS - WORKSHEET II

ESTURINE PLANT ADAPTATIONS

ADAPTATION	FUNCTION	PLANT
Air-filled tissue	provides oxygen to submerged plant tissue	spatterdock broad-leaved cattail saltmarsh cordgrass arrow arum
Tall main stalk	facilitates pollination	wild rice big cordgrass common reed broad-leaved cattail
Large rhizome	anchors plant and stores food	spatterdock broad-leaved cattail big cordgrass
Long, flexible leaf	bends easily in water	wild celery eelgrass saltmarsh cordgrass
Stiff, rigid leaf	stands upright in moving water	sweet flag black needlerush yellow iris
Arrow-shaped leaf	allows water to flow easily over the leaf	arrow arum arrowhead pickerelweed lizard's-tail
Thick, wax-covered leaf	prevents water loss	spatterdock glasswort saltmarsh aster seaside goldenrod
Salt on leaves	removes salts from plant tissue	saltmarsh cordgrass salt grass

Exploring Estuarine Waters

BACKGROUND

The physical and chemical properties of estuarine water vary with diurnal tidal rhythms and seasons of the year. The constant fluctuations in salinity, water density, turbidity, temperature, velocity, dissolved oxygen levels, and nutrient content make an estuary a dynamic and challenging ecosystem in which to live.

TIDE

Students visiting an estuary, especially for the first time, will enjoy observing tidal patterns during their field experience. They may discover high tide levels at the water's edge by searching for debris lines collected along the shore or by investigating water marks left on trees and posts. Low tide levels will be evident with the exposure of mud flats and the lowered boat moorings on docks and piers. When these natural signs are difficult to find, students may devise their own water gauge for monitoring tidal fluctuations. By placing a pole in shallow water prior to field activities and then marking the water height on the pole at specific times during the day, the class can determine measurable changes in water level.

SALINITY

The saltiness, or salinity, of water varies greatly throughout the Chesapeake Bay region. Salinity levels may range from zero parts per thousand (ppt) in Otter Point Creek in the northern Bay to seventeen parts per thousand in the southern waters of Monie Bay. Seasonal changes in rainfall strongly influence these salinity patterns. For example, spring rains and snowmelt create freshwater conditions in large expanses of the upper Bay. Summer drought, however, may reduce the flow of freshwater from rivers, changing areas of no salinity into brackish environments by early August.

DENSITY

Salinity also determines the density, or heaviness, of waters mixing in the Bay. Saltwater, which is heavier than freshwater, sinks to the bottom of the estuary and moves northward up the Bay as a wedge below the surface layer of freshwater.

CURRENTS

Currents and current velocity also present challenging and changing conditions in an estuary. The velocity or speed of water flowing from rivers and streams into the Bay increases considerably during heavy rainfall and rapid snowmelt. The rush of water into the Chesapeake creates strong currents which sometimes overpower the upstream movement of tides. In some extreme cases, the freshwater flow of the Susquehanna River prevents tidal changes in the Bay mainstem from occurring for days at a time. Wind also influences or enhances river velocity when strong wind patterns, currents, and falling tide all coincide.

PURPOSE:

To study the physical and chemical properties of estuarine water; to understand the importance of water quality to plants and animals living in an estuary.

SETTING:

From a dock or pier in any Component of the Chesapeake Bay National Estuarine Research Reserve.

TIME REQUIRED:

2 to 3 hours

MATERIALS:

- pH test kits
- dissolved oxygen test kit
- thermometers *(tied on long strings)*
- Secchi disk
- 30-meter measuring tape
- small sticks or twigs
- watch with second hand
- laminated directions for pH and DO test kits *(3 sets per test)*
- Exploring Estuarine Waters Worksheet *(one per team)*
- laminated copies of Water Quality Testing Sheets 1, 2, 3, 4, and 5 *(3 sets)*
- clipboards *(one per group)*
- pencils *(one per group)*
- large jar or milk jug with lid *(for chemical waste)*

VOCABULARY:

acidic	temperature
pH	density
basic	tide
salinity	dissolved oxygen
benthic	turbidity
SAV	estuarine
brackish	velocity
sediment	salinity
current	

SEDIMENT

In addition to its impact on currents, heavy rainfall combines with land use practices in a watershed to cause the erosion of soil from exposed fields and construction sites into the many tributaries of the Bay. Some of this soil remains suspended in the water column, creating the clouded, turbid stream conditions which are now so familiar in most agricultural and urban areas after a heavy rain. The remaining soil, or sediment, settles on stream bottoms and along the shoreline as the water flows downstream.

Both aspects of erosion severely impact estuarine plants and animals. Sediment that settles on a stream bed suffocates benthic, or bottom-dwelling, organisms. Suspended soil particles clog the gills of fish and crabs, limiting their ability to filter dissolved oxygen from the water. Turbidity also decreases the amount of sunlight reaching underwater plants. This reduction in light slows or inhibits the photosynthetic power of submerged plants.

TEMPERATURE

Water temperature is another critical variable in an estuary. Air temperature in the Bay area varies seasonally from 0 degrees Celsius in winter to 35 degrees Celsius in summer. Water temperature, however, changes more slowly. Surface water will be cooler than the surrounding air mass in spring and summer but its temperature will be as warm as or warmer than the air temperature in fall and winter. Water temperature also varies with water depth. Deeper waters tend to be colder and to change temperature more slowly than surface water.

pH

The pH, or hydrogen ion concentration, of water strongly influences conditions in an estuary. pH is measured on a scale of 1 to 14 and reflects the acidity or alkalinity of a liquid. A pH reading of 0 to 6.9 indicates acidic conditions while a reading of 7.1 to 14 reflects a basic or alkaline environment. A pH of 7 is considered neutral.

The pH of an aquatic ecosystem greatly affects the abundance and kinds of organisms living in it. For example, many amphibian and fish larvae require a narrow pH range of 6.0 to 8.0 in which to live. A change in pH either above or below this range may jeopardize the survival of these organisms. The sensitivity of aquatic species to acidic conditions becomes a growing concern in the Chesapeake watershed as the acidity of rainfall in the Eastern United States steadily increases. Rain falling in Maryland has been recorded with a pH as low as 4.3, while the average pH of rainfall throughout the United States is 5.6.

DISSOLVED OXYGEN

Dissolved oxygen is another critical factor affecting water quality in an estuarine system. Oxygen plays a critical role in the respiration of most aquatic organisms. Dissolved oxygen levels increase in aquatic systems during daylight hours as the rate of photosynthesis of floating and submerged plants increases. Conversely, oxygen levels decrease in the evening hours as the rate of photosynthesis decreases. Oxygen levels may also be low in ponds and bays containing an excessive amount of decaying organic matter as oxygen is used during decomposition.

High oxygen levels typically occur in cold, turbulent waters which support a diversity of plant and animal communities. Most aquatic species require dissolved oxygen levels of 6 parts per million (ppm) or greater in order to survive. The minimum water quality standard for dissolved oxygen levels in Maryland is 5 parts per million.

PREPARATION

Visit the estuarine study area prior to the field trip if time and distance permit. If a park naturalist is available for the field study, meet with him or her to discuss the details of the activities at this time. In the event that a naturalist will not be present, find the best location for water quality studies and plan the logistics of transporting testing equipment to the site. Equipment may be available for loan at Jug Bay Wetlands Sanctuary, Patuxent River Park, and Otter Point Creek if arrangements are made in advance. Equipment may also be available through the local school system.

Before the field trip, read the directions for each water quality test to become familiar with procedures for measuring each parameter. Copy and laminate:

- 3 sets of directions for each test kit
- 3 sets of Water Quality Worksheets 1, 2, 3, 4, and 5
- 2 sets of directions for each station
- Exploring Estuarine Waters Worksheet for each team.

If you laminate the copies, be certain to include crayons or waterproof markers in the field supplies.

Discuss the concepts of tides, currents, salinity, turbidity, sedimentation, pH, and dissolved oxygen levels with students and the methods used to measure each. Have students practice using the various test kits by analyzing school water or water samples brought from home. The class may practice other procedures, such as measuring flow rate and turbidity, on a small creek or stream near the school.

Calibrate thermometers and attach loops of string to each. Also tie a five-meter length of cord securely to the Secchi disk and mark the cord in decimeters with a permanent marker.

Discuss the purpose, location, and activities for the field study with the class immediately prior to the trip. Review the concepts to be studied, the tests to be performed, and the procedures to be followed. Divide the group into teams of two to three students and assign a particular water quality test or measurement to each team. This will be the first test or study that the team will perform on the day of the field trip.

Most importantly, arrange for parent or adult volunteers to accompany the class on the field trip. One adult per team will be a helpful ratio when students are involved in their estuarine studies.

PROCEDURE

When you arrive at the field study location, you may wish to take a short walk with the students to familiarize them with the estuary and the many habitats it encompasses. Allow the group time to explore the area and record preliminary observations on plant and animal life in the estuary. Ask a few thought-provoking questions about the surroundings to stimulate the students' curiosity. For example, you may say, "What hints does the river or creek give us today about the best time of day to find the low tide mark?"

Then organize students and adults into their pre-arranged work teams. Distribute the assigned test kit, equipment, worksheet, and laminated set of directions to each group. Place each team at its appropriate station.

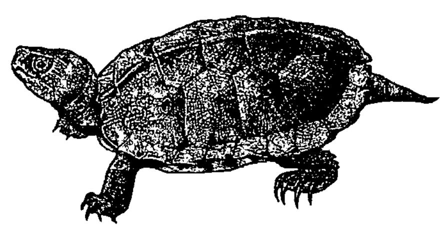
Remind teams to handle chemicals and other equipment carefully and to dispose of all chemical waste in the designated chemical waste jar. Each team is to perform its assigned test and then record the results on the worksheet.

Once the first set of tests are complete, signal the teams to rotate to the next station. All kits, directions, and equipment are to remain at the original stations. Each team keeps its Exploring Estuarine Waters Worksheet. It may be helpful to number each investigation as well as the corresponding station and equipment. Continue the rotation process until each team has visited each station once and recorded its results.

CONCLUSION

When all investigations are complete, compile the results of each testing procedure on a large posterboard and compare the findings. (This may be done the following day in class if necessary.) Note any correlations or relationships that may exist among or between the various water quality parameters. Discuss any factors that may have influenced your results.

Discuss with students the ways in which each water quality characteristic influences the life of plants, animals, and other organisms living in the estuary.



RELATED ACTIVITIES

Additional field studies may include searching for invertebrates, seining for fish, or exploring marsh plant communities.

Laura Callahan

Laura Callahan

WATER QUALITY STATION 1 - TURBIDITY

The turbidity test measures the clearness or clarity of water.

DIRECTIONS:

1. Holding the end of the rope, carefully lower the Secchi disk into the water from a position on the dock. Keep the disk in a vertical position so that it does not "travel" horizontally with the current.

2. Lower the disk into the water until it disappears. Then slowly raise the disk until you first see it reappear. Ask team members to help you determine when this point is reached. Note the place on the rope which was at the water's surface when the disk reappeared.

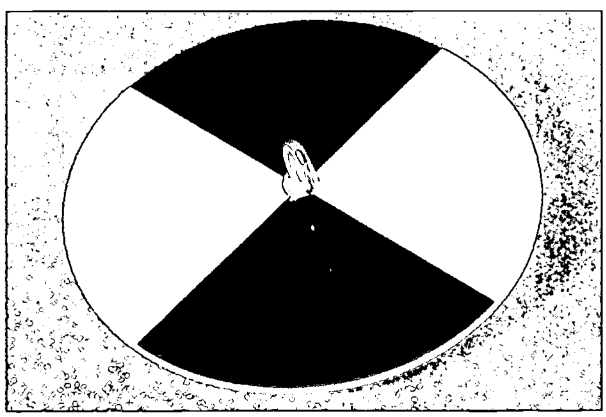
3. Carefully pull the disk from the water. Mark the high water point (the point at the water's surface) on the rope with a pencil or hold it with your fingers.

4. Measure the distance in decimeters from the top of the disk to the high water mark on the rope.

5. Record the distance under Station 1: Trial 1 on the Exploring Estuarine Waters Worksheet.

6. Repeat the test at the same location and record your results under Station 1: Trial 2.

7. Add the results of Trials 1 and 2 together and divide by 2. Your answer is the average Secchi disk reading for turbidity at that particular location.



Secchi disk

WATER QUALITY STATION 2 - TEMPERATURE

This test measures air temperature and water temperature.

DIRECTIONS:

Air temperature and water temperature taken at two different depths will be measured and recorded. Therefore three individuals are needed, each with a thermometer tied to a long string. One student will measure surface water temperature, a second student will measure bottom water temperature, and the third student will measure air temperature. Compare the readings on all three thermometers before beginning the investigation to be certain they coincide.

1. Student #1 Holding the thermometer by the string, move to a position in which the sun will not shine directly on the thermometer. Be careful not to swing the thermometer or touch the bulb end. After two minutes, read the air temperature and record your results under Station 2: Air 1 on the Exploring Estuarine Waters Worksheet.

   Move several feet away, wait two minutes, and take a second reading. Record your results in the blank for Air 2.

   Move to a third area, wait two minutes, and take a third reading. Record your results in the blank for Air 3.

   Add the three readings together. Divide the total by 3. The answer is the average air temperature.

2. Student #2 With the string looped around your hand, place your thermometer carefully into the water just below the water's surface. Hold the thermometer in this position for two minutes. At the end of two minutes, quickly remove the thermometer from the water. Be careful not to touch the bulb. Read the temperature and record your results under Station 2: Water Surface 1 on the Exploring Estuarine Waters Worksheet.

   Move 10 feet away from the first testing location and repeat this procedure. Record your results in the blank forWater Surface 2.

   Move to a third sampling location and repeat the procedure. Record your results in the blank for Water Surface 3.

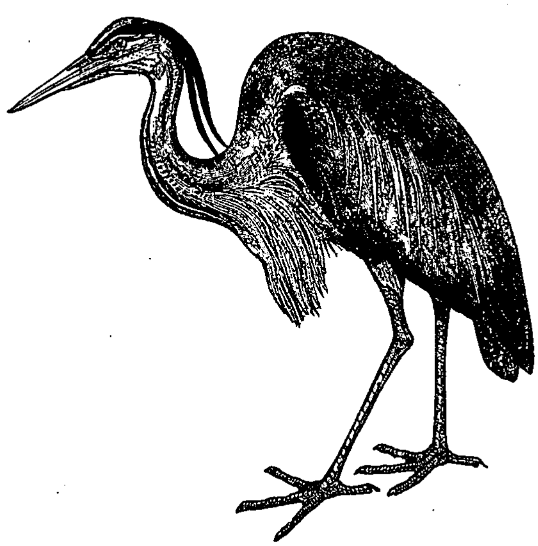
   Add the three readings together. Then divide the total by 3. The answer is the average surface water temperature.

3. Student #3 With the string looped around your hand, place your thermometer carefully into the water so that it barely touches the bottom. Be careful not to force it into the bottom sediment. Hold the thermometer in this position for two minutes. At the end of two minutes, quickly remove the thermometer, read the temperature, and record the results under Station 2: Water Bottom 1 on the Exploring Estuarine Waters Worksheet.

   Move several feet away from the first testing location and repeat the procedure. Record your results in the blank for Water Bottom 2.

   Move to a third testing area and repeat the procedure. Record your results in the blank for Water Bottom 3.

   Add the three readings together. Divide the total by 3. The answer is the average bottom water temperature.



WATER QUALITY STATION 3 - VELOCITY

The velocity test measures the speed or flow rate of moving water.

DIRECTIONS:

1. Measure a ten-meter course along the river bank where the water runs freely and there are few rocks, logs, or other obstacles in the water. Place a colored stake at each end of the course and one in the middle. Lay several small sticks at the upstream stake.

2. Choose a person to stand at each end of the course. Point A is the upstream end with the sticks. Point B is the downstream end. The third person on the team stands in the middle of the course, Point C, with a stop watch or a watch with a second hand.

3. When all team members are in position, the person at Point A drops a stick into the water and shouts "go." This is the signal to the timekeeper to begin marking the time.

4. The person at Point B watches the stick as it travels the length of the course. As the stick passes the downstream stake, the Point B person shouts "stop." This signals the time-keeper to stop the watch.

5. The timekeeper calls out the number of seconds it took for the stick to travel ten meters. The person at Point B records the time under Station 3: Trial 1 on the Exploring Estuarine Waters Worksheet.

6. Repeat the test several times, recording all of the results.

7. Add the results of all the trials together. Divide this total by the number of trials or times a stick was dropped. For example, if a team conducted five (5) trials, it would add the results of all 5 trials together and then divide the total by 5. The answer represents the average number of seconds it takes a stick travel ten meters.

   Example: 7 sec + 6 sec + 8 sec + 6 sec+ 8 sec = 35 seconds

   $$\frac{35\text{ seconds}}{5\text{ tosses}} = 7\text{ seconds}$$

8. Then divide the length of the course, 10 meters, by the average number of seconds calculated in # 7. The answer is the average distance a stick traveled in one second.

   Example: $$\frac{10\text{ meters}}{7\text{ seconds}} = 1.4\text{ meters/second}$$

9. The average distance a stick traveled in one second is the stream speed or velocity. Can you convert the speed of your stick to miles per hour?

Water Quality Station 4 - Dissolved Oxygen

The dissolved oxygen test measures the amount of oxygen dissolved in water.

TEACHER'S NOTE: The dissolved oxygen test requires skill and precision in handling chemicals, some of which are toxic or caustic. Close adult supervision is necessary for each team of students performing the test.

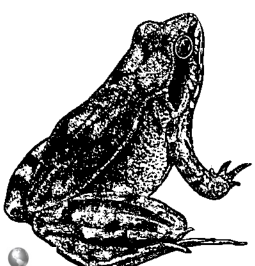
STUDENT'S NOTE: Follow the directions given in the dissolved oxygen kit, being very careful not to spill any chemicals on your skin, clothing, or surroundings. Be careful not to splash yourself or others when placing the lid on the sample bottle to which chemicals have been added. Dispose of all liquid chemical waste in the chemical waste bottle. Put other waste in designated containers. If the procedure calls for shaking a mixture, tightly secure the lid of the bottle and then, while holding the lid in place, gently tilt the bottle back and forth until the ingredients are dissolved. Rinse your hands with clean water when the test is complete. Record your results on the Exploring Estuarine Waters Worksheet.

Water Quality Station 5 - pH

The pH test measures the hydrogen ion concentration of water.

DIRECTIONS:

pH may be measured easily using a pH meter, a chemical kit, or specially prepared pHydrion paper. Carefully follow the directions for whatever type of testing equipment you are using. Record your results on the Exploring Estuarine Waters Worksheet.



Exploring Estuarine Waters Worksheet

Student Names ______________________________

Estuary Name ______________________________

Location ______________________________

Date ______________ Time ______________________________

Weather Conditions: ______________________________

____

Station 1: TURBIDITY

Secchi Disk Measurement

Trial 1 ______________

Trial 2 ______________

Average ______________

Station 2: TEMPERATURE

Temperature Reading

Air	Water Surface	Water Bottom
1.	1.	1.
2.	2.	2.
3.	3.	3.
Total	Total	Total
Average ________	Average ________	Average ________

Station 3: VELOCITY

Velocity Measurement

Trial 1 ____________ sec.   Length of Course ___________

Trial 2 ____________ sec.

Trial 3 ____________ sec.

Trial 4 ____________ sec.

Trial 5 ____________ sec.

Total = ____________ sec.   Average = __________ sec.

Length of Course in meters = _________ meters

Average Time in seconds = _________ second

Velocity of water = $\frac{\text{Number of meters}}{\text{second}}$ = $\frac{\_\_\_\_\_\_ \text{ meter}}{\text{second}}$

Bonus: How many miles will your stick travel in one hour?

Station 4: DISSOLVED OXYGEN

Dissolved oxygen reading: __________ mg/l

Station 5: pH

pH reading: _________

Fish Features

BACKGROUND

A large variety of fish live in the waters of the Patuxent River and other tributaries of the Chesapeake Bay. Many of these species differ noticeably from each other because of **adaptations** they possess for survival in a **riverine** ecosystem. The placement of the mouth, body and tail shape, and arrangement of the dorsal fin often reveal a wealth of information about the eating habits and life styles of these aquatic organisms.

Not only do fish vary in their size, shape, and feeding habits, they also differ considerably in the **habitats** they occupy. For example, some species swim at or near the water's surface while others prefer to dwell in the deeper, darker waters of the river channel. Still others spend their lives hiding amid the submerged aquatic vegetation at the water's edge.

Fish play a very important role in the Chesapeake Bay ecosystem and are a vital link in **estuarine** food webs. Some species consume **plankton** or aquatic plants while others prey upon smaller fish, insects, and crustaceans. In turn, many fish serve as a food source for mammals and reptiles, as well as birds such as herons, egrets, osprey, and bald eagles. Historically, fish protein also comprises an important element in the diet of human populations.

For more than three centuries fishing has played a critical role in the economy of the Chesapeake Bay. However, with the combined effects of overfishing, habitat loss, and declining water quality during the last thirty years, the fishing industry has suffered drastically. Harvests of commercially valuable species such as striped bass (rockfish), American shad, alewife, and blueback herring have reached all-time lows. Although a recent ban on striped bass harvesting has helped to increase the number of Chesapeake Bay striped bass, shad and herring populations in the Bay are still at record low levels.

PREPARATION

Before the field trip, encourage students to share their knowledge of estuarine and freshwater fish with the class. Those who have gone fishing will have many interesting tales to tell. Discuss the life history and spawning habits of **anadromous** and **catadromous** fish and the adaptations which these organisms possess to survive the changing conditions of the Bay. Explore the reasons why these particular species survive in the Chesapeake Bay watershed.

Prepare a pre-trip activity for the class on the relationship of fish body shapes to eating styles and habitat.
You may wish to invite a fisherman or aquatic biologist to the class to demonstrate these features using live fish.

Arrange for other adults to assist you in the field activity, especially in the demonstration and handling of the **seine**.

PURPOSE:

To collect and observe fish in estuarine waters. To examine the structural differences existing among these fish as well as their swimming patterns and feeding styles.

SETTING:

In the shallow waters of Jug Bay or Otter Point Creek or on the shores of Monie Bay.

TIME REQUIRED:

1 to 2 hours

MATERIALS:

10-foot seine
5 plastic buckets
2 glass aquariums
3 small fish nets
3 small plastic containers
field guide to freshwater fish or *Fish Key for Jug Bay Wetlands Sanctuary*
Chesapeake Bay, A Field Guide by Christopher White
Life in the Chesapeake by Alice Lippson

VOCABULARY:

adaptation	habitat
anadromous	plankton
catadromous	riverine
estuarine	seine

Send a note to parents explaining the purpose of the trip and the items that students will need the day of the study: lunch, drink, old tennis shoes, towel, plastic bag, and a change of clothes. Students may be wading waist-deep in water while seining and will need to change clothes before returning to school. When discussing the activity with the students, give each one the option of getting wet or helping to remove fish from the nets on the shore.

PROCEDURE

Seining is an ancient technique employed by Native Americans and early colonists in Maryland to collect fish. The methods used by these early peoples are very similar to the procedure students will use during this field investigation.

First carry the nets and other equipment to the field study location. Appoint teams of students to handle the seines and designate other responsibilities for the remainder of the group. Individuals may fill water buckets, help prepare the aquariums, and remove fish from the nets when the seines are brought to shore. Remind students that fish may only be handled with wet hands to protect the mucous coating which covers their bodies. Then gather the students in a semi-circle to demonstrate proper seining techniques.

SEINING TECHNIQUE

1) Hold the end-poles of the seine upright with the weighted side of the net down. Then roll the net around the poles.

2) Walk into the water with the rolled net until the water is hip-deep.

3) Face the shoreline and begin to unroll the net. As you do so, keep the lower, weighted portion of the net on the river bottom. Grasp the pole with one hand high on the pole and the other on the lower end near the water. Keep the pole tilted slightly towards yourself.

4) With the net open, walk slowly to the shore, gently curving inward toward each other as you do so. As the seine moves along the bottom, it will encircle fish that swim into its path.

5) Just before you reach the shoreline, carefully raise the bottom of the net and lift it from the water. Be certain to keep the net taut and the bottom of the seine horizontal so the fish will not swim out.

6) Carry the outstretched net to the beach and lay it open on the sand or grass along the water's edge.

7) With wet hands, gently scoop the fish from the net into buckets of clean river water.

After the net is emptied, assign a second team of students to operate the seine and repeat the process. Transfer fish representing each species from buckets to the aquaria or to ziploc bags containing water for study and observation.

Allow time for the students to observe the fish and take notes on body shape, swimming patterns, and behavior. Encourage students to sketch each fish, paying particular attention to the fins, tail, body shape, and mouth location.

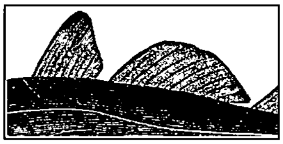
CONCLUSION

Compare the placement of the mouth, shape of the tail, and body shape of the fish to the eating habits, swimming style, and habitat requirements for each species based on the students' observations. Discuss any adaptations that the fish may possess which helps them to survive in the estuary. You may wish to use fish keys and guides to identify the various species.

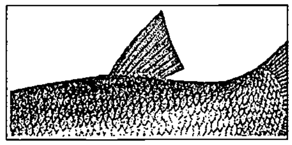
Important: When the activity is completed, carefully return all fish to the river.

A KEY TO NINE COMMON FISH SPECIES FOUND AT JUG BAY WETLANDS SANCTUARY

1. Two dorsal (top) fins
   Go to 2

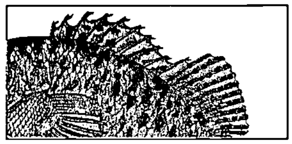


One dorsal fin
Go to 7

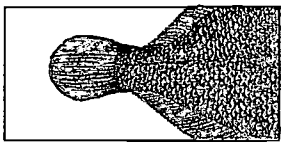


2. Two dorsal fins distinctly separated
   Go to 3

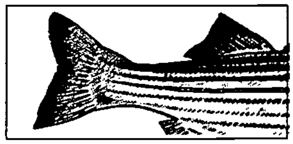
Two dorsal fins joined
Go to 6



3. Tail fin rounded or broom-shaped
   Go to 4

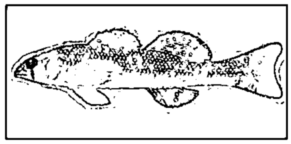


Tail fin slightly forked
Go to 5



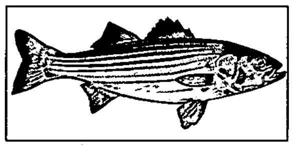
4. Small slender profile; x's and w's on side;
   black "teardrop" under eye;
   length 4-18 cm, average = 5.3 cm.

<u>*Tessellated Darter*</u>



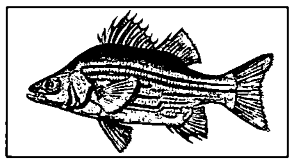
5. Streamlined body; 6 to 8 horizontal stripes on silver side;
   anal fin starts under middle of second dorsal fin;
   length 4-18 cm, average = 9.5 cm.

<u>*Striped Bass*</u>



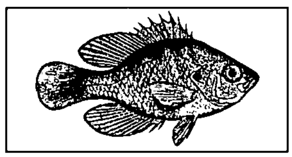
Deep body; sloped shoulder; plain silver side - young has faint stripes; anal fin even with second dorsal fin; length 3-24 cm, average = 9.5 cm.

<u>*White Perch*</u>

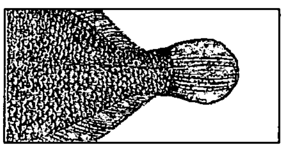


6. Oval profile; black "earflap" on gill cover has red spot;
   wavy blue lines on orange cheeks;
   length 3-16 cm, average = 8.3 cm

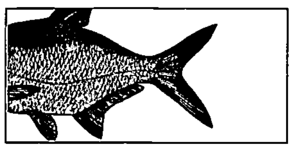
<u>*Pumpkinseed Sunfish*</u>



7. Round or broom-shaped tail
   Go to 8

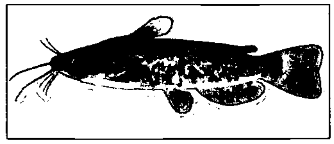


Forked tail
Go to 10



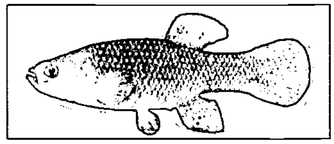
8. Mouth terminal and surrounded by "whiskers" or feelers;
smooth skin, no scales evident; small fleshy dorsal "fin" near tail; length 3-27 cm, average = 7 cm.

Brown Bullhead Catfish



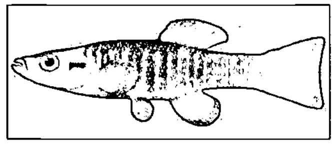
9. Tail tip almost round: body plump; snout short and rounded; females plain pale olive; males with many silver-blue spots on body and fins;
length 1-10 cm, average = 6.1 cm.

Mummichog



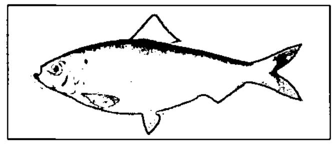
Tail tip broom-shaped; body streamlined; snout long and pointed; females with a few black vertical bars; males with many silvery-blue vertical bars;
length 1-10 cm, average = 6 cm.

Banded Killifish



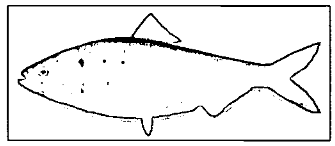
10. Body deep and laterally compressed; saw-like scales on belly; silvery body color with a dark shoulder spot (very young specimens may not show spot);
length 3-11 cm, average = 5.1 cm.

Alewife



Same as above but shoulder spot followed by row of smaller spots; length 6-13 cm, average = 9.6 cm.

American Shad



Related Activities

Following the field study, discuss the importance of species diversity with the students and its applicability to the Chesapeake Bay watershed. Discuss the reasons why there may be a need for fish management plans in the Bay. Ask students to research the plans which have been tried and then present the results to the class.

Ask for volunteers to explore the history of seining and the countries and/or areas where it is still in use today. Discuss other fishing techniques that are used by fishermen around the globe. How do these methods of fishing relate to dwindling resources and the growing need for fisheries management.

Play "Fishy Who's Who" or "Fashion a Fish" from Aquatic Project Wild.

SNAIL SURVEY

BACKGROUND

The marsh periwinkle, Littorina irrorata, is a small snail found in **brackish** and saltwater marshes. It spends most of its life on saltmarsh cordgrass, Spartina alterniflora. Periwinkles feed during low tide on algae and **detritus** that collect at the base of the **cordgrass**. However, as the tide rises, snails crawl up the stiff grass leaves to escape blue crabs, terrapins, and other predators. They are capable of breathing both in and out of the water by means of modified **gills**, but their bodies must remain moist at all times. By watching the direction that snails are moving on the cordgrass, one may determine whether the tide is rising or falling.

Periwinkles are very abundant in the salt marshes of Monie Bay. The procedure for estimating **population** size followed in this activity is based on a method used by biologists to estimate **population density**, or the number of individuals of a given species living within a defined area. This method consists of counting the number of individuals found in a square meter plot and then multiplying that number by the number of square meters contained in the entire study area. The result is an estimate of the population size.

PREPARATION

Introduce the field study by explaining to the students that they will be visiting a brackish marsh in the estuarine habitat of Monie Bay. They should be prepared to get their feet wet as tidal changes are very pronounced in this area and there is no boardwalk. Send a letter to parents requesting that participants wear old tennis shoes and bring the following:

- a towel
- change of clothing
- a second pair of shoes
- lunch

Explain to students that during the field study they will be determining the number of periwinkle snails inhabiting the salt marsh. Discuss the importance of population numbers to biologists. Ask students to think of possible ways to count the thousands of snails in the marsh. Copy the Snail Survey Worksheets I and II.

PROCEDURE

Take a quiet walk through the marsh to observe the waterfowl, birds of prey, and other animals living in this habitat. On the walk, note tidal conditions and whether the tide is rising or falling. Examine the tall saltmarsh cordgrass along the shore, feeling the rough edges of the leaves. Also examine the low, wispy saltmeadow cordgrass on the high marsh, noting how the leaves curl inward. Search for the periwinkles on the saltmarsh cordgrass and, if the tide is low enough, look for fiddler crabs scurrying over the mudflats.

PURPOSE:

To estimate the size of a snail population inhabiting a salt marsh.

SETTING:

A salt marsh on the Chesapeake Bay, particularly in the Monie Bay Component. The parking lot at the Dame's Quarter Boat Ramp on Messick Road three miles west of the Monie Bay sign is a good location.

TIME REQUIRED:

1 to 2 hours

MATERIALS:

Snail Survey Worksheet I *(one per group)*
Snail Survey Worksheet II *(one per student)*
clipboard
pencil
50-meter tape
meter sticks *(one per group)*
plastic flagging tape
calculator

VOCABULARY:

brackish	cord grass
detritus	population
gills	population density

Explain that the Snail Survey is one method that biologists use to determine the number of periwinkles living in a marsh.

1. Measure an area of the marsh along the shoreline which is 4 meters wide and 25 meters long. This plot contains 100 square meters.

2. Divide the students into small groups or teams and select a recorder for each. Ask each team to move to a separate plot within the 100 square meter area.

3. Instruct each team to measure and mark a one-square meter plot (1 meter long by 1 meter wide) within the study area without overlapping on their neighbors' plots. Students may tie flagging onto a cordgrass stem or leaf at each corner of the square to mark their plot.

4. Then ask each team to **count and record** the number of periwinkles found in its square meter plot. When the count is complete teams are to remove the flagging and return to the shore.

5. When all teams have finished counting periwinkles, ask one representative from each team to record the number of snails found in its square meter plot on the class data sheet.

6. Make a bar graph of the number of snails found per square meter on a large piece of poster board.

7. Appoint a student to determine the **average** number of snails per square meter. This is done by adding the number of snails found in each study plot and then dividing the total by the number of plots. The answer is the **average number of snails per plot or square meter.**

8. Multiply the average number of snails per square meter by 100 meters to estimate the total number of periwinkles in 100 square meters of saltmarsh cordgrass.

9. Estimate the number of 100-meter plots present in the marsh.

10. Multiply the number of plots by the average number of snails in 100 meters to obtain an estimate of the snail population in the marsh.

CONCLUSION

The next day in class, have students work in small groups to complete the questions on Snail Survey Worksheets I and II. Discuss the answers. Then ask why it is important for biologists to know the number of a given species living in a particular area. To monitor the growth or decline of a species, biologists must have a baseline population estimate for a given area. Study examples of species in the Chesapeake Bay ecosystem which have had declining populations in recent years such as the peregrine falcon, American oyster, striped bass, American shad, or canvasback duck. These population declines were determined from data collected over the years by wildlife biologists in the Chesapeake Bay region. Because of the availability of this scientific information, biologists were able to document population trends and to initiate species recovery programs.

RELATED ACTIVITIES

Initiate a Blue Crab Management Project with the class by doing the following:

1. Choose a species living in Maryland waters such as the Maryland blue crab.

2. Collect information on blue crab population numbers for the past several decades.

3. Based on these findings, determine what trends, if any, are evident for the blue crab population.

4. Brainstorm appropriate management actions that would help to improve the blue crab population in the Chesapeake Bay.

5. Compare your management plan to any the state may have enacted.

6. Write a letter to your local delegate asking him/her to enact legislation supporting your management plan for Maryland blue crabs.

Adapted from "Fiddle Facts" in Project Estuary by Gail Jones

Snail Survey - Worksheet I

Population Estimation

Record the number of snails found in each square meter plot:

Plot 1 ____________ Plot 4 ____________

Plot 2 ____________ Plot 5 ____________

Plot 3 ____________ Plot 6 ____________

1. Add the number of snails in each plot to find the total number of snails counted.

____________ snails

Example: 10 + 12 + 20 + 14 + 18 + 16 = 90 snails

2. Divide the total number of snails counted by the number of square meter plots studied (6). The answer represents the average number of snails found in one square meter.

____________ snails/square meter

Example: 90/6 = 15 snails/sq. meter

3. Multiply the answer for # 2 by 100. The answer is the average number of snails found in 100 square meters.

____________ snails/100 sq.meters

Example: 100 meters x 15 snails = 1500 snails/100 square meters

4. How many 100-meter plots are in the cordgrass marsh? Estimate the number of plots.

Example: 800 square meters = 8 plots ____________ plots

5. Multiply the number of plots by the average number of snails in 100 square meters. This answer represents the approximate number of snails living in the marsh.

Example: 1500 snails x 8 plots = 12,000 snails ____________ snails

Snail Survey - Worksheet II

Please answer the following questions based on observations you made during the snail survey experience.

1. Why did the number of snails in each square meter plot vary?

2. Are you likely to find the same number of snails in each plot if you repeat the study in six hours? Explain your answer.

3. What results will you expect if you repeat the study in two weeks?

4. How accurate do you think your estimate of the marsh periwinkle population is? What factors may have affected the accuracy of your estimate?

5. Discuss several techniques that might improve or verify the accuracy of your data.

Part VI

Matthew Chasse

Post Field Trip Activities

Cool Covers

BACKGROUND

Forests and vegetated buffer zones along streams, rivers and estuaries influence water quality in many ways. Planted shorelines hold soil in place, reduce erosion, absorb rainwater, control flooding by slowing stream velocity, shade and cool waterways, filter pollutants, and trap agricultural and urban run-off before it enters surface water. All of these factors improve water quality and enhance the health of rivers and the Bay.

PREPARATION

Gather the necessary materials and practice the demonstration before doing it for the class.

PROCEDURE

Place the tray on a table where it will be visible to the entire class. Fill the upper left quarter of the tray with a layer of soil and gently press the soil into place. This section represents the bare, exposed soil evident on construction sites and uncovered farm fields throughout the watershed.

Now fill the upper right-hand portion of the tray with soil, being careful to leave a one-inch opening down the center of the tray. Cover the soil with a generous layer of sphagnum moss. This section of the tray represents vegetative land cover, wetlands, forests, and grasslands which anchor the soil with plant root systems and filter the rain water as it runs over the land.

Using a meat baster filled with water, create a flowing river down the middle of the tray. Then, with the spray bottle, mist both sides of the pan until the soils are moist. Now have students imitate rainfall by spraying both sides of the tray and observing the results. **(The exposed soil will run off the land into the river while the covered half will absorb most of the water.)**

Next place a few drops of red food coloring on both the bare and sphagnum-covered sides of the tray to represent an oil spill or toxic waste disposal site. Spray both sections with water and observe what happens to the red pollutant. **(The dye will run off the soil into the river on the exposed section but will be absorbed by vegetation on the covered portion of the tray.)**

Divide the class into small discussion groups with each group selecting a leader, secretary, and reporter. Allow 15 minutes for groups to discuss the following questions:

1. If the water flowing down the middle of the tray represents a tributary in the Chesapeake Bay watershed, then what will happen to the pollutants as the river flows to the Bay?

PURPOSE:

To demonstrate that plant communities such as wetlands, forests, and meadows absorb rainwater, prevent erosion, and reduce the amount of sediment and pollutants entering rivers and streams.

SETTING:

In a classroom

TIME REQUIRED:

30 minutes to 1 hour

MATERIALS:

bucket of garden soil
paint roller tray
pitcher of water
plastic meat baster
red food coloring
sphagnum moss (from a florist)
spray bottle of water
trowel

VOCABULARY:

buffer zone
erosion
pollutant
run-off
vegetative
watershed

2. In what ways might pollutants and sediment affect the fish, oysters, and other organisms living in the Bay and its tributaries?

3. Explore possible ways water pollutants might eventually reach the ospreys, eagles, and other birds nesting in the marshes of the Bay.

4. How do marsh plants help keep soil and pollutants from entering Bay waters?

At the end of 15 minutes, ask for a short report from the group reporters on answers to the above questions.

RELATED ACTIVITIES

1. Visit a construction site near the school to study storm water management plans and sediment control measures. Then take a walk to a local stream after a rainfall to assess the effectiveness of these soil retention practices on the watershed. If possible, compare stream conditions both above and below the construction area, especially in terms of turbidity.

***

2. The Chesapeake Bay Critical Areas Act requires that a buffer zone of vegetated land extend at least 100 feet from the shorelines of the Bay and its tributaries. Along a stream, measure a zone which extends 100 feet from the bank. Then determine approximately what percent of this 100-foot buffer area is forested or covered with grass and shrubs. Relate these conditions to the health of organisms living in the tributary.

Adapted from "Carving Rivers" The Chesapeake Bay: It Starts With You

DECISIONS, DECISIONS

BACKGROUND

This activity simulates a town council or county council meeting at which individuals representing various community groups present their opinions on a proposed land use change in the Chesapeake Bay watershed.

Decisions about use of land and water resources within a geographical region or political jurisdiction are not always easy to make. Often the economic and environmental interests of community members conflict, resulting in heated debates, long-term hostilities and, in some cases, illegal actions. The debate over the use of old growth forests in the Pacific Northwest stimulated just such controversy. Students may be unaware that similar conflicts and discussions may exist in their own communities.

In every city, county, or township, proposals come before the local government for road widening, building of shopping centers, or construction of new housing developments. All such projects impact the local environment. While some community members think that economic growth and employment outweigh environmental concerns, others may feel that the environment deserves equal consideration in terms of the future health and well being of our world. Frequently, individuals with differing viewpoints do not research the facts sufficiently to find unbiased information on the topic. However, in our democratic society, when a decision is being made by a town or county council, all citizens within that jurisdiction not only have a right to their own opinions but they also have a constitutional right to voice those opinions during a public meeting or in writing.

PREPARATION

Find a proposed project in the local community which may, either directly or indirectly, impact the health of the Chesapeake Bay. Research the issues surrounding the proposal in preparation for the students' discussion. List at least five special interest groups that will likely support the project and five groups that will oppose it. Then, prepare an index card for each of the groups bearing a fictitious name of an individual and the interest which he or she represents. State in a few sentences what view this person holds concerning the project.

Suggested projects: housing development, marina, road construction, sewage treatment plant, playground development, landfill expansion

Suggested special interest groups: developer, state highway department representative, carpenter, fisherman, waterman, banker, mayor, park naturalist, biologist, home owner, boat owner

PURPOSE:

To illustrate the complexity of community decision-making concerning land and water issues.

SETTING:

In the classroom following a field trip to an estuary

TIME:

1 - 2 hours

MATERIALS:

Paper
Pencils
Local newspapers

VOCABULARY:

land use

PROCEDURE

Present the project you have chosen to the class, carefully explaining all the details of the proposal in an unbiased, matter-of-fact manner. Try not to influence the students' opinion of the project in any way. Use transparencies, charts, maps, etc. to explain exactly what the project entails.

Then ask for volunteers to represent the special interest groups that either support or oppose the project. Assign one or two students to each group. The remaining students will represent the town or county council.

Distribute the information cards to each special interest group. Then ask each student representative to make a short speech to the county or town council urging council members to vote on his or her behalf. The council may ask questions of the special interest speakers during this time. The council's role will be to listen to all sides of the issue and then decide on what is best for the entire community.

This is an impromptu debate and, therefore, one that is not extensively researched by the students. Individuals are to present the views of the special interest group which they represent and not their own personal views.

After the roles are assigned, meet with the speakers to set the ground rules. Suggested guidelines are as follows:

1. Each presentation will be limited to 5 minutes or less.

2. Speakers will use persuasion to convince the council.

Also meet with the council members to discuss what types of questions they will ask. Some suggested questions are as follows:

1. In what way will this project help our community?

2. How many people will be served?

3. What impact will this project have on local taxes?

4. How will this project affect our local environment?

5. What effect will this project have on county services such as water supply, sewerage, sewage treatment, roads, schools, libraries, etc.

6. What impact will this project have on the Chesapeake Bay?

These questions may also be used by the special interest groups to help them in preparing their presentations.

You will act as a facilitator for the discussion. At the conclusion of the presentations and questions, ask the council to vote on the issue. If the council requires more information before it can reach a decision, it may postpone the vote until a future date.

RELATED ACTIVITIES

Have students explore real land-use issues in their communities by reading newspaper articles and by interviewing their neighbors. The simulation activity may be repeated after the students have completed their research.

BAY BOUNTY

BACKGROUND

Rich with plant life, estuaries number among the most productive ecosystems in the world. The unique mixing of freshwater from rivers with saltwater from the sea stirs nutrients and minerals into the water column, creating a nutrient-rich medium in which microscopic plant life and submerged aquatic vegetation (SAV) abound. Phytoplankton, submerged grasses, and other photosynthesizing species together produce one of the most abundant food supplies available on planet earth. Zooplankton, crustaceans, larval fish, and innumerable estuarine invertebrates all feast endlessly on this plant material which thrives in the warm, nourishing waters of the Bay. Microscopic animals, in turn, serve as food for larger organisms such as crabs, turtles, waterfowl and the many fish which flourish in Chesapeake waters.

People also share in the rich productivity of estuaries. Native Americans and early European settlers living along the Bay harvested much of their food from its waters by venturing no further than the shoreline. They wove marsh grasses into baskets and shelters and fashioned pottery from the clay found along the banks.

European settlers developed new life styles in the Chesapeake region, centering their existence on fishing, oystering, crabbing, and boat-building. Many colonial communities sustained themselves completely on the food, clothing and material goods which they gathered from the surrounding water and marshlands. They feasted daily on crabs, oysters, and rockfish, species that were once plentiful in the Chesapeake Bay.

Today, however, descendants of these early watermen are looking to cities and industrial centers for their livelihood rather than to the Bay. The waters of the Chesapeake which once teemed with herring and rockfish are now slowly filling with sediment, nutrients, and toxins from urban and suburban centers and agricultural lands.

PREPARATION

Collect as many commercial items as possible that are produced from Bay organisms and plant life. Ask colleagues and friends to help in the search. Remember that some Bay products may have had changing uses throughout the centuries. For example, salt marsh hay was once used as food for livestock and also as a building material for temporary dwellings. Sweet flag served as a bedding material for both animals and humans alike. Oyster and clam shells were traded by Native Americans for other goods from neighboring tribes. As a result of this bartering system, shells from the Chesapeake region may have travelled as far north as upper New York State and as far west as the Mississippi River. History books on colonial Maryland and the maritime museums in both Calvert and Talbot Counties are excellent sources for additional information.

PURPOSE:

To discover the many foods, materials, and household items that have their origins in the waters and marshes of the Chesapeake Bay.

SETTING:

In the classroom, following a trip to the Bay

TIME REQUIRED:

30 minutes to 1 hour

MATERIALS:

Note: food items may be packaged in a can, box, or jar.

oyster stew	marshmallows
clam chowder	arrowroot cookies
frozen crabcakes	down coat
frozen fish sticks	reed basket
wild rice	clay bowl
herring	calcium pills

other objects made from bay organisms

Bay Bounty Worksheet *(one per team)*

VOCABULARY:

mineral	phytoplankton
nutrient	plant
overharvesting	productivity
photosynthesis	resource

PROCEDURE

Place the items on a table in the classroom where they may be examined by the students prior to the discussion. Investigating the collection will stimulate their interest and curiosity.

Before beginning the activity, set up ten or more stations displaying Bay products throughout the room. It is helpful if the number of stations corresponds to the number of student teams you will form. Number or name each station.

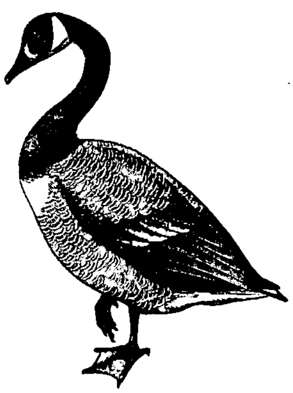
Then divide the class into teams of two students each, giving each team a clipboard and a worksheet. Instruct one member of each team to record team member names and station names or numbers on the worksheet. Assign each team to a station and explain the order for rotation.

Introduce the activity by explaining that all the display items have been made from Chesapeake Bay plants or animals. The challenge to each team is to identify the plant, animal, or material from which the product has been made and to determine its current use. Allow the teams several minutes to examine the items at their assigned station and record their results before signaling for teams to rotate to the next station. Continue the rotation until each team has returned to its originally assigned station.

When the worksheets are completed discuss each item with the class as a whole. Explain the more innovative uses of Bay organisms in commercial industry, especially those that are non-food related. For example, candles are scented with the fruits of bayberry, eelgrass serves as a packing material for live crabs, and clam and oyster shells are ground into fertilizer or formed into jewelry for tourists. The blood of horseshoe crabs is used to test for bacterial contamination in pharmaceutical products.

CONCLUSION

Encourage students to think of other objects produced from Bay resources that are important in today's society. For example, Elodea, a submerged aquatic plant, is sold in pet stores as a decorative plant for aquaria. Emphasize to the students that certain Bay resources, such as Elodea and marsh mallows are either grown commercially or synthetically reproduced to supply market demands. Overharvesting Bay organisms for commercial industries depletes the Bay's biological resources and disrupts the balance of this estuarine ecosystem.



RELATED ACTIVITIES

Plan a Bayfest as a conclusion to the activity. Prepare a list of snacks made from Bay products such as marshmallows, Rice Krispies treats, and rose hips iced tea. Have students volunteer to provide the various snacks for the celebration.

Entertain those who attend the Bayfest with the following:

1. Read poems and stories about estuaries, such a Sidney Lanier's poem, "The Marshes of Glynn," and Tom Horton's book, Bay Country.
2. Lead songs about the sea, sea chanties, and watermen work songs.
3. Use a tape recorder to play background sounds of the estuary, such as waves rippling over water, birds calling, geese and ducks migrating, streams flowing, insects buzzing.
4. Make prints of animal tracks.
5. Make fish prints on paper or T-shirts.
6. Draw pictures of the estuary using water colors or chalk.
7. Write poems or free verse about a visit to an estuary.

Bay Bounty Worksheet

Team Members: ______________________________

____

Station	Item	Source	Use
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Part VII.

Appendix

Glossary

acidic - having an hydrogen ion concentration or pH value less than 7

adaptation - a structural or functional characteristic of an organism that improves its chances to survive and reproduce

anadromous - going up rivers to spawn

basic - alkaline; having an hydrogen ion concentration or pH value greater than 7

bay - a wide inlet of the sea

benthic - bottom-dwelling; living on or closely associated with the bottom of a body of water

brackish - water of moderate salinity, usually found in estuaries where freshwater from rivers mixes with saltwater from the sea

buffer zone - a vegetated area between a stream, lake, or bay and an adjacent ecosystem which helps to protect the water resource

catadromous - going to the sea to spawn

current - a flow of water or air, especially when strong or swift, in a definite direction

detritus - partially decomposed plant and animal matter

dissolved oxygen (D.O.) - the oxygen that is dissolved in water

diversity - a measure of the number of different species living in an ecosystem

dynamic - active, energetic; changing

ecology - the study of living organisms and their relationships to each other and to the environment

ecosystem - the living and non-living things occupying a given region

emergent plant - an aquatic plant rooted in the bottom of a lake, stream, wetland, or estuary that rises above the water's surface

environment - the living and non-living elements that effect an organism or a group of organisms

erosion - the process by which the surface of the earth is worn away by water, ice, or wind

estuarine - coastal or found in an estuary

estuary - a semi-enclosed body of water in which freshwater from a river meets and mixes with saltwater from the sea

freshwater - water that contains no salt

gill - the respiratory structure of fish and other aquatic organisms through which carbon dioxide from cells is exchanged with oxygen from the surrounding water

habitat - the specific environment in which an organism lives

landuse - manner in which land is used by man

mineral - an inorganic substance from the earth which is essential to plants and animals

nocturnal - active, such as feeding and moving about, at night

nutrient - any substance, such as nitrogen and phosphorus, that is necessary for the growth of living things

overharvest - to gather or trap too much of a natural resource, thereby threatening the population size of the species

pH - a measure of the hydrogen ion concentration, (i.e. acidity or alkalinity) of a solution. pH values range from 0 to 14 with 0 being the most acidic and 14 being the most alkaline. A pH of 7 is neutral

photosynthesis - the process by which green plants, in presence of sunlight, convert carbon dioxide and water to sugar and oxygen

phytoplankton - microscopic plant life, consisting mostly of algae, found floating or drifting in the ocean, estuary, river, lake or other bodies of water

plankton - microscopic plant and animal life found floating or drifting in the open water

plant - a living organism possessing cellulose cell walls that has the ability to make its own food

pollutant - a harmful chemical or waste material discharged onto the land or into the water or air

population - a group of organisms of the same species living in a specific area

population density - the number of individuals of one species living in a given land area (such as a square meter, square acre, etc.)

productivity - the rate at which plants convert sunlight to chemical energy

resource - anything used by an organism to meet its needs including air, water, minerals, plants, fuel, and other animals

rhizome - an underground stem, usually growing horizontally at or under the soil surface

riparian - located along the edge of a stream or river

riverine - on or near the banks of a river

run-off - water from rain, snow, or irrigation that runs over the ground on its way to rivers, lakes, and bays

salinity - the amount of salt in water. Sea water has 30-35 parts of salt to a thousand parts of water (ppt). Fresh water has a salinity of less than 0.5 ppt and brackish water has a salinity between 0.5 and 30 ppt.

salt marsh - a wetland area periodically flooded by salt water

salt water - water containing over 30 parts per thousand of salt

salt water wedge - a river of salt water which flows upstream under the surface freshwater in an estuary

SAV - submerged aquatic vegetation; plants that grow under water

scat - animal droppings (feces)

sediment - soil, sand, and minerals washed from land into waterways

sedimentation - the process by which sediments such as soil particles are deposited on the bottom of a lake, river, or bay

spring - a flow of water from the ground

tide - the rhythmic rise and fall of ocean and bay caused by the gravitational pull of the moon and the sun

tributary - a creek or river that flows into a larger river or a bay

turbidity - a cloudiness in water that is caused by plankton and/or suspended soil particles

veliger - an oyster larva

watershed - the total land area from which water and melting snow drain into a creek, river, or bay

wetlands - land areas along fresh water and salt water that are flooded all or part of the time

Plants and Animals of Otter Point Creek

WOODY PLANTS - TREES AND SHRUBS

(w = occurs mainly in wetlands)

Arrowwood w
Black willow w
Boxelder w
Buttonbush w
Elderberry
Highbush blueberry
Red maple
River birch w
Sassafras
Silver maple
Spicebush
Sweetgum
Sycamore w
Willow oak

HERBACEOUS PLANTS

(w = occurs mainly in wetlands)

Arrow arum w
Arrowhead w
Arrow-leaved tearthumb w
Broad-leaved cattail w
Bur-marigold w
Cardinal flower w
Jack-in-the pulpit
Jewelweed
Pickerelweed w
Common reed w
Rice cutgrass w
River bulrush w
Spatterdock w
Spring cress w
Swamp buttercup w
Tall coneflower w

MAMMALS

Beaver
Chipmunk
Cottontail
Grey squirrel
Muskrat
Opossum
Raccoon
Red fox
River otter
White-tailed deer

BIRDS

American black duck
Barred owl
Belted kingfisher
Blue-winged teal
Canada goose
Great blue heron
Great egret
Green heron
Mallard
Marsh wren
Osprey
Red-winged blackbird
Spotted sandpiper
Wood duck
Yellow warbler

FISH

Banded killifish
Blueback herring
Bluegill
Catfish
Chain pickerel
Largemouth bass
Mummichog
Striped bass
White perch
Yellow perch

REPTILES & AMPHIBIANS

American toad
Black rat snake
Box turtle
Bullfrog
Garter snake
Green frog
Mud turtle
Northern water snake
Painted turtle
Snapping turtle
Spotted salamander
Spotted turtle
Spring peeper
Wood frog

INVERTEBRATES

Crayfish
Dragonfly
Earthworm
Pillbug
Water beetle
Water strider
Zooplankton

PLANTS AND ANIMALS OF JUG BAY

WOODY PLANTS - TREES AND SHRUBS

(W = *occurs mainly in wetlands)*

Arrowwood W
Beech
Buttonbush W
Highbush blueberry W
Mockernut hickory
Pink azalea
Red maple
Red oak
Sassafras
Silky dogwood W
Smooth alder W
Spicebush
Swamp rose W
Swamp magnolia W
Sweetgum
Sweet pepperbush W

HERBACEOUS PLANTS

(W = *occurs mainly in wetlands)*

Arrow arum W
Arrowhead W
Broad-leaved cattail
Halberd-leaved tearthumb W
Horsemint
Turk's cap lily W
Lyre-leaved rockcress
Jack-in-the pulpit
Jewelweed
Pickerelweed W
Reed grass W
Spatterdock W
Swamp rosemallow W
Sweet flag W
Wild rice W
Bufflehead duckLoblolly PineWinged monkey-flower

MAMMALS

Beaver
Eastern chipmunk
Eastern cottontail
Gray squirrel
Mink
Muskrat
Opossum
Raccoon
Red fox
River otter
White-footed mouse
White-tailed deer
Woodchuck

BIRDS

American black duck
Bald eagle
Belted kingfisher
Common yellowthroat
Eastern bluebird
Eastern phoebe
Great blue heron
Green-winged teal
Mallard
Scarlet tanager
Sora rail

FISH

Alewife
American shad
Banded killifish
Largemouth bass
Mummichog
Pumpkinseed sunfish
Striped bass
Tesselated darter
White perch

REPTILES & AMPHIBIANS

American toad
Black rat snake
Box turtle
Bullfrog
Five-lined skink
Garter snake
Green frog
Mud turtle
Northern water snake
Painted turtle
Red-backed salamander
Spotted salamander
Spring peeper
Marbled salamander
Wood frog

INVERTEBRATES

Blue crab
Crayfish
Dragonfly
Earthworm
Grass shrimp
Marsh snail
Pillbug
Spider
Zooplankton

Plants and Animals of Monie Bay

WOODY PLANTS - TREES AND SHRUBS

(w = occurs mainly in wetlands)

Greenbrier
Groundsel
Loblolly pine
Marsh elder w
Poison ivy
Swamp magnolia
Sweet gum
Wax myrtle

HERBACEOUS PLANTS

(w = occurs mainly in wetlands)

Big cordgrass w
Black needlerush w
Lance-leaved goldenrod
Narrow-leaved cattail w
Olney three-square w
Orach
Saltmarsh bullrush w
Saltmarsh cordgrass w
Saltmeadow cordgrass w
Saltmarsh fleabane w
Saltgrass w
Seaside goldenrod
Seaside mallow w
Swamp rose w
Tidemarsh waterhemp w
Widgeon grass w

MAMMALS

Marsh rice rat
Meadow vole
Muskrat
Nutria

FISH

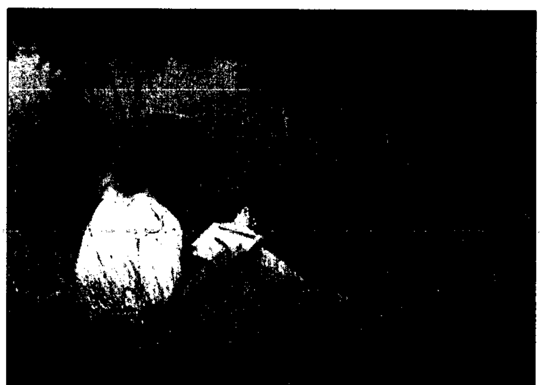
Atlantic menhaden
Atlantic silverside
American eel
Bluefish
Mummichog
Striped bass
Striped killifish
White perch

INVERTEBRATES

American oyster
Atlantic ribbed mussel
Blue crab
Grass shrimp
Marsh fiddler crab
Marsh periwinkle snail
Soft-shelled clam
Zooplankton

REPTILES AND AMPHIBIANS

Black racer
Black rat snake
Diamondback terrapin
Fowler's toad
Hognose snake



Laura Callahan

BIRDS

American bittern
American coot
American wigeon
Bald eagle
American black duck
Black-crowned night heron
Blue-winged teal
Bufflehead
Canada goose
Canvasback
Clapper rail
Common gallinule
Common tern
Double-crested cormorant
Gadwall
Glossy ibis
Common goldeneye
Greater yellowlegs
Green heron
Green-winged teal
Greater black-backed gull
Great-crested flycatcher
Hooded merganser
Lesser scaup
Marsh wren
Northern harrier
Northern pintail
Northern shoveler
Orchard oriole
Osprey
Peregrine falcon
Pied-billed grebe
Ruddy duck
Semipalmated sandpiper
Tri-color heron
Tundra swan
Virginia rail
Willet
Wood duck
Yellow-crowned night heron

Organizations

Alliance for the Chesapeake Bay
6600 York Road
Baltimore, MD 21212
(410) 377-6270

Anita C. Leight Estuary Center
700 Otter Point Road
Abingdon, MD 21009
(410) 612-1688

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

Chesapeake Bay Maritime Museum
P.O. Box 636 Navy Point
St. Michaels, MD 21663
(410) 745-2916

Chesapeake Bay National Estuarine Research Reserve in Maryland
Maryland Department of Natural Resources
Tawes State Office Building, E-2
580 Taylor Avenue
Annapolis, Maryland 21401
(410) 260-8730

Chesapeake Bay Program Communication Office
Annapolis City Marina
410 Severn Avenue, Suite. 109-110
Annapolis, MD 21403
(410) 267-0061

Chesapeake Bay Trust
60 West Street, Suite. 200A
Annapolis, MD 21401
(410) 974-2941

Calvert Marine Museum
P.O. Box 97
Solomons, MD 20688
(410) 326-2042

Environmental Concern, Inc.
P.O. Box P
St. Michaels, MD 21663
(410) 745-9620

Izaak Walton League of America
707 Conservation Lane
Gaithersburg, MD 20878
(301) 548-0150

Jug Bay Wetlands Sanctuary
1361 Wrighton Road
Lothian, MD 20711
(410) 741-9330

Maryland Dept. of Agriculture
50 Harry S. Truman Pkwy, Rm. 307
Annapolis, MD 21401
(410) 841-5700

Maryland Dept. of the Environment
2500 Broening Highway
Baltimore, MD 21224
(410) 631-3000

Maryland Dept. of Natural Resources
Conservation Education
Tawes State Office Building
580 Taylor Avenue, E-2
Annapolis, MD 21401
(410) 260-8710

Maryland Dept. of Natural Resources
Wildlife Division, Area Manager/
Monie Wellington Wildlife Management Area
32733 Dublin Road
Princess Anne, MD 21853

Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218-5210
(410) 554-5525

Maryland Save Our Streams
258 Scotts Manor Road
Glen Burnie, MD 21061
(410) 969-0084

Maryland Science Center
Education Department
601 Light Street
Baltimore, MD 21230
(410) 685-2370

Maryland Sea Grant College
University of Maryland System
0112 Skinner Hall
College Park, MD 20742-7640
(310) 405-6371

National Aquarium In Baltimore
Department of Education & Interpretation
Pier 3 501 East Pratt Street
Baltimore, MD 21202
(410) 576-3800

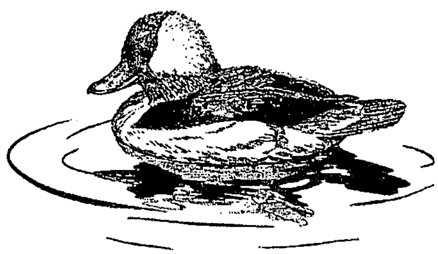
Patuxent River Park
Maryland National Capital Park and
Planning Commission
16000 Croom Airport Road
Upper Marlboro, MD 20772-8395
(310) 627-6074

Patuxent Wildlife Research Center
U.S. Department of the Interior
11400 American Holly Drive
Laurel, MD 20708-4014
(301) 497-5590
TDD: (301) 497-0540

Smithsonian Environmental
Research Center
P.O. Box 28
Edgewater, MD 21037
(410) 798-4424 Annapolis
(410) 269-1410 Baltimore
(301) 261-4190 Washington

US Fish & Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401
(410) 224-2732

Wildfowl Trust of North America,
Inc. / Horsehead Wetlands Center
P.O. Box 519 Perry Corner Road
Grasonville, MD 21638
(410) 827-6694



Useful Publications

Brown, Lauren. Grasses: An Identification Guide. Houghton Mifflin Company. Boston. 1979.

Caduto, Michael J. Pond and Brook, A Guide to Nature and Freshwater Environments. University Press of New England. Hanover, New Hampshire. 1990.

Chesapeake Bay: Introduction to an Ecosystem. U.S. Environmental Protection Agency, Washington, D.C. 1995.

Chesapeake Bay National Estuarine Research Reserve in Maryland. Management Plan. U.S. Dept. of Commerce. State of Maryland Department of Natural Resources. 1990.

"Chesapeake Wetlands", "Nutrient Pollution", "Where Have All The Grasses Gone?" "Striped Bass", "Shad", "Peregrine Falcon", and other fact sheets. U.S. Fish and Wildlife Service, Chesapeake Bay Estuary Program. Annapolis, Maryland.

Coulombe, Deborah A. The Seaside Naturalist. Prentice-Hall, Inc. Englewood, New Jersey. 1984.

Habitat Requirements for Chesapeake Bay Living Resources. ed. Funderbunk, S.L., Mihursky, J.A., et al. Chesapeake Research Consortium, Inc. Solomons, Maryland. 1991.

Hedeen, Robert A. The Oyster: The Life and Lore of a Celebrated Bivalve. Tidewater Publishers. Centreville, Maryland. 1986.

Horton, Tom. Bay Country. Johns Hopkins University Press. Baltimore and London. 1987.

Horton, Tom. Turning the Tide. Chesapeake Bay Foundation, Island Press. Washington, D.C. 1991.

Klingel, Gilbert C. The Bay. Johns Hopkins University Press. Baltimore, Maryland. 1951.

Lawrence, Susanna H. Audubon Society Field Guide to Natural Places of Mid-Atlantic States: Coastal. Pantheon Books. New York. 1984.

Lippson, A.J. The Chesapeake Bay in Maryland: An Atlas of Natural Resources. Johns Hopkins University Press. Baltimore and London. 1973.

Lippson, A.J., M. Haire, et al. Environmental Atlas of the Potomac Estuary.

Lippson, A.J., and R.L. Lippson. Life in the Chesapeake Bay. Johns Hopkins University Press. Baltimore and London. 1984.

MacKiernan, Gail. "Where Freshwater and Saltwater Meet: The Chesapeake Bay Estuary" in Atlantic Naturalist. Audubon Naturalist Society. Chevy Chase, Maryland. 1991.

McCormick, J., and H.A. Somes, Jr. The Coastal Wetlands of Maryland. MD Department of Natural Resources. Annapolis, Maryland. 1982.

Meanley, Brooke. Birds and Marshes of the Chesapeake Bay Country. Tidewater Publishers. Cambridge, MD. 1975.

Odum, W.E., et al. The Ecology of Tidal Freshwater Marshes of the United States East Coast. U.S. Fish and Wildlife Service. Washington, D.C. 1984.

Preston, Walter W. History of Harford County. Press of Sun Book Office. Baltimore, Maryland. 1901.

Quinn, John R. Our Native Fishes. Countryman Press, Inc. Woodstock, Vermont. 1990.

Silberhorn, Gene M. Common Plants of Mid-Atlantic Coast: A Field Guide. Johns Hopkins University Press. Baltimore, Maryland. 1982.

Teal, John and Mildred. Life and Death of a Salt Marsh. Random House. New York, New York. 1969.

Tiner, Ralph W. Field Guide to Coastal Wetland Plants of Northeastern United States. University of Massachusetts Press. Amherst, Massachusetts. 1987.

Tiner, Ralph W. Field Guide to Non-tidal Wetland Identification. MD Dept. of Natural Resources and U.S. Fish and Wildlife Service. Annapolis, Maryland. 1988.

Tiner, Ralph W. Mid-Atlantic Wetlands: A Disappearing Natural Treasure. U.S. Fish and Wildlife Service. Washington, D.C. 1987.

Touart, Paul Baker. Somerset: An Architectural History. Maryland Historical Trust. Annapolis, Maryland. 1990.

Warner, W.W. Beautiful Swimmers: Watermen, Crabs and the Chesapeake Bay. Little, Brown and Co. Boston, Massachusetts. 1976.

White, Christopher. Chesapeake Bay: A Field Guide. Tidewater Publishers. Centreville, Maryland. 1989.

Maryland Department of Education Learning Outcomes

In May, 1990, the Maryland Department of Education published a series of learning outcomes for science, social studies, math, reading and language/writing skills. The outcomes are keyed to the Maryland School Performance Assessments taken by students in grades 3, 5, 8, and 11.

Activities in this guide support the designated learning outcomes, particularly in the areas of science and social studies. The first chart, Selected Science and Social Studies Outcomes for Grades 5 to 8, lists many of the outcomes and indicators outlined by the Department of Education with an identifying numerical abbreviation (Outcome, Grade level, Indicator). The second chart, Science and Social Studies Outcomes for Ecology of an Estuary Activities, indicates the learning outcomes and indicators occurring in the activities found in this guide.

SELECTED SCIENCE AND SOCIAL STUDIES OUTCOMES FOR GRADES 5 TO 8

Science Outcomes

1. Students will demonstrate their acquisition and integration of major concepts and unifying themes from the life, physical, and earth\space sciences.

2. Students will demonstrate the ability to interpret and explain information generated by their exploration of scientific phenomena.

3. Students will demonstrate ways of thinking and acting inherent in the practice of science.

4. Students will demonstrate positive attitudes toward science and its relevance to the individual, society, and the environment and demonstrate confidence in their ability to practice science.

5. Students will demonstrate the ability to employ the language, instruments, methods, and materials of science for collecting, organizing, interpreting, and communicating information.

6. Students will demonstrate the ability to apply science in solving problems and making personal decisions about issues affecting the individual, society, and the environment.

SCIENCE INDICATORS

GRADE 5

151 - Collection of evidence to explain the interaction and interdependence of living things

152 - Observing interactions and changes in the physical and chemical world

153 - Investigation of natural resources and processes that contribute to the uniqueness of Earth

252 - Demonstrating that scientific knowledge is based on evidence

253 - Demonstrating that scientific knowledge allows us to make predictions

255 - Developing a testable hypothesis

256 - Recognizing the importance of comparing data collected by different groups, places, and times

351 - Developing tests to find answers to questions

352 - Giving evidence to support answers

353 - Generating "what if" questions

451.- Recognizing that scientists explore everyday questions

452 - Recognizing that everyone can do science

453 - Demonstrating persistence

454 - Accepting challenging tasks with enthusiasm

551 - Using appropriate instruments and materials to test hypotheses, measure, present data, etc.

552 - Explaining findings orally and in writing

652 - Describing a local environmental problem

653 - Using your knowledge to make a decision about this problem

655 - Devising a plan of action that addresses this problem

GRADE 8

181 - Investigation of...the impact of human behavior on other living organisms and the environment

182 - Exploration of the...interactions of matter and energy

183 - Collection and interpretation of evidence that leads to an understanding of the processes of change in the earth

281 - Generating a consensus based on data

283 - Accepting peer review of your data

285 - Detecting bias in a scientific argument

286 - Describing advantages and limitations of physical models

381 - Modifying one's ideas based on additional evidence or ideas

481 - Demonstrating a belief in the usefulness of science in understanding the world

482 - Demonstrating a belief in the ability to understand science

581 - Using appropriate instruments and materials to demonstrate controlling variables, analyzing data, drawing conslusions

582 - Communicating procedures and findings orally and in writing

682 - Using your knowledge...to take a position on an issue

683 - Defending your position before your peers

SELECTED SOCIAL STUDIES OUTCOMES FOR GRADES 5 TO 8

3. Students will develop an understanding of geographic concepts and processes needed to examine the role of culture, technology, and the environment in the location and distribution of human activities.

5. Students will demonstrate an ability - individually and as part of a group - to gather information, think critically, and solve problems as needed to facilitate responsible decision-making, to understand complex ideas, and to generate new ideas.

SOCIAL STUDIES INDICATORS

GRADE 5

351 - Locating places and natural features by interpreting and constructing maps etc.

352 - Examining people's adaptation to and modification of their environment as a result of changes in technology

357 - Demonstrating a sense of personal responsibility for environmental decisions made at the state and national levels

551 - Obtaining, interpreting, organizing, and using information from asking questions and observing

552 - Interpreting information from graphics, maps etc.

553 - Defining problems from the social sciences identify resources and prepare solution based on available data

554 - Making and analyzing personal decisions and reflecting on the results

555 - Participating in a group in a variety of roles

GRADE 8

381 - Locating places, cultural features, and natural features by interpreting and constructing maps etc.

382 - Evaluating environmental issues and recommend ways of protecting the environment while meeting human needs

383 - Evaluating the ways humans modify their physical setting to meet economic meeds, and the resulting changes in their quality of life.

581 - Obtaining, interpreting, organizing, and using information from asking questions and observing

582 - Interpreting information from graphics, maps etc.

585 - Analyzing situations to determine what group action is required and demonstrate skills needed to move a group to action

SCIENCE AND SOCIAL STUDIES OUTCOMES FOR ECOLOGY OF AN ESTUARY ACTIVITIES

1. **TRACK THAT TRIBUTARY** (Grades 5 - 8): Science 153, 252, 253, 351, 355, 451, 452, 453, 454, 552, 652; 183, 283, 286, 381, 481, 482, 582, 682. Social Studies 351, 552, 553; 381, 382, 383, 582.

2. **MIXING WATERS** (Grades 3 - 6): Science 131, 132, 133, 231, 232, 331, 333, 335; 151, 152, 153, 252, 253, 255, 353, 451, 452. Social Studies 531, 532; 551, 552.

3. **THE OYSTER BAR** (Grades 3 - 5): Science 131, 132, 133, 232, 233, 331, 335, 432, 531, 532; 151, 152, 153, 252, 253, 255, 256, 351, 452, 552. Social Studies 332, 333, 535; 352, 357, 551, 555.

4. **COOL COVERS** (Grades 3 - 5): Science 131, 132, 133, 231, 232, 331, 334, 335, 336; 151, 152, 153, 252, 253, 255, 256, 351, 353, 451, 452, 551. Social Studies 332, 333, 534, 535; 351, 352, 357, 551, 554, 555.

5. **WHO AM I?** (Grades 4 -8): Science 252, 351, 352, 353, 451, 452, 453; 281, 283, 381, 481, 482, 683. Social Studies 551, 552, 555; 581, 582, 585.

6. **WHO LIVES HERE?** (Grades 3 - 6): Science 131, 231, 232, 331, 432; 151, 252, 253, 255, 256, 352, 353, 451, 452, 453. Social Studies 535; 551, 555.

7. **PATTERNS OF PLANTS** (Grades 4- 8): Science 131, 132, 231, 232, 233, 331, 334, 336, 432, 532; 151, 153, 252, 253, 255, 256, 351, 352, 353, 451, 452, 552; 181, 182, 183, 281, 381, 481, 482, 582. Social Studies 535; 551, 555; 383, 581.

8. **EXPLORING ESTUARINE WATERS** (Grades 3 - 8): Science 132, 133, 231, 232, 233, 331, 333, 334, 432, 433, 531, 532; 152, 153, 252, 253, 255, 256, 351, 353, 451, 452, 453, 454, 551, 552; 182, 183, 281, 283, 381, 481, 581, 582. Social Studies 535; 551; 581.

9. **FISH FEATURES** (Grades 6 - 8): Science 181, 182, 183, 281, 283, 381, 481, 462, 581, 582. Social Studies 581, 582, 585.

10. **SNAIL SURVEY** (Grades 6 - 8): Science 181, 182, 183, 281, 283, 285, 286, 381, 481, 482, 581, 582. Social Studies 381, 581, 582, 585.

11. **DECISIONS, DECISIONS** (Grades 5 - 8): Science 253, 256, 352, 353, 451, 454, 652, 653, 655; 283, 285, 381, 481, 682, 683. Social Studies 352, 357, 551, 553, 554, 555; 382, 383, 581, 585.5.

12. **BAY BOUNTY** (Grades 3 - 5): Science 131, 132, 133, 231, 331, 333, 335, 336, 432, 433, 531, 532; 151, 152, 153, 252, 253, 255, 256, 352, 353, 452, 453, 454, 551. Social Studies 332, 333, 532, 534, 535; 352, 357, 551, 552, 553, 554, 555.

OTHER RESOURCES FOR RELATED ACTIVITIES

Aquatic Project Wild. Western Regional Environmental Education Council. Boulder, Colorado. 1987.

Exploring the Chesapeake at the Smithsonian. Smithsonian Environmental Research Center. Edgewater, Maryland. 1994.

The Chesapeake Bay, It Starts With You. Maryland Department of the Environment. Baltimore, Maryland. 1989.

Chase, Valerie. The Changing Chesapeake. National Aquarium in Baltimore. Baltimore, Maryland.

Chase, Valerie. Living in Water. National Aquarium in Baltimore. Baltimore, Maryland. 1987.

Cornell, Joseph. Sharing Nature with Children. Ananda Publications. Nevada City, California. 1979.

Firehock, Karen. Hands On Save Our Streams—The Save Our Streams Teacher's Manual for Grades One Through Twelve. Izaak Walton League of America. Gaithersburg, Maryland. 1994.

Firehock, Karen. Save Our Streams—Volunteer Trainer's Handbook. The Izaak Walton League of America. Gaithersburg, Maryland. 1994.

Guidance Manual For Volunteer Water Quality Monitoring in Maryland. Maryland Volunteer Water Quality Monitoring Association, Chesapeake Bay Trust. 1995.

Jones, Gail. Project Estuary. North Carolina National Estuarine Research Reserve. Raleigh, North Carolina. 1989.

Jones, Gail. Sound Ideas. North Carolina National Estuarine Research Reserve. Beaufort, North Carolina. 1993.

Kellogg, Loren Larkin. Save Our Streams—Monitor's Guide to Aquatic Macroinvertebrates. Second Edition. Izaak Walton League of America. Gaithersburg, Maryland. 1994.

Lynn, Brian. Discover Wetlands. Washington State Department of Ecology. Olympia, Washington. 1988.

Mason, Rich and Luise Woelfein. Chesapeake Bay Watershed Activity Guide. U.S. Fish and Wildlife Service. Annapolis, Maryland. 1993 Draft.

Mitchell, Mark K., William B. Stapp. Field Manual for Water Quality Monitoring. 6th Edition. Thomson-Shore, Inc. Dexter, Michigan. 1992.

Slattery, Britt. WOW, The Wonders Of Wetlands. Environmental Concern. St. Michaels, Maryland. 1991.

Virginia's State Parks. Virginia Institute of Marine Science. Virginia Department of Conservation and Recreation. Richmond, Virginia.

"Webbing", Current, vol. 10. National Marine Educators Association. Pacific Grove, California. 1990.

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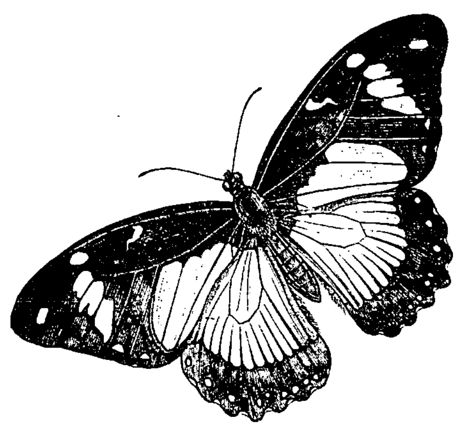

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