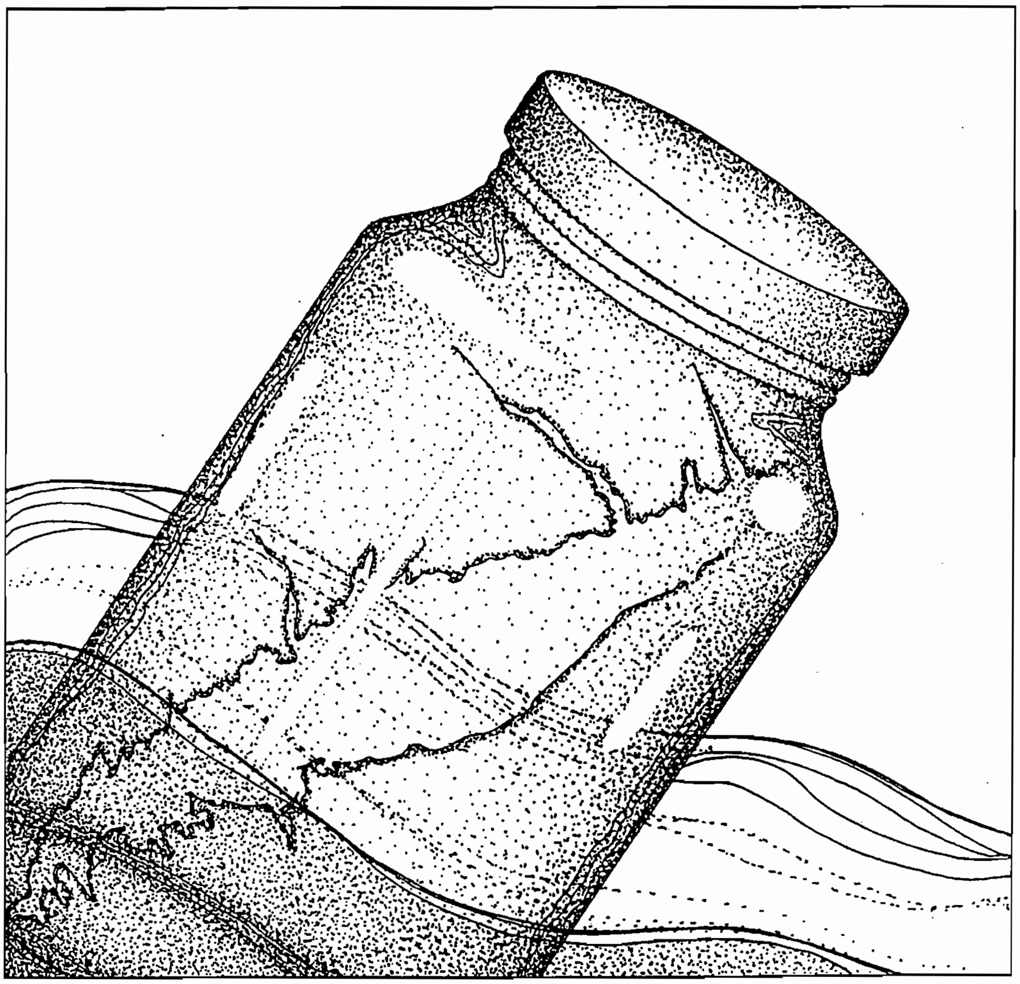
LONG ISLAND S•O•U•N•D IN•A•JAR



ACTIVITIES FOR YOUTH • DEMONSTRATING HUMAN IMPACT ON AQUATIC SYSTEMS

Heather M. Crawford
Connecticut Sea Grant Extension Educator

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Preface

Long Island Sound in a Jar has been a long time coming and has been through several detours and circumnavigations during its journey to completion. I still find it hard to believe that when I started this project back in 1991, all I was trying to do was fill a request for a collection of water-based educational activities that could be used at all the 4-H camps in Connecticut. Some of those camps had ponds and streams to explore while at others the only significant water body was the swimming pool. After the first summer, counselors who used the activities were enthusiastic enough that it was suggested I consider how to adapt the collection for use in all summer camps. A little later someone pointed out how valuable such a guide would be to any informal youth education activity group. Then, finally, it was "Heather, why don't you use this as the basis for a formal school curriculum?"

With each change, believe me, I was sailing deeper into uncharted waters. Sometimes the only thing keeping me going (besides the threats of violence from a variety of colleagues) were the continuing calls from teachers and youth leaders looking for ways to teach about Long Island Sound, and the fact that when I went out and used these activities with a group of kids, they enjoyed themselves and picked up on my desired "take-home message". There have been deletions and additions (somewhere around 1996 a reader pointed out that it would be good for a publication called "*Long Island Sound in a Jar*" to at least mention *something* about estuaries) of background material and activities. There have been more rewrites and draft versions and sample activities than even I have been able to keep track of. I hope that this final version will be able to serve two audiences, the classroom teacher and the informal youth group leader or camp counselor, who share the goal of giving children a better understanding of the working of our planet and its inhabitants while discovering the explorer, scientist, writer, actor or inventor in themselves.

Because I hope to serve two audiences with one publication, some of the included material may seem more or less useful to a particular reader. Teachers may find the newspaper column reprints useful as classroom reading assignments. Informal educators may prefer to use them as additional background material. Those of us with no formal training in educational theory will find the material on childhood developmental stages, provided by Dr. Maureen Mulroy, helpful in choosing or adapting activities to be appropriate to our audience.

I've accumulated a lot of collaborators, critics (in the best sense of the word), and editors on this journey from bright idea to hard copy publication. In somewhat chronological order, I'd like to acknowledge and thank the following people: Bari Dworkin, for initially talking me into working with the summer camps; Laura Briggs, my summer intern that year, and all the camp managers and counselors, for "field-testing" and providing written evaluation of my initial effort; Maureen Mulroy for providing me with both verbal tips and the written material on how to fit programs to the audience; Norm Bender, for forcing me to keep the project in my plan of work and, with Wanda Little, for early guidance and the continual access to youth groups for activity testing; Nancy Balcom, for reading, prodding and catching some serious omissions; Robin Mose, for her fresh eye when I could NOT read the manuscript one more time and for her valuable summary of the ecosystems and historical uses of Long Island Sound; and Peg Van Patten, for reading, commenting and getting things to final publication readiness. I hope all our efforts are useful for at least as long as it has taken to put this all together.

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Foreword

As researchers dive deeper into the oceans and reveal new information about history, biology, earth science, and global change, educators are searching for activities to help students understand the connections between people, oceans and our environment. The myriad discoveries, from the wreck of the *H.M.S. Titanic* to the climactic effects of El Niño, appear prominently in the media and have sparked great student interest. At career exploration events I have attended over the past few years, guidance counselors have found "marine science" one of the most-requested options, and even unpaid-internship programs are turning away applicants!

Unfortunately, today's teachers have so many demands on their time that it's difficult to keep up with the news about marine and aquatic science, and to understand sometimes conflicting data. Educators need up-to-date, accurate information that they can present in a way that will engage their students, yet they rarely find excellent background material and effective activities in the same publication. *Long Island Sound in a Jar* provides both, so I believe it will be an exceptionally useful tool for teachers in Connecticut and beyond.

The greatest strength of *Long Island Sound in a Jar* lies in its interdisciplinary approach. It includes fascinating historical notes, a complete glossary, clear examples of how water influences life on earth, and lessons that connect people everywhere with oceanic systems. Most importantly, it offers a lot of fun activities that will have you and your students experimenting, laughing, and understanding the Sound as never before. Break out the paper towels and roll up your sleeves—you're about to enter *Long Island Sound in a Jar*!

Amy Haddow
The Maritime Aquarium

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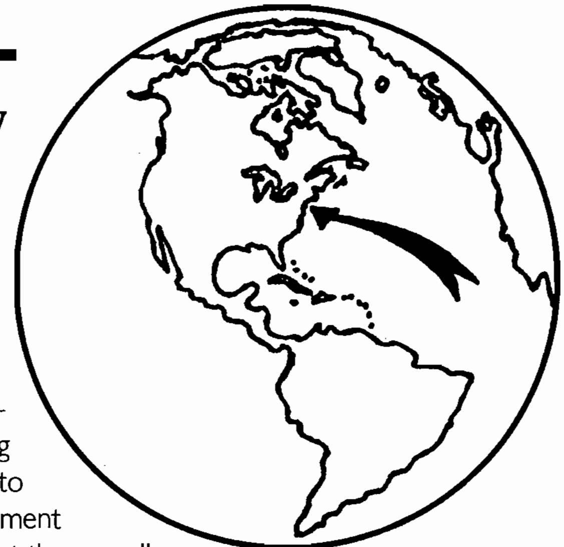
Chapter One

Long Island Sound – The Estuary



Background for Instructors

If, from space, you zoom in on Planet Earth at the coordinates: 41 degrees North latitude, 73 degrees West longitude, you would focus on the rough center of a body of water. Measurement equipment would tell you that this water body was roughly 110 miles long from west to east and 21 miles wide at its widest point, narrowing to small openings at the eastern and western ends. Bathymetric equipment would show the deepest point in the water body to be 350 feet, but the overall average depth to be 65 feet. A geological survey would reveal a complex array of sands, silts, boulders and bedrock both under the waters and forming the shores of this water body. An oceanographic survey would reveal a combination of currents, tides and fresh water inputs creating highly variable salinity patterns. Biological sampling would reveal vast numbers of individuals from extremely tolerant species of plants and animals, and, along the shore, dense concentrations of human beings. Yet even with all this information, it is still difficult to understand this body of water we know as Long Island Sound.

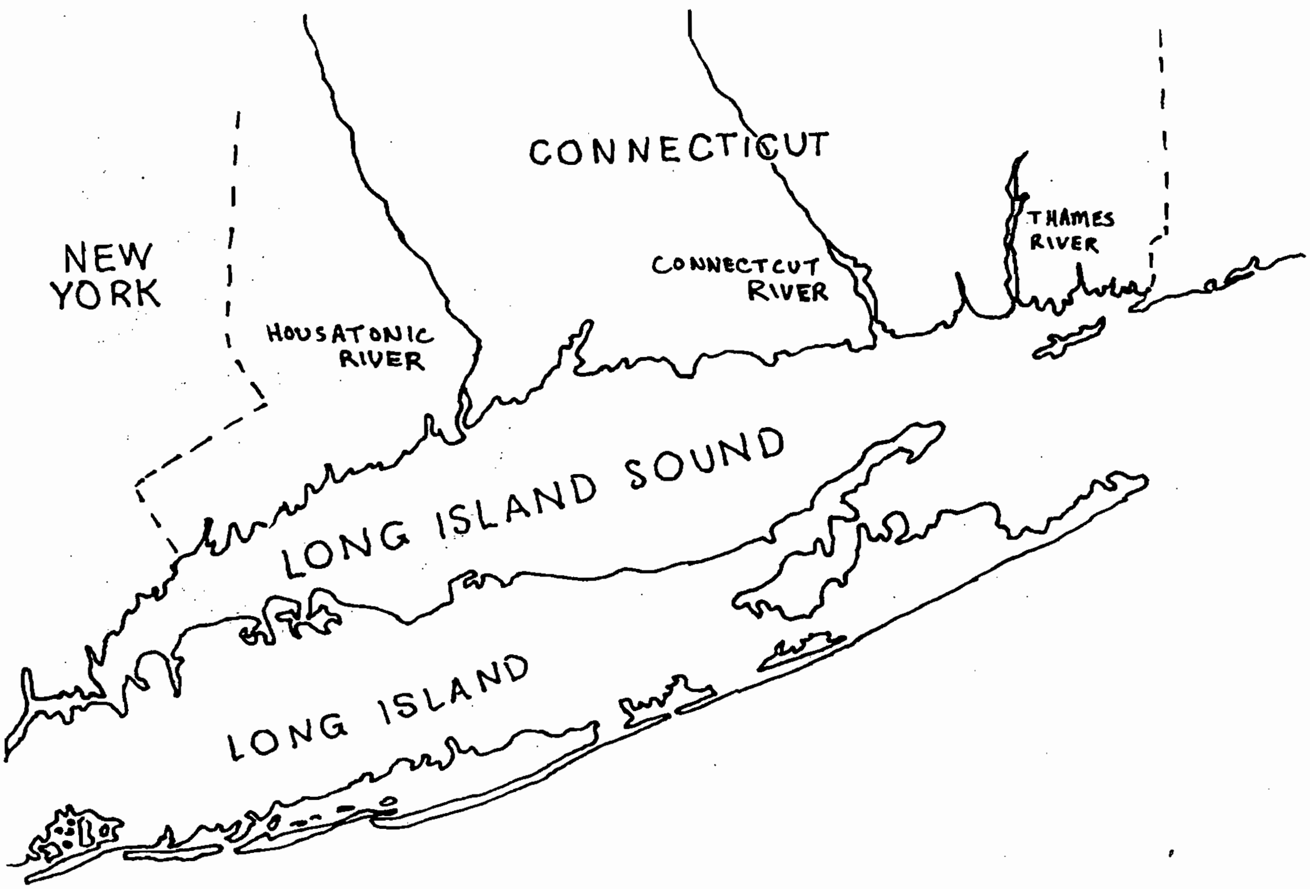
So really, what is Long Island Sound? This is a question that can be answered in many ways, depending on how you choose to describe the body of water and associated landscape that carries the name Long Island Sound. In the following paragraphs, some common ways of describing the Sound are outlined, and then some more detailed descriptions will be given.

First of all, Long Island Sound is a "sound", a geographical term that is frequently used but little understood. A "sound" is the body of water that lies between an island and the mainland. Depending on the size of the island and its distance from the shore, a "sound" can be quite small and protected or large and open. There can be small "sounds" within a larger "sound", as in areas like the Thimble Islands off Branford, CT which are located within Long Island Sound.

Another way to describe Long Island Sound is as an estuary. An **estuary** is a protected coastal body of water in which salt water from the ocean meets and mixes with fresh water from a river or stream. Long Island Sound is a very large, complex estuary, with two sources of salt water and four major rivers: the Connecticut, Thames, Housatonic and Quinnipiac, as well as many smaller streams, providing fresh water to the system. The large estuary of Long Island is made up of many smaller estuaries where each of the rivers or streams enters the Sound.

Long Island Sound is also an example of an **ecosystem**, a community of organisms interacting with each other and the physical environment in which they live. The concept of ecosystem is important when studying the integrity of the environment. If one aspect of the physical environment is changed, such as summertime oxygen levels, or the community changes, as with the removal of a base prey item, the entire ecosystem could be impacted. For example, although Long Island Sound and the Chesapeake Bay are both estuaries, their diverse physical features, and different temperature and salinity patterns, have led to slightly different ecosystems, based on varying species of plants and animals.

Within an ecosystem, various habitats exist. A **habitat** is simply the area where an organism lives. A habitat must meet the individual requirements of an organism by providing proper food, oxygen/water, space, and shelter. Long Island Sound's habitats have been characterized in a number of ways, but the basic classification includes water-land interface, **salt marsh**, **tidal flats**, **rocky intertidal**, **sandy beach**, and **subtidal zone**, which is divided into the open water (**pelagic**) and bottom-dwelling (**benthic**) habitats.



However you choose to look at Long Island Sound, it is important to consider its location on the planet. Located at 41 degrees North latitude, Long Island Sound is almost exactly half way between the North Pole and the Equator. Over the course of a year, the Sound experiences weather conditions similar to both the tropics and the Arctic. During winter months Long Island Sound shares average water temperatures as low as -1° C with an area extending from Nova Scotia to the Chesapeake Bay. In the summer, a continuous zone of warm surface water temperatures as high as 22° C extends from Cape Cod to the Caribbean Sea. Shifting between these two weather extremes creates the four distinct seasons of the year and affects both the physical features and the ecosystems of the Sound.

When described as an estuary, the key feature of the Sound is the mixing of fresh and salt water. There are two connections to the Atlantic Ocean in Long Island Sound: the Race at the eastern end and the East River at the western end of the Sound. Most of the Sound's salt water enters through the Race. With each incoming tide, 25 billion gallons of salt water enter the Sound at the Race. Fresh water enters the Sound in two ways: from the rivers and streams and as direct **precipitation** in the form of rain or snow. The Long Island Sound region receives between 30 and 40 inches of precipitation spread fairly evenly through the year, but fresh water is not delivered to the Sound that way. When it rains during warmer months, the water runs down rivers and into the Sound fairly quickly. In colder months, when precipitation occurs as snow, the fresh water stays on the land until the spring melt and then enters the Sound all at once. This leads to an annual variation in fresh water entering the Sound, peaking in the early spring and reaching a low in late summer.

The salinity of the Sound varies depending on weather, tides, and season. Seawater in the open ocean has a salinity of 35 parts per thousand (35 ppt, or 35 ‰). The average salinity in Long Island Sound is 28 ppt. At the mouth of the Quinnipiac River in New Haven Harbor, surface salinity can be as low as 15 ppt after a summer storm. Cold salt water, because of its higher **density** (further information in chapter two on physical properties of water), lies below warmer fresher water. This horizontal **thermal stratification**, combined with the multiple sources of fresh and salt water, give Long Island Sound a unique and complex circulation pattern. Temperature and salinity fluctuations are two major environmental factors to which estuarine organisms must be adapted.

The other major factor affecting organisms living in Long Island Sound is its landscape: the actual shape and substrate (soils and rocks) that form the basin of the Sound. The actual basin of Long Island Sound was probably a result of **erosion** from streams predating the last ice age. The rest of the land features of Long Island Sound and its shoreline were formed during the most recent ice age, over 20,000 years ago. An ice sheet nearly a mile thick covered Long Island Sound, scraping up an average 20 meters of surface sediments as it moved slowly southward.

When the earth's temperature gradually rose, and the great glacier receded, the scoured rock and sediments were "dropped". This accumulated debris, called a "**moraine**", formed a ridge down the middle of what is now Long Island, New York. Long Island Sound was a fresh water lake until between 19,000 and 15,000 years ago while sea level rose to the level of the Sound. As sea levels continued to rise to the level of the current shoreline, the Sound became the estuary it is today. In the following centuries and millennia, plants and animals migrated into the newly created Sound and took advantage of the variety of environmental combinations that distinguish the different habitats of the Sound.

Habitats of Long Island Sound

Subtidal Zone

The subtidal zone is the area constantly under water. Because physical conditions do not vary greatly, a wide variety of life is supported. This area is divided into the benthic zone, inhabited by the **benthos**, or bottom-dwelling organisms, and pelagic zone, inhabited by organisms that live in the water column. Flatfish and crabs are examples of benthos, and jellyfish and most roundfish, like bluefish, live in the pelagic zone.

Water-Land Interface

The water-land interface is the area where daily tidal submergence does not occur, but the land is still affected by the marine environment. **Spring tides** (extra high and low tides occurring twice monthly during full and new moons), salt spray, and heavy flooding all limit the type of organisms that can survive in this salt-influenced zone.

Intertidal Zone

The intertidal zone is the area between the highest high tide and lowest low tide. This zone can be broken up into several habitat types (rocky intertidal, beaches, sand or mud flats, and salt marshes) based on the geology of the area. Organisms living in any intertidal habitat must be able to survive regular exposure to sun and wind (which cause dehydration) as well as submergence in the water.

Salt Marshes

Salt marshes straddle the zones of daily tidal submergence and periodic submergence of the water-land interface. High marsh is characterized by vegetation that can withstand infrequent flooding of salt water, such as the short form of cordgrass. The low marsh is flooded twice daily during high tide, and is home to the tall form of cordgrass and organisms which do not require constant submergence, such as fiddler crabs, or mobile creatures, like fish, which can leave the area when the tide goes out.

Tidal salt marshes are a highly valued habitat. They have some of the highest productivity rates, meaning the amount of living material produced in a given area. A salt marsh produces seven times more biomass (leaves, roots, nutrients, etc.) per acre than a cornfield. Nutrients from the salt marsh enter the **food web** and support a vast array of organisms. In fact, it has been estimated that 75% of all coastal fish species utilize the marsh as feeding or spawning grounds during their lifetime. Many species of shellfish, crabs, snails, worms and small land mammals inhabit the marsh area. Because of this diversity of plant and animal life, salt marshes also provide resting and feeding stops along flyways for migratory birds.

Tidal marshes act as buffers. One acre of salt marsh can hold 30,000 gallons of water; an important feat when considering the devastation flooding can cause in developed areas stripped of their wetlands. The grasses found in marshes provide shelter and cover for animals. They also filter impurities out of the water and trap sediments and contaminants.

Despite the tremendous significance of tidal marshes, 50-65% of Connecticut's original salt marshes have disappeared, through development, dredging, filling, and overharvesting. The remaining marshes experience some degree of degradation from pollution. In fact, some experts claim that the greatest long-term threat to the sustainability of our fisheries is loss of fish habitat associated with marshes. In Connecticut, the Tidal Wetlands Act in 1969 and the Coastal Management Act in 1979 are responsible for creating a new conservation atmosphere for wetlands, but the lost marshes can never be completely replaced.

Tidal Flats

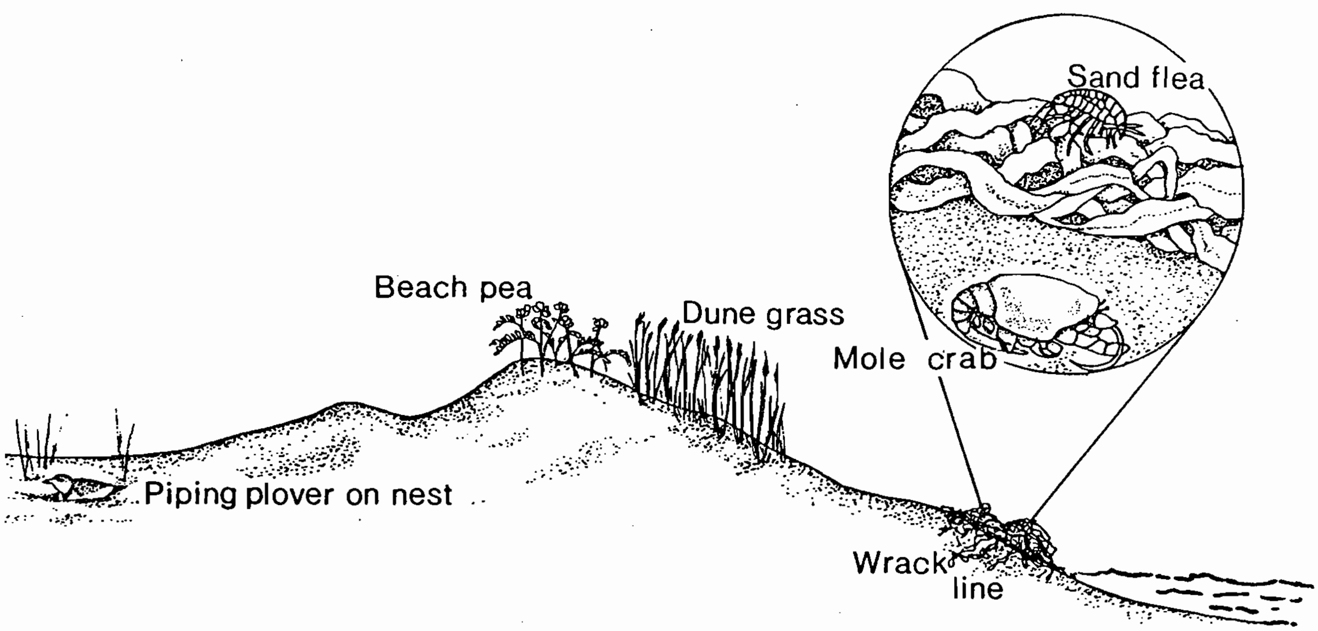
Tidal flats are shifting banks of either sand or mud. Usually they occur in areas where wave action prevents marsh grasses from taking root. The lack of vegetation both allows more sediment movement (look for the wave ripples carved into the surface of a sand flat at low tide) and provides even less protection from the sun and wind for organisms living in this habitat. Initially appearing devoid of life, a closer look reveals various animals living buried within the sediment to reduce the drying and temperature fluctuations. Worms and clams are two such burrowers. At high tide many mobile organisms move into this area to feed.

Rocky Intertidal Zone

The rocky intertidal zone also experiences drying periods between tides, but has the added stress of intense wave action. The organisms adapted to this habitat possess special adaptations to anchor themselves to the rocky substrate, such as the byssal threads of mussels and cement of barnacles. Seaweeds living in the rocky intertidal zone have evolved chemical compounds that hold water, preventing complete dehydration from sun and wind exposure.

Beaches

Sandy beaches combine the stress of wave action with the drying of low tide. Like tidal flats, many species burrow into the sand for protection from exposure to sun and drying. A turn of a shovel will reveal several types of worms, clams, and mole crabs.



When discussing the ecosystem of Long Island Sound with its various habitats and organisms, a picture of a complex, yet balanced environment emerges. However, a discussion of the Sound is not complete without talking about humans and their impacts on the ecosystem. Historically, humans have played an increasingly significant role in shaping the environment of Long Island Sound.

Indians have long taken advantage of the riches of the Sound. Archeological evidence shows that Native Americans have been using the Sound as a source of food, medicine, and commercial trade items for over 10,000 years. When permanent European settlements along the Sound were established in the mid-1600's, the colonists took advantage of the same abundance of resources. Even though most of these early colonists were farmers, the Sound provided important food supplies. Salt hay from the marshes fed cattle; lobsters and other fish were fed to pigs.

By the 1700's, use of the Sound included trade, shipping, and shipbuilding. Much industrial development was also occurring as factories manufacturing many different items were built. During the 1700's, oystering and salmon fishing were an economic mainstay. However, as dams were built on the rivers to support industrial uses, the spawning shad and salmon could not reach their birth streams and suffered a dramatic population decrease. By the mid-1800's, oystering was so important that Connecticut became the first state to write laws establishing underwater oyster farms as private property. Even so, overharvesting, several years of poor survival of the young of the year and pollution problems were responsible for the oyster fishery coming dangerously close to collapse. Not until the late 1900's did the Sound reclaim its fame for delicious oysters.

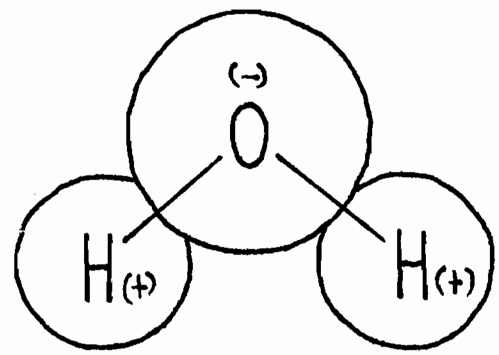
In the 1800's, as trade and shipping increased, tidal wetlands, thought to be useless land, were dredged or filled to make way for deeper harbors or to allow the building of ground transportation, such as the railroad. Factories continued to discharge millions of gallons of waste material into the Sound and its tributary rivers. Because of the beauty of Long Island Sound, it became a popular vacation spot at the turn of this century. As more people flocked to the region, construction and development quickly expanded along the shoreline. Today, more than five million people live within fifteen miles of the Sound's coastline. Pollution from increasing volumes of land development and transportation contributes to contaminated runoff or **nonpoint source pollution** entering the Sound.

The ecosystem of Long Island Sound is home to a tremendous number of species, including humans. As humans, we have the most potential to negatively impact the Sound. Unchecked development will ultimately destroy one of the larger and most highly utilized estuaries in the world. Creating a balance between human needs and conserving the ecosystem is the most important issue facing the future of Long Island Sound.

Chapter Two

Water Wonders

Background for Instructors



Water Molecule

If you just look at the chemical formula for water (H_20), it seems that water is a simple enough compound consisting of two atoms of hydrogen and one atom of oxygen. However, the structure of this small, lightweight molecule gives it several unique characteristics that have contributed significantly to the patterns of life on this planet. Consider that water is one of only three naturally occurring liquids under normal atmospheric conditions and that the other two liquids are petroleum and mercury, and then try to imagine an ecological system based on mercury! Other important characteristics of water include:

- an uncommon tendency for water molecules to cling together due to an attraction between the hydrogen and oxygen atoms in different water molecules
- an ability to absorb or release large amounts of heat/energy before changing temperature
- a uniquely temperature-dependent density pattern: water is most dense at 4° C or 39° F and becomes less dense above and below this key temperature
- **transparency**, or the ability to allow light to pass through water
- the ability to dissolve many different substances or compounds.

There are many other molecules of similar size and weight we can compare to water, such as ammonia (NH_3), methane (CH_4), and carbon dioxide (CO_2), but none of these substances exhibit any of the properties of water.

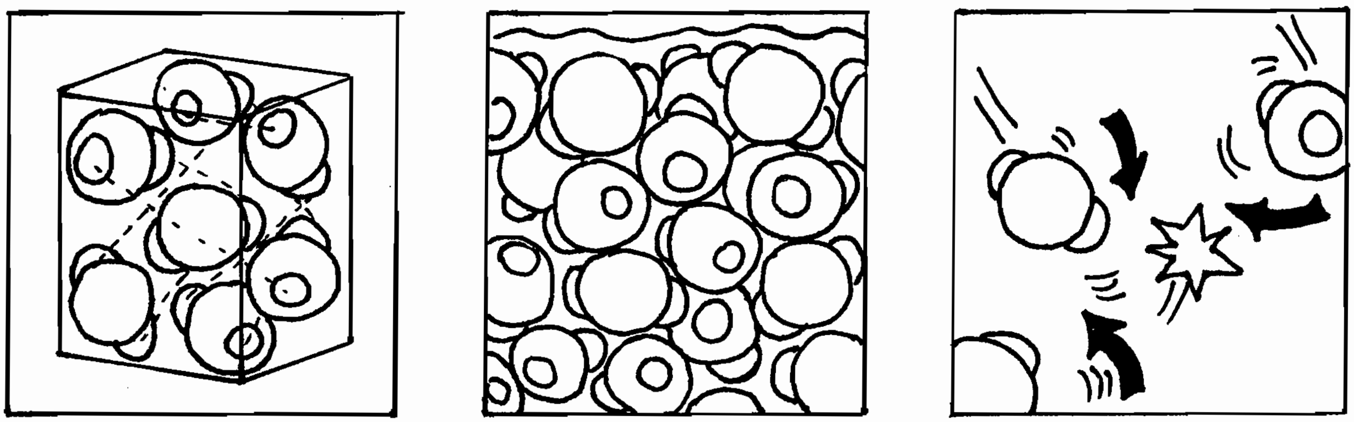
Molecular Structure

The secret of water's unique characteristics lies in the arrangement of atoms within the molecular structure of water. Both of the hydrogen atoms are arranged to one side of the oxygen atom. These hydrogen atoms carry a positive charge (like an electrical charge) and oxygen atoms carry a negative charge, causing the entire molecule to have a net charge of zero. Because of this arrangement of atoms, a water molecule acts like a very tiny magnet, with a "positive" side and a "negative" side, and like magnets, the oppositely charged ends of different molecules are attracted to each other. A molecule with this arrangement is referred to as "**polar**".

Water absorbs Heat

The attractive force between water molecules is known as a "hydrogen bond." It is not as strong as the bonds that join the hydrogen to the oxygen within the water molecule, but breaking this bond to separate water molecules does require energy. It is the hydrogen bonds formed between water molecules that keep water in a liquid form at room temperature.

To move from a liquid to a gaseous form (**evaporation**), each gram of water must absorb 540 calories of energy. When the gas reverts to its liquid form (**condensation**), all that energy is released to the air around the water molecules. The release of energy through the condensation process provides the energy that powers hurricanes and thunderstorms. As water freezes to ice or melts from ice, energy is also released or absorbed. The large amounts of energy required to heat or cool water means that water temperature changes much more slowly than the temperature of the surrounding air. Large bodies of water, like Long Island Sound, can affect the surrounding air temperature by acting as a "**thermal sink**", explaining why it is frequently several degrees cooler at the shore during the summer and several degrees warmer in winter.



Density

Most liquids become denser as they cool, but water's polar molecules change this pattern. While in its liquid form, water molecules move around each other randomly. Hydrogen bonds continually form and break between different molecules depending on the energy available. Decreasing water temperatures indicate a decreasing availability of energy. When water temperatures reach 4° C, there is not enough energy available to break hydrogen bonds once they have formed and water reaches its greatest **density**. As the temperature decreases further, the continual formation of hydrogen bonds forces water molecules to line up in crystalline formation. This becomes visible to us when the temperature reaches 0° C and ice forms. The rigidity of this crystalline structure forces the water molecules to take up more room than when they were moving randomly in their liquid form. So ice, the solid form of water, is actually less dense than the liquid form. This is why ice floats and why the densest water, at 4° C, is found at the bottom of lakes and ponds. When water gets colder than 4° C, it rises to the surface and freezes, allowing life to persist in the deeper waters throughout the winter months. Great science fiction stories have been written about the effects on life if ice suddenly became denser than water.

Dissolved materials also affect the density of water. Salt water is denser than fresh water because of the quantities of salt and other minerals it contains. Water from the open ocean has a salinity of 35 parts per thousand (ppt) which means that 35 grams of salts have been dissolved in 1000 grams of water. Density can be a complicated concept to explain. Think about a bucket of feathers and a bucket of sand: which one is heavier? Sand is denser than feathers, so a bucket of sand is heavier than a bucket of feathers even though it takes up the same amount of space. The density of water is affected by two independent factors (temperature and dissolved materials). There can be situations where warm salty water is denser than cold fresh water. The relationship between these two density factors is extremely important in determining the environment of an **estuary**, like Long Island Sound, where fresh and salt water meet and mix.

Water is Transparent

Because water is transparent, light can travel far below its surface. The availability of light enables plants of all sizes to grow underwater. **Phytoplankton**, tiny one-celled plants that float in the waters of our lakes and oceans, are responsible for about one-half of all the **photosynthesis** that occurs on our planet. Along with providing oxygen, phytoplankton forms the base of many **food chains**.

Crystal clear water appears blue in color. Other colors are caused by small particles suspended in the water. **Oceanographers** and **limnologists** (scientists who study oceans and lakes) can often determine what sort of particles are in the water by looking at the apparent color of the water. Suspended sediments such as silts and clays may cause a brown color, although some phytoplankton can make the water look brown. Other phytoplankton cause the water to look green, yellow or red.

Water is a Universal Solvent

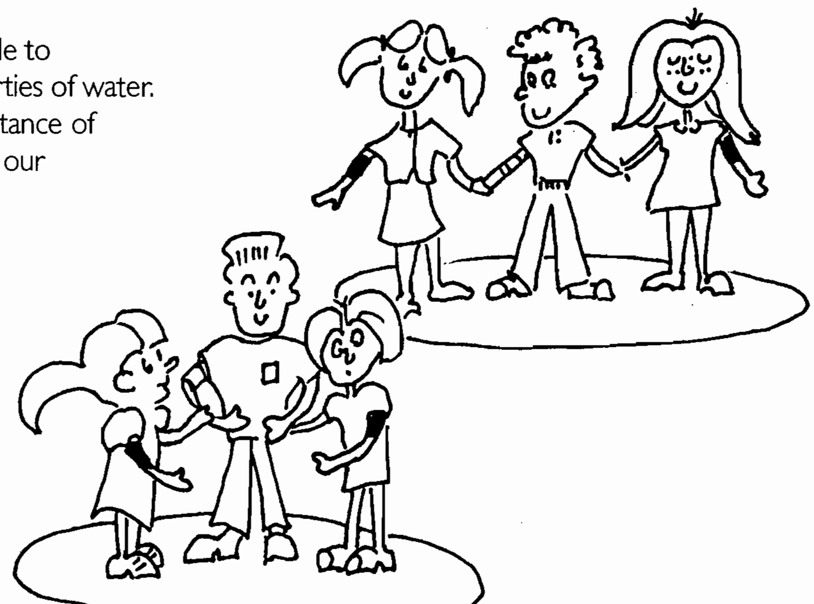
The polar structure of water enables it to dissolve all polar compounds (like salts composed of one positively-charged particle and one negatively-charged particle) and many nonpolar compounds (like sugars, which have no charges within their structure). Water also dissolves gases like oxygen, nitrogen, and carbon dioxide. This ability to dissolve almost anything (given enough time) makes water ideal for transporting substances through living bodies or around the planet. Water, in the form of blood, carries nourishment through your body and removes wastes. It carries **nutrients** into plants and salts from eroding rocks into our oceans.

A difference exists between materials dissolved in water and materials suspended in water. A substance dissolved in water (making a **solution**) generally has been divided to a size where it actually fits between the water molecules. It is very difficult to remove dissolved materials from water without an energy-intensive procedure like **evaporation** or reverse osmosis. A substance suspended in water will eventually settle out of still water with smaller particles settling at a much slower rate than larger particles.

Somewhere in between dissolved substances and suspended substances comes a group of substances that, when mixed with water, create a "colloidal suspension". The materials involved are not dissolved in the water but they also will not settle out of the water. Milk is an excellent example of a colloidal suspension. One way to differentiate between a solution and a **suspension** is to determine whether you can see through the liquid. Solutions are generally fairly transparent while suspensions are generally opaque.

Objectives

- Children will understand and be able to demonstrate several unique properties of water.
- Children will understand the importance of the properties of water for life and our environment.



Learning Activities

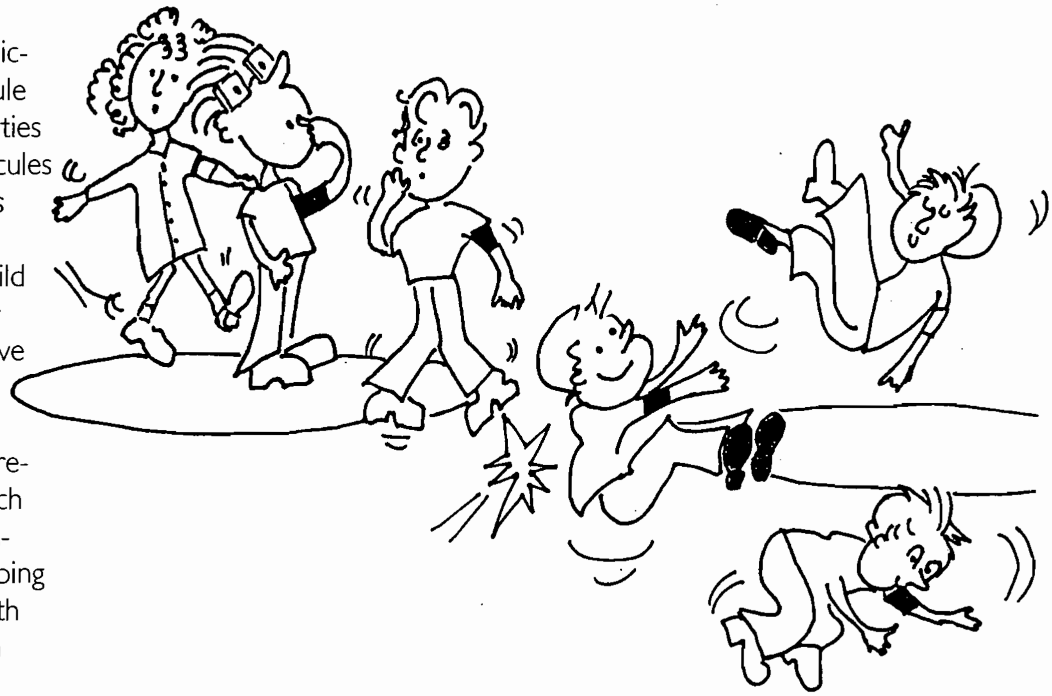
1. Molecular Tag
2. Hydrogen "Bonding"
3. Density Made Visible

Activity Outlines

1. Molecular Tag

Materials needed:
tags or arm bands in two colors
a large cleared area or an outside location

Show the group a picture of a water molecule and discuss the properties that make water molecules special. Divide the class into groups of three, preferably with one child being somewhat larger than the other two. Give each small group three tags, two representing hydrogen and one representing oxygen. Ask each group to arrange themselves in a triangle, clasping hands in the middle with the identifying mark on their outside arm.



Mark boundaries for the "container" and tell the group that they are liquid water and have them start moving around within the "container", forming and breaking hydrogen bonds as they pass near other groups. Say that the temperature is getting colder and they are moving more slowly and the hydrogen bonds are getting harder to break (and colder and slower and colder and slower...) until you reach 0° C and the water freezes. At 0° C, have everyone grab hold where their hydrogen bonds are formed and see if they can successfully create the crystalline structure of ice.

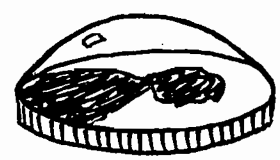
Once they have seen how they look, reverse the process by telling them the temperature is rising and the ice is melting, etc. As the "water temperature" rises, the groups should be moving around faster and faster until some groups accidentally move outside the "container" boundaries. Groups that fall out of the boundaries have broken all their bonds with other water molecules and evaporated. You can try getting the "water" all the way to boiling, but only if the children do not appear to be in danger of hurting themselves. End by "cooling" down the water again.

Ask where they think the energy came from to heat up the water and where it went when the water was cooled down.

2. Hydrogen "Bonding"

Materials needed:

construction paper or round balloons in two colors
tape
markers or pencils
scissors
waxed paper
toothpicks
squeeze bottles of colored water (red, blue, yellow)
copies of water race course and Water Drops worksheet
pennies
eye droppers
vegetable oil



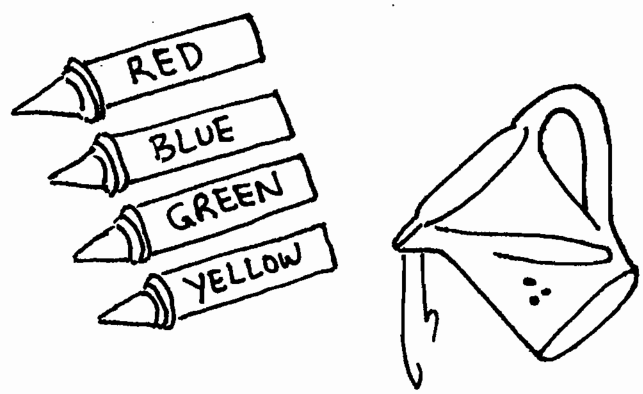
A. Make models of water molecules out of construction paper or balloons, with one large circle for the oxygen and two smaller circles for the hydrogen. Put several of the molecules together, keeping the opposite charges next to each other, to show how the attractive forces between the molecules make them stick together.

B. Give each person a square of waxed paper and two toothpicks. Sprinkle water drops of different colors onto the waxed paper. Each person can experiment with the drops, following the ideas on the "Water Drops" worksheet. Then place a drop of vegetable oil on the waxed paper and have them compare the oil to water.

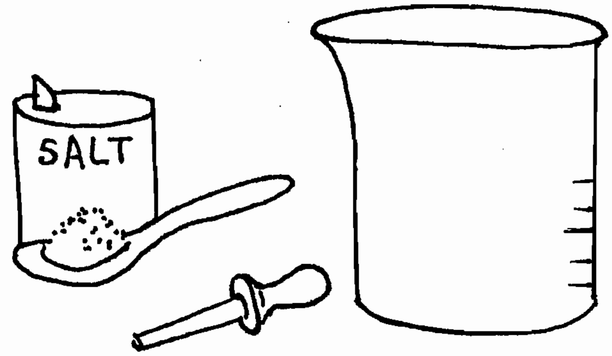
C. Pass out one penny, a container of water and an eyedropper to small groups of two or three. Ask each group to guess how many drops they think they can put on a penny before the water runs off. Have them write down their guess, then try it, writing down the actual number of drops. You will be surprised! Try it with other coins as well.

3. **Density Made Visible**

Materials needed:
4 beakers or jars for sample solutions
a beaker, graduated cylinder or narrow jar for each small group
eye droppers
food coloring
salt
access to microwave oven and/or refrigerator



In two beakers, make a salt solution by mixing one tablespoon salt into one cup water. Fill two other beakers with fresh water. Color the water in each beaker a different color. Using a microwave or refrigerator, make one fresh- and one salt-water beaker warmer or colder than room temperature. You will end up with something like the following: warm, fresh water (green): cold, fresh water (yellow); warm, salt water (red); and cold, salt water (blue). Fill a jar with clear, room temperature tap water. Place the tip of an eyedropper filled with one of the colored solutions halfway into the tap water. Have the group predict whether the solution will float or sink.



The possibilities for experimentation are wide. Some examples: layer warm water on cold water; fresh water on salt water; see if all four solutions can be layered and which solution ends up on top of which; time how long it takes layers to mix if sitting undisturbed; etc.

Wrap-up: Wind up the activity period by asking the group to tell you what they have learned about water and to list all the properties that make water so special. (The major points that should be mentioned are: shape of molecule, magnetic attraction between molecules, dissolving power, transparency, heat absorption, changes in density with temperature, etc.)

Water Drops

Procedure:

1. Squeeze several drops of water onto your square of waxed paper. Be careful not to let the drops get too near the edge of the paper.
2. Use your toothpick to examine the drops: touch and move the drops and observe their behavior. Be careful not to poke your toothpick through the waxed paper or this won't work.
3. Draw a side view and a bird's eye (looking from overhead) view of a drop. Describe its shape.

Side view

Bird's eye view

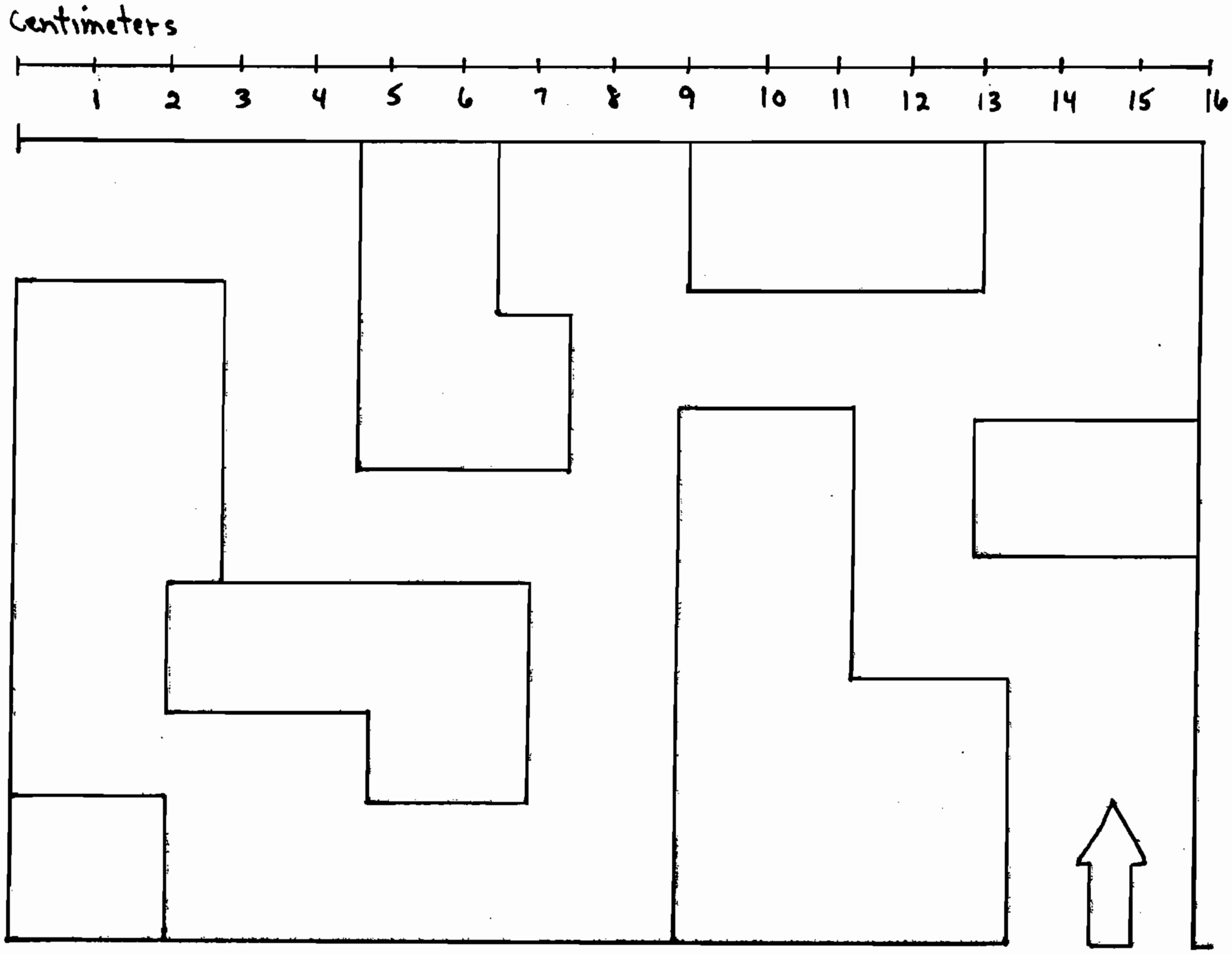
4. Make two drops touch each other. What happens? Try to take the drops apart again. Can you do it?

5. Do larger and smaller drops act differently?

6. Mix different color drops together and see what colors you can make. Can you get the colors apart again once they have been mixed?

7. Tape another piece of waxed paper over the water maze racecourse and see how fast you can move a drop through the maze. Then see how far you can make a drop stretch across the scale. If one inch equals 2.54 centimeters (cm), how many inches can you stretch your water?

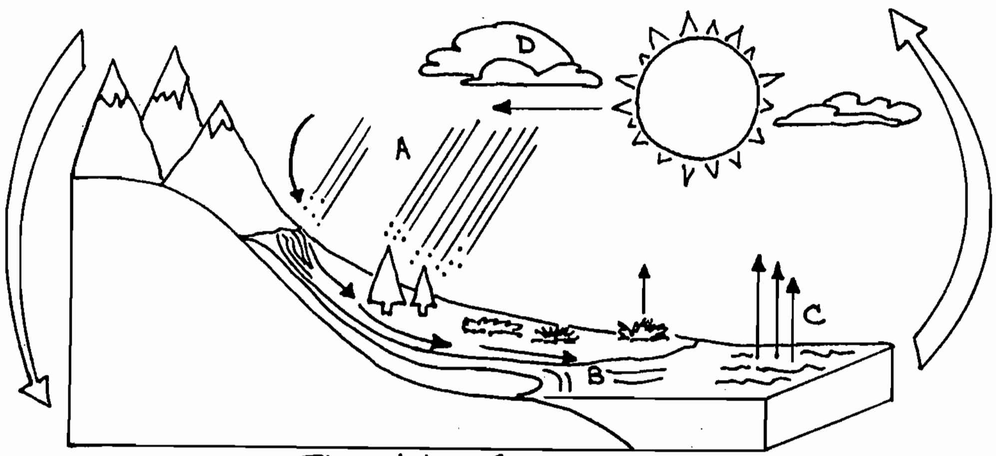
When you are done, mop up the water drops with a paper towel or sponge, and then throw your waxed paper and toothpick in a trash can.


Centimeters
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

The Water Cycle, Watersheds, and Groundwater

Background for Instructors

Scientists do not know exactly when liquid water first appeared on our planet, but they estimate it was more than four billion years ago, as the planet crust temperature dropped below water's boiling point. Water formed from the gases of hydrogen and oxygen in the atmosphere and was also shot from the center of the planet by volcanic eruptions. This newly released liquid water accumulated until it covered most of the planet and created the first oceans. This water also carried many other compounds out of the atmosphere, just as today's rain washes air pollution from the sky. The first rain started the hydrologic, or water, cycle and it continues to this day.



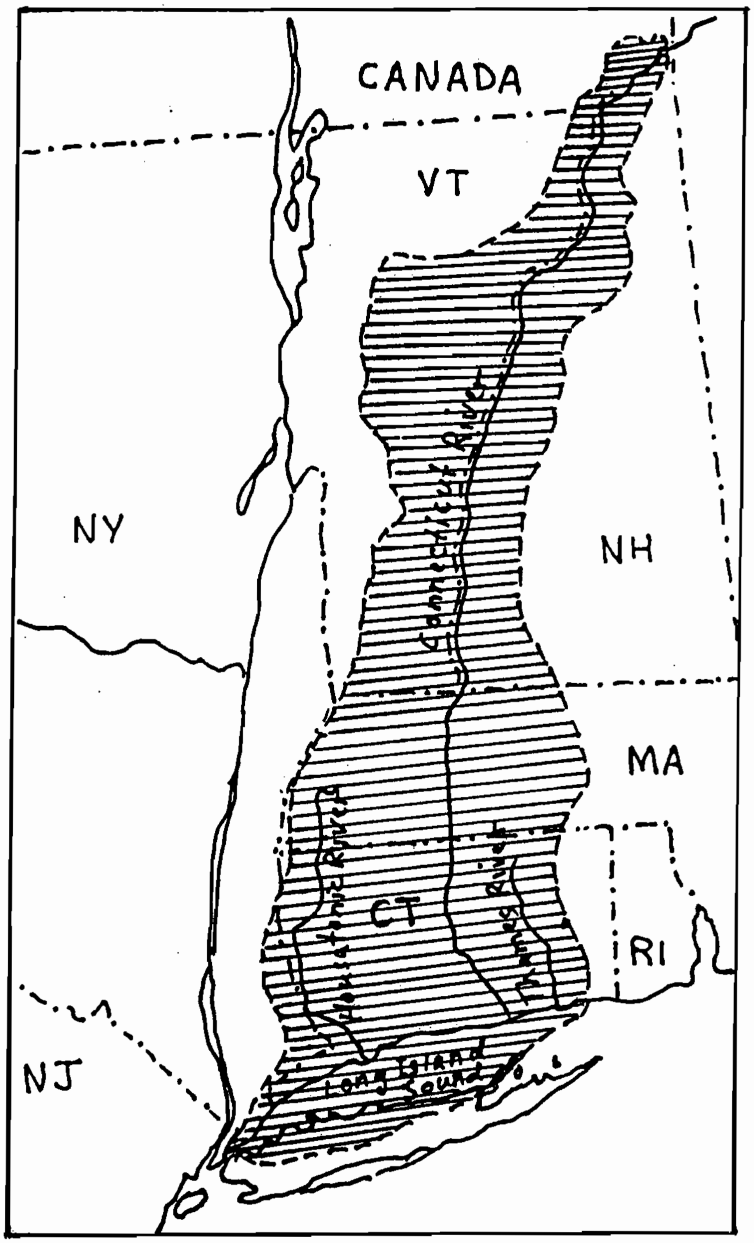
The Water Cycle
A. Precipitation
B. Run off
C. Evaporation
D. Condensation

The water cycle can be divided into four parts or phases. All the water in the world is somewhere within this cycle. The four major phases of the cycle include: air water (in the form of fog or cloud vapor), condensation/precipitation, earth water (in the form of ice, surface water, or ground water) and evaporation. Water taken up and made a part of a living organism (be it plant or animal) is temporarily pulled out of this cycle. Water then re-enters the cycle after helping the organism grow, transport food or eliminate wastes. Water that moves into the groundwater system, into the deep ocean, or is frozen into an ice cap or glacier can take thousands of years to move into the next phase of the cycle.

Water is easily seen moving from air to ground in the form of **precipitation**. **Evaporation**, however, is less visible. The fog that forms over lakes or the ocean in the early morning is the evaporation/**condensation** process made visible. Steaming pavement after a fast summer thundershower is also evaporation made visible. Evaporation is the reason the oceans do not overflow.

Water also returns to the clouds through the processes of living organisms. When animals breathe or perspire, they give off water vapor. Plants have a similar mechanism called **transpiration**. Water taken in by the roots is pulled up through the plant in tiny tubes, known as xylem, all the way to the leaves where it exits the plant by evaporation through tiny pores. The evaporation of water though the leaves provides the force to move the water up the plant and it requires a LOT of energy. It has been estimated that the energy required to move water from the roots to the leaves of a redwood would be great enough to boost a can of soda into low planetary orbit!

Water is never really standing still, even when we see it in a lake or in the ocean. The path that a drop of water takes once it hits the ground is determined by what it hits (rock, asphalt, soft dirt) and the topography of



The watershed of Long Island Sound

the land. The water drop is either absorbed into the ground to become part of the groundwater, or runs over the surface of the ground until it enters a small stream or brook and becomes part of the surface water system. Streams run together and form rivers, which empty into lakes or oceans.

The entire area of land and accompanying water that drains to a water body is called the **watershed**. The Connecticut, Housatonic, and Thames Rivers contribute 90% of the fresh water entering Long Island Sound. Long Island Sound is referred to as the **receiving waters** for these major Connecticut rivers. The Sound's watershed encompasses 90% of Connecticut and extends to the headwaters of the Connecticut River near the Canadian border.

You can visualize a watershed by cupping your hands and imagine the cup they form is a valley. All the rain that falls in the valley of your hands will run "downhill" to the bottom and form a pond. All land within a watershed, even great distances away from the receiving water body, is still connected to it via rainwater runoff. Understanding this connection helps in understanding one of the important problems of Long Island Sound, **nonpoint source pollution**. Water, running over the ground to the receiving water, picks up everything that has ended up on the ground, such as: trash, dirt; **pathogens** (disease-causing bacteria and viruses) from animal waste and failing septic systems; chemicals, such as gasoline, oil, and antifreeze from vehicles; pesticides and fertilizer from lawns and farm fields; and heavy metals and other materials from industrial sites. All these pollutants are carried to Long Island Sound where they degrade the water and damage the ecosystem.

Groundwater is the water found beneath the surface of the earth. It may be flowing in between particles of soil or through cracks in rocks. Most groundwater comes from precipitation that has soaked into the ground through the surface soil. All groundwater eventually reappears as surface water, either in the form of springs or by feeding directly into streams or lakes or estuaries.

Many regions of the country rely on groundwater wells for their water supply. Groundwater supplies water to nearly half the households in our country and is the primary source of irrigation water for agriculture in the United States. This dependence on groundwater is causing problems in some sections of the country where the demand for water is exceeding the supply of groundwater. In some areas in Texas and Oklahoma, so much groundwater has been removed from the system that the landscape has actually sunk and changed shape.

In other areas, groundwater is threatened when the overlying surface is covered so that the groundwater supply cannot be recharged. On Long Island, where groundwater is the only source of fresh water, so much of the ground of Long Island is covered with houses and asphalt that the natural recharging process cannot keep up with the demand for water. The governments have had to create groundwater recharge basins that are designed to direct rainwater into the groundwater.

Most people picture well water or spring water as being exceptionally pure and good to drink because it has been filtered and protected by the earth and is far from any sources of contamination. Unfortunately, we have shown that humans can pollute even the waters in the depths of the earth and that groundwater is quite vulnerable to contamination. Soil is simply not a good enough filter to protect groundwater from some of the contaminants that we have dumped on the ground over the years.

There are many activities that can lead to groundwater contamination, including: industrial and agricultural waste disposal, poorly designed landfills, leaking underground storage tanks, failing septic systems, improperly applied agricultural fertilizers and pesticides, and the list goes on. Once these substances are released on the ground, they move down through the soil and into the groundwater. Some of these chemicals, such as phosphates or the bacteria from septic systems, are filtered from the water by attaching or adsorbing to the soil particles before they reach groundwater unless the groundwater is very close to the surface. Other chemicals, more soluble in water, are not likely to be adsorbed by soil particles and are more likely to contaminate groundwater. The type of soil and quantity of chemical involved also affect the possibility of groundwater contamination.

Note: Adsorption differs from **absorption** in that when something is ADSORBED, it is stuck to the surface of the other substance. When something is ABSORBED, it is taken within the other substance. You can demonstrate the difference with a shallow pan of water, some fine sand or corn meal and a sponge. When the sponge is used to remove the water and sand or meal from the container, the water is absorbed into the sponge while the sand or meal is adsorbed and thus sticks to the surface of the sponge.

Once groundwater is contaminated it takes a very long time, if it is even possible, for it to purify itself. In surface waters, there are a variety of chemical and biological reactions that help to speed the purification of contaminated water. These reactions include evaporation to the atmosphere, biological uptake and breakdown by sunlight or microorganisms. Since none of these processes are available to groundwater, purification is almost impossible. Slow movement of groundwater and the colder temperatures within the earth also slow down the purification process. Even when a contamination source is very small, such as a leak from a home heating oil tank, the expense of cleaning up the groundwater can be astronomical.

The best way to ensure a constant supply of clean groundwater is to protect the water now rather than trying to clean it up later. Connecticut has state laws created under an "Aquifer Protection Act," designed to keep activities using potentially contaminating substances out of areas where groundwater is used or could be used as a source of drinking water. The regulations are new, and are not yet completely in place, but the goal is to protect the water supplies of Connecticut, now and in the future. Protecting groundwater is important because, through the water cycle, all that water will eventually end up in Long Island Sound.

Objectives

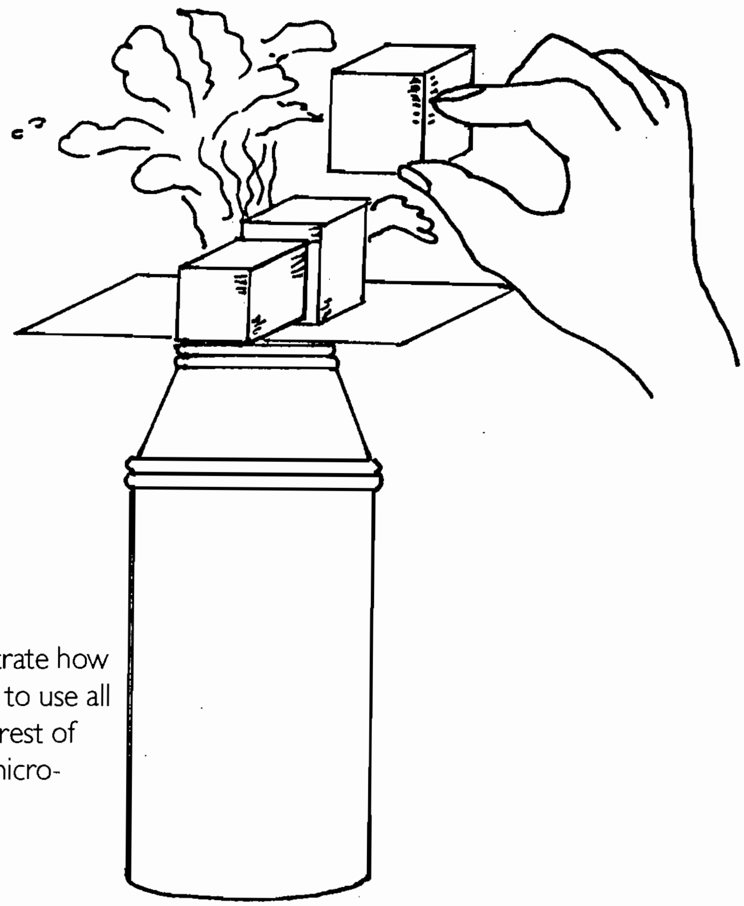
- Children will understand the hydrologic cycle through experimentation and observation.
- Children will understand that water is a finite resource.
- Children will be able to define and demonstrate the concept of watersheds and nonpoint source pollution
- Children will understand where groundwater fits into the water cycle.

• Children will understand how we depend on clean groundwater for our water supply.

• Children will understand why groundwater is vulnerable to pollution.

Learning Activities

1. The Changing Forms of Water
   Hot Water Bottle and Ice Cubes
   Water Cycle Microcosm
2. Create a Water Cycle Poster
3. Modeling Runoff in a Watershed
4. Create a Watershed Puzzle
5. Making a Groundwater Model
6. Soil as a Filter



Activity Outlines

1. The Changing Forms of Water

These are only a few of the possible ways to demonstrate how water moves through the water cycle. It is not necessary to use all of these in one activity period. It may be best, in the interest of keeping the activities moving, to set up the water cycle microcosms first, then start the other parts of this activity.

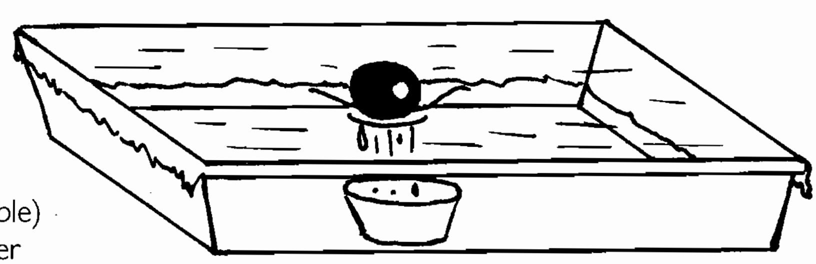
a. Hot Water Bottles and Ice Cubes

Materials needed:
narrow necked bottle or thermos
hot water
ice cubes
dark background

By holding an ice cube over the mouth of a thermos or a narrow-necked bottle full of hot water, you can create a fog cloud. The cloud will show up best in indirect light against a dark background.

b. Water Cycle Microcosm

Materials needed:
clear glass or plastic container
plastic wrap
water
small weight (such as a pebble or marble)
cup that fits completely inside container



Place water in the bottom of the clear container and set the cup in the center of the container. The cup should not float, but rest firmly on the bottom. Cover the container loosely with a piece of plastic wrap but make sure the edges are sealed. Place the small weight in the middle of the plastic wrap so it is directly above the cup in the container. Place the container in direct sunlight where it can absorb heat.

After a short time, water should start condensing on the underside of the plastic wrap, rolling to the point under the weight and dripping into the cup, creating a water cycle. If you have enough materials, you can have several small groups make different microcosms and place them in different areas to see how fast the cycle can be started. Note: If you start this with hot water, it works MUCH faster.

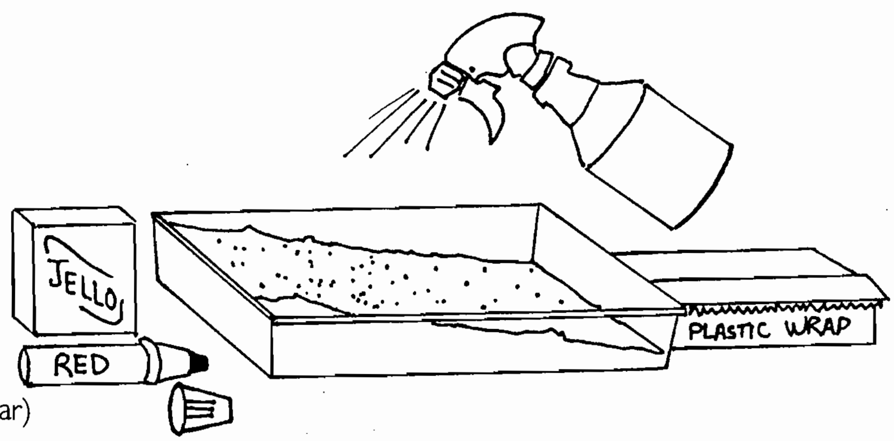
2. Create a Water Cycle Poster

Materials needed:
large sheets of paper (at least poster-sized)
crayons or markers
list of parts of the water cycle and topographic features

Depending on the size of the group, you may want to have everyone work on one poster or break up into smaller groups and create several posters. The idea is to create a landscape and then decide how the water will circulate through the water cycle in the picture. You can start off with a list of topographic features that should be included, or you can get the entire group to come up with a list and have each team make a poster that includes all the items on the list. Once the posters have their landscapes, use different color markers to show where the different parts of the water cycle are in operation. Save the posters for a later program when water pollution is investigated.

3. Modeling Runoff in a Watershed

Materials needed:
large shallow container, like brownie pan
sand to half fill container
aluminum foil or plastic wrap
water-soluble markers
brightly colored powders (Jell-O®, drink mix, colored sugar)
water in a spray bottle



Place sand in container, making a slope in the long direction and keeping sand below rim of container. Dampen sand and shape contours and valleys leading to unfilled end of container. Place sheet of aluminum foil or plastic wrap over sand and shape to contours. Use the spray bottle to "rain" on your newly created "watershed" and observe where the water goes. Sprinkle contours with colored powders or draw on land uses with soluble markers to represent pollutants and spray more water on the model. Observe how water carries the "pollutants" to the receiving waters.

4. Creating a Watershed Puzzle

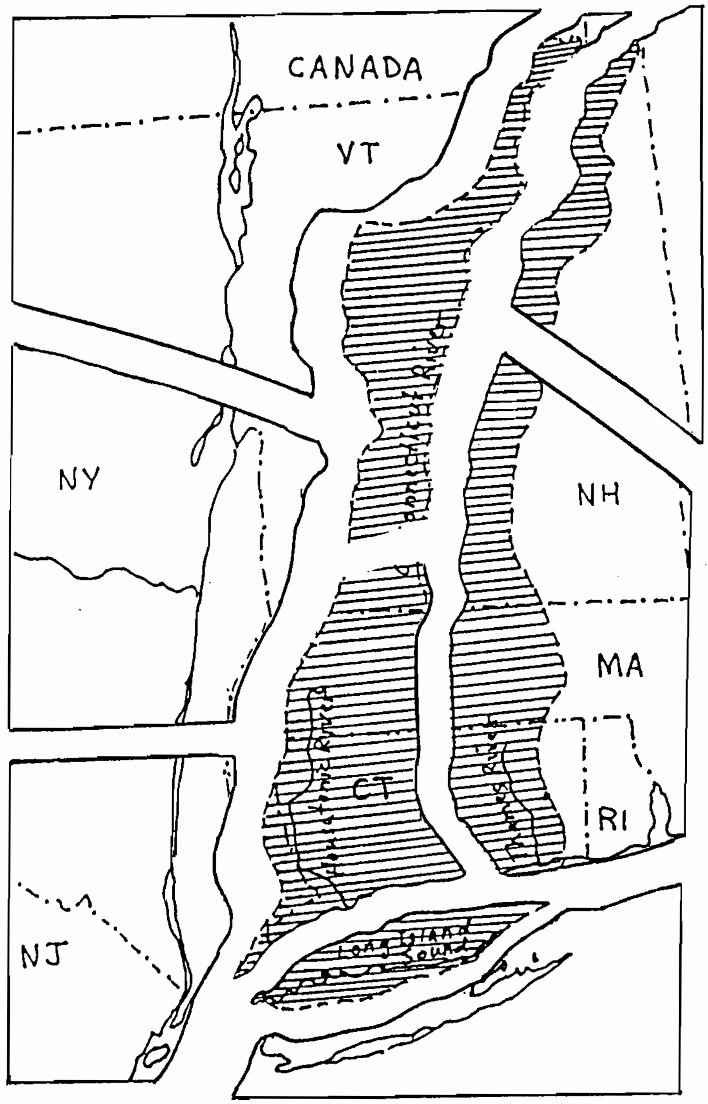
Start with a map of the natural drainage basins in your community or region. For example, the Connecticut Department of Environmental Protection (CTDEP) has a map for the whole state, "Natural Drainage Basins in Connecticut", which can be obtained from the DEP Natural Resource Center in Hartford. You can also use USGS topographic maps to outline individual watersheds and create your own map. If this is necessary, be sure to mark each watershed outlet and give each watershed area an identification code. The CTDEP has a booklet entitled "Map-Reading and Watershed Delineation Skills for Inland Wetland Commissioners" that nicely describes how to determine watershed boundaries on topographic maps. Other agencies have similar resource materials available.

Highlight key features on your base map. These may be the rivers and streams, school and neighborhood locations, monitoring sites, or other local reference points. Make at least two copies of the base map, one to act as the puzzle guide and one to cut up for puzzle pieces. Depending on the complexity of watershed borders and cutting skills, several copies may be necessary.

Cut one copy of the base map into individual sub watershed areas. Include as separate puzzle pieces the receiving water body and the watershed identification key.

Mount pieces on heavy cardboard or Styrofoam® mounting media and re-cut edges. You can mount the map before separating puzzle pieces if you are confident of your cutting abilities.

The puzzle is a great hands-on way to discuss watersheds. The separate puzzle pieces make clear that water stays within one area and only leaves a watershed through the outlet point and that watersheds are determined by the shape of the land, not by political boundaries. Some other helpful suggestions are:



- Make the puzzle pieces as large as feasible. This may mean enlarging individual pieces after the base map is separated. If there are one or two very large pieces, consider separating them into two pieces and marking them appropriately.

- For a quick and simple puzzle for one-time use, copy pieces directly onto heavyweight paper.

- Color makes the puzzle both more interesting and easier to interpret.

- Have older students make watershed maps and puzzles and use them to teach younger children about watersheds and the water cycle.

5. Making a Groundwater Model

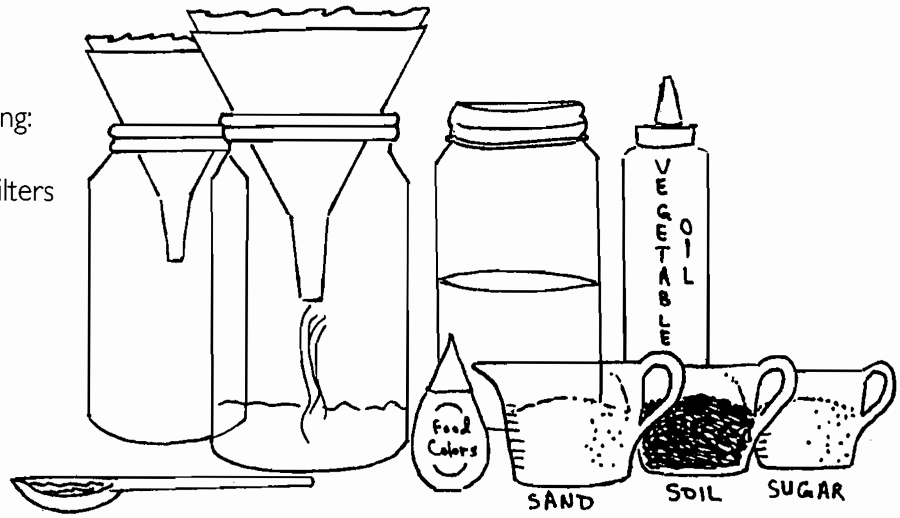
Materials needed:
large glass or clear plastic container
mixture of sand and gravel
water

Pour the sand and gravel mixture into the container, making a layer several inches thick that slopes toward one side of the container. Add water until you can see the level of the water within the soil in the container. Explain that the visible line of water is the "water table" or the upper limit of the groundwater. Below the water table the pores between the grains of sand and gravel are filled with water, and this water is the groundwater.

Continue adding water to the container until there is standing water visible over the lowest side of the sand and gravel mixture and the water table is visible in the mixture on the other side of the container. Ask the group to compare the level of water on both sides of the container (the same on both sides). Explain that swamps, streams and ponds are actually areas where the water table is higher than the surface of the ground because of uneven topography. Ask the group what would happen if more water was added to the container ("pond" will get larger as water table gets higher) or if a well was placed in the dry land area (pond will get smaller if too much water is removed and the water table is lowered). Emphasize the tie between precipitation, groundwater and surface water.

6. Soil as a Filter

Materials needed:
Each group will need the following:
3 jars, 1 with a lid
2 pieces cheesecloth or coffee filters
2 funnels
sand
potting soil
measuring spoons
sugar
vegetable oil
food coloring
water
large container for waste water



Divide the group into groups of four or five. Have the groups set up their soil filters as described on their worksheet and place the funnels over two of the jars. The experimental solutions are mixed in the third jar as described on the worksheet. The soil should be a more effective filter than the sand because soil has smaller particles, making it easier for substances to adsorb onto the soil. The vegetable oil should be filtered out by the soil, but the sugar and food coloring should pass through both filters.

End the exercise with a brief discussion about how we use the soil to purify our household wastewater and the potential problems associated with failing septic systems.

SOIL AS A FILTER

1. Set up your soil filters as follows: Put the filter papers inside the funnels. In one funnel, place several tablespoons of sand into the filter paper. In the second funnel, place several tablespoons of potting soil into the filter paper.

2. Place the two soil filters over two of the jars.

3. Fill the third jar half full of water and add one teaspoon of sugar. Shake the mixture well. Describe the results in the "Before" column on the worksheet.

4. Pour half of the mixture into each of the funnels. Describe the results in the "After" column on the worksheet.

5. Empty the two jars and repeat the experiment three times with the following mixtures:

   - 3 drops food coloring in a half jar of water
   - 1 teaspoon vegetable oil in a half jar of water
   - a half jar of plain water

Record all your observations.

What is a more effective filter: sand or soil?

What substances were easy to filter out?

What substances were hard to filter out?

Was the plain water cleaner or dirtier after being filtered?

What do you think happened?

Student Worksheet

SOIL AS A FILTER

		Sand		Soil	
		Before	After	Before	After
Jar 1	Clarity				
	Taste				
	Color				
Jar 2	Clarity				
	Taste				
	Color				
Jar 3	Clarity				
	Taste				
	Color				
Jar 4	Clarity				
	Taste				
	Color				
Jar 5	Clarity				
	Taste				
	Color				

Chapter Four

Food Chains – The Links of Life

Background for Instructors

The process through which organisms interact to obtain energy is actually much more complicated than the simple system used in this learning activity. When we talk about **food chains**, we are describing the simple one-by-one relationship in which an organism eats something and is then eaten by something else. When you look at nature as a whole, this simple relationship becomes more complicated. Most organisms eat a whole variety of other organisms (including others of their own species at times) and are in turn eaten by many different organisms, so the picture looks much more like a web than a chain.

All forms of life in the ocean are tied together in food chains. The **food web** is the total of all the food chains. Every food chain in the ocean starts with a plant, because plants are the only organisms that can take the energy in sunlight and transform it into living tissue. This process is called **photosynthesis**. Because of this ability, plants are referred to as **primary producers**. Plants require sunlight, water, carbon dioxide, and some mineral nutrients to perform this amazing feat, so the base of the food chain necessarily is located near the surface of the ocean where light is available.

Most of the plants in the ocean (and in other deep-water bodies) are **phytoplankton**, tiny one-celled plants floating around in the water column. Only in areas of shallow water along the coastline are there larger plants (the macroalgae, or seaweeds) that grow attached to substrate.

There is an exception to the status of plants as the sole source of primary productivity. In the deep oceans, hot water vents spew forth superheated, mineral-enriched water. Bacteria associated with these vents can transform the sulfur compounds from these enriched waters into living tissue. Some very elaborate food chains have been developed around these vents based on these sulfur-transforming bacteria and they have only recently been discovered and studied.

All animals are consumers of some kind because they are not capable of transforming their own energy. Animals that feed directly on plants are known as **first-order consumers**, or **herbivores**. This group includes the **zooplankton** (the tiny animals floating around in the water column), some fish (herrings and sardines), shellfish, some crustaceans (crabs and shrimp), and other animals that occasionally eat plants.

Second-order consumers, or **carnivores**, are those animals that eat the first-order consumers. This group includes many fish and birds. **Third-order consumers** are those animals that feed on second-order consumers and so on up the line. Any animal that eats another animal is a carnivore. It is likely that an individual animal in the higher orders of consumers will feed at several levels within the food chain over its life. For example, in some species of fish, the very young fish (or larvae) will first eat phytoplankton, switch to zooplankton, and then consume other fish as adults.

Just as plants are the base or beginning of a food chain, at the other end of any food chain are the **scavengers** and **decomposers** who play a special and important role in the ecological cycle. By breaking down dead plant and animal material, they release **nutrients** back into the water or onto the ocean floor, making them available for the plants or other organisms. Without this recycling, the ocean would eventually be depleted of nutrients and phytoplankton would no longer be able to transform energy, leading to a major crash of the **ecosystem**. In general, every link of the chain and the web is dependent on all the other links and a weakness at one level can have disastrous consequences for the other levels.

Describing the ecosystem in terms of food chains and food webs gives a picture that there is about the same amount of matter at each level of the chain. This is definitely not the case. A more accurate way to picture the ecosystem, in terms of biomass, is to think of a food pyramid, with the primary producers at the base, supporting the entire system, and then subsequent levels of first-order, second-order, third-order, and so on, consumers. With each step up the pyramid, the number of organisms, the total living weight, and the total available energy decreases. This decrease occurs because there is energy lost each time it is transferred from one organism to another. This is one way of understanding why you can see thousands and thousands of copepods (which feed on phytoplankton) in a school and only a few mummichogs and even fewer striped bass. (For an actual diagram of a food pyramid, refer to the booklet, *Plants and Animals of Long Island Sound*, page 24.)

Objectives

- Children will understand the concepts of food chains and food webs and how energy flows through these chains.

- Children will be able to describe a balanced food chain.

Learning Activities

I. Food Chain Game

Activity Outline

This is a tag game that illustrates how members of a food chain obtain energy. Participants wear armbands identifying themselves as different organisms and must chase organisms below them in the food chain while avoiding being caught by those above them. Energy is represented by dried beans, or other small objects, which are exchanged when one organism is tagged by another organism higher in the food chain. The object is for an individual to get as many dried beans as possible.

Materials needed:
dried beans, about one pound (or use packing "peanuts", pebbles, marbles or shells)
colored armbands or tags, four different colors
kitchen timer with bell
large open area with boundaries

Preparation
Armbands in four different colors represent the four parts of the food chain. They should be prepared and handed out in the following ratios:

Phytoplankton (green):	6
Copepods (yellow):	4
Mummichogs (blue):	2
Striped Bass (white):	1
Decomposers (black):	1

The colors are only suggestions. One instructor represents the sun and will be passing out the energy dried beans. A second adult, or one lucky kid, can play the Decomposer and chase all the other organisms. When the Decomposer catches someone, they have to give him/her all their dried beans.

Before starting the game, discuss how the sun is the source of energy for all living things and how plants have the ability to convert sunlight into food, which is then available for other organisms. No matter what we eat, indirectly we are eating sunlight. Ask the group if they can think of anything we eat which did not originally come from the sun. In this activity, the dried beans distributed by the instructor (representing the sun) will represent energy units, known as photons, which are used by phytoplankton in photosynthesis.

Discuss the food chain in terms of Long Island Sound. There are plants in the form of phytoplankton in the Sound. What eats the phytoplankton? Little critters like copepods. What eats the copepods? Little fish like mummichogs. What eats the mummichogs? Bigger fish like the striped bass. Describe the game to the group, explaining that the instructor will be the sun who will give out energy dried beans to the phytoplankton who will be chased by the copepods, etc. Ask the children which level on the food chain they think will have the most dried beans at the end of the game. Explain the rules and lay out the boundaries while you hand out the tags. It is faster if you hand out the tags rather than letting the children decide what they want to be.

After everyone is wearing an armband or tag, have the phytoplankton come to the sun for his or her first dried beans. Remind them that they can come back to the sun any time to get more dried beans. The phytoplankton should enter the playing area, then the copepods, then the mummichogs, and then the striped bass. The Decomposer enters last and starts collecting his/her victims' dried beans. When someone is tagged, even by the Decomposer, they are out of the game.

Rules:

1. The phytoplankton are the only players who can receive energy dried beans directly from the "sun", and they can do this as often as they want in the course of the activity. Copepods can only tag phytoplankton, mummichogs can only tag copepods and striped bass can only tag mummichogs.

2. Everyone should remember this is a tag game; anyone tackling or pulling on another player is out.

3. While a dried bean exchange is taking place, the players involved are "safe" and may not be tagged.

4. The instructor will set the boundaries and no one should leave them. Running out of bounds to avoid capture leads to the Decomposer who gets all that player's dried beans.

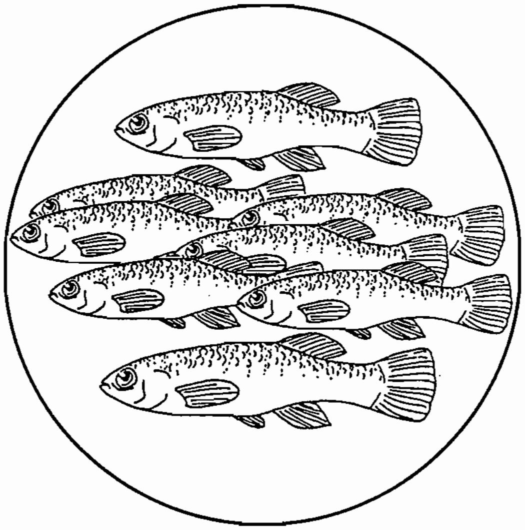
After about 10 minutes, or when the sun has run out of dried beans, the game is over and each group (phytoplankton, copepods, mummichogs, and striped bass) should count their dried beans.

Discussion

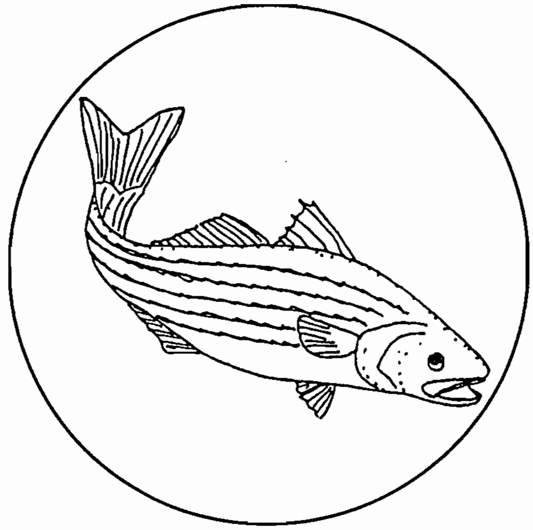
Usually, when the game ends, a large number of dried beans should have made their way through the food chain to the striped bass and the Decomposer.

If there is more time, try running the game a second time with equal numbers of individuals in each food chain group to see what happens. (The biggest change will be in the number of tags when the food item tagged has no energy to pass on up the food chain because there are too many predators.)

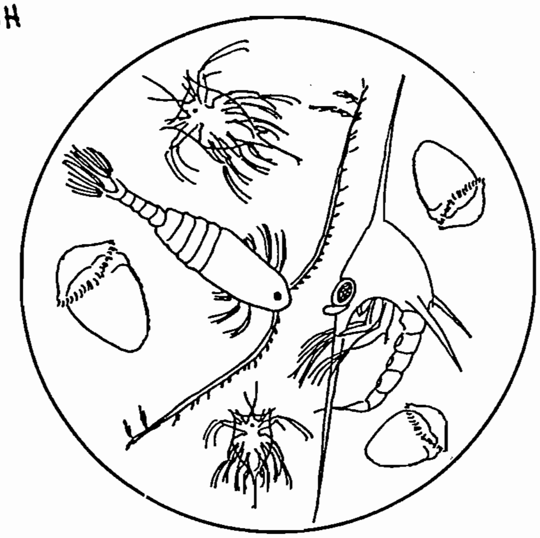
Another variation of the game is to allow the phytoplankton to tag the Decomposer and collect one dried bean for each tag. This represents the nutrients that the plants get from decaying matter. It should be noted that nutrients are really not the same as the chemical energy the dried beans represent, but that they help the plant grow in the same way vitamins help us grow. Another way to make the game more realistic is to have "safe" spots where the copepods and mummichogs can hide from predation, but players cannot remain in these spots without "starving."



SMALL FISH

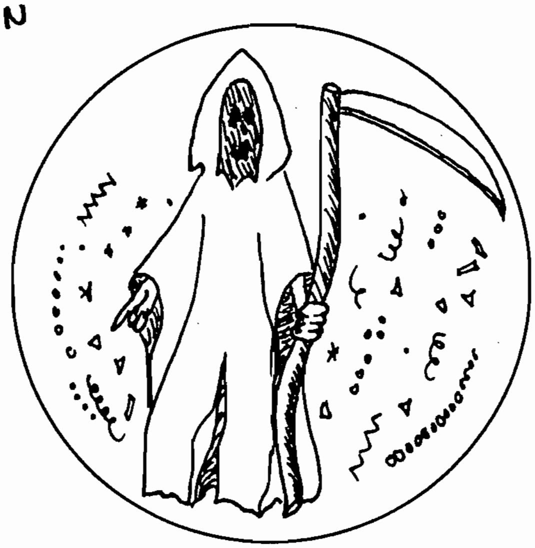


LARGE FISH



ZOOPLANKTON

PHYTOPLANKTON



BACTERIA

Chapter Five

Collecting Life in Water

Background for Instructors

When you consider the fact that the majority of the planet surface (78%) is covered with water (and that 97% of that is salt water) it seems clear that the study of aquatic organisms is important. If, however, one considers the **biosphere**, or volume of space within which life exists, the importance of aquatic systems becomes overwhelming. In terrestrial systems, the biosphere averages no more than 40 meters in thickness, from the deepest root system to the top of the tallest tree. In the open ocean, the biosphere can be as thick as 4,000 meters, from the water's surface to the abyssal depths, where exquisitely adapted animals survive on food that falls from the upper layers of the ocean or take advantage of food energy created by bacterial chemosynthesis rather than photosynthesis. It has been calculated that 99.98% of our planetary biosphere is oceanic and only 0.02% is terrestrial.

Providing opportunities for students to examine aquatic plants and animals from both freshwater and marine ecosystems, "up close and personal," will introduce them to an incredible diversity of life forms and raise an interest in aquatic ecosystems. Such an interest is important to fully understand the importance of protecting our water resources, both for human use and as the "habitat", or home, for the vast majority of life on our planet.

Habitat is a key concept in the study of terrestrial or aquatic ecosystems. In simple terms, an organism's habitat is the space that contains everything it needs to survive and successfully produce the next generation. A good habitat must contain: adequate food (for plants this is **nutrients** and sunlight); water/oxygen (terrestrial plants and animals require adequate water supplies and aquatic organisms require adequate oxygen levels); shelter or protection from both hungry predators (**herbivores** for plants) and the weather; and space to move around in and find others of the species for creating the next generation. Rather than space, stationary organisms like oysters require enough members of their species in close proximity to successfully reproduce by spawning (releasing eggs and sperm into the water at the same time to mix and create larvae).

The elements of a habitat must be present in their proper balance for an organism to survive and be ecologically successful. Having plenty of food available is of little use to an animal if there is no shelter from predators. Likewise, plants may have great growing conditions but be unsuccessful in reproducing if there are no pollinators.

Plants and animals have specific habitat requirements, defining where individuals of the species will be successful. Many species exhibit specialized changes or **adaptations** to their shape, coloring, etc. to take best advantage of a specific habitat type. Other adaptations may affect how an animal captures food or protects its young. Any adaptations have taken place over long time periods. Some species have so closely adapted to their habitat that it may take only a very small change in temperature, rainfall, or human disturbance to transform the area from good to poor habitat. When habitats are altered or destroyed, either by natural catastrophes like hurricanes or by human development, such species will suffer, possibly to the point of becoming endangered or extinct.

Taking students into the field is the best way to make the link between an organism and its habitat. Maintaining a classroom aquarium is another excellent way to allow students to become familiar with the habitat requirements of different organisms and to observe their activity in an almost natural environment. Whether you are in the field for observation or collection purposes, try to relate the apparent needs and adaptations of the animal to the habitat from which it has been taken. Some clues to these relationships are:

Color: Animals living in or on the bottom of a water body will tend to be brownish with camouflage-type patterns on their upper surface. Animals living in the water column will tend to be more transparent or silvery in color. Many water column animals also exhibit countershading, where the upper surface or back is dark and the lower surface or stomach area is silvery white, causing the animal to blend in with the background no matter the direction from which it is observed. Aquatic plant colors will differ based on their depth below the water's surface and the major pigment they use for **photosynthesis**. Green plants tend to be found close to the surface where they can utilize the red light waves in sunlight and red seaweeds tend to be found in deeper waters which are only reached by the blue light waves.

Jaws, Teeth, and Claws: the bigger they are, the better the chance the animal is a predator.

Eggs: during the summer, lots of aquatic organisms carry clusters of brightly colored eggs, usually attached to their abdomen (stomach) area.

Scales: Fish with loosely attached or rough scales tend to be slow swimming or bottom-dwellers. As fish become faster and more streamlined, they tend to have smaller scales. In some species of rapidly swimming, predatory fish, like tuna, the scales have almost disappeared.

If you can take students on a field trip to the shore or another local water body, there are a few things to consider, both to protect the students and the **ecosystem** they are exploring.

Safety

- Make sure you have an adequate number of briefed chaperones (no less than one adult per ten students) to keep an eye on young explorers. Have the students in a buddy system or small groups as well.
- Make sure students are properly dressed for getting wet and dangerous footing. Sneakers or water shoes should be required. You may cut down on the "drenched and not prepared factor" by having a small group volunteer to come prepared to get completely wet.

Conservation

- Rocky tidepools, dunes, and tidal marsh areas are limited in size and ecologically fragile. Emphasize conservation practices before leaving the classroom.
- Suppress the "save it and take it home" impulse. Overcollecting can damage local populations and prevent other site visitors from seeing the more unusual species. Check with the Department of Environmental Protection about collecting permits. Under certain conditions it is lawful to collect specimens for a classroom aquarium, but some species may not be collected.
- Be sure students gently return rocks to their original position if they pick them up. Many animals live under rocks for protection: they will die or be eaten if left exposed. Be sure students replace animals where they found them. Some animals have specific feeding requirements and live at specific tidal heights. Moving them to another part of the shoreline may kill them.
- Students should be discouraged from throwing rocks at the water or running over erodible banks and dunes. Even a few people intruding into these fragile areas can permanently damage both the physical structure of the area (through **erosion**) as well as the habitat value.
- Make sure that all litter from lunches is collected and taken back to school. Consider running a "mini-beachsweep" as part of the field trip. Having students record the trash they collect from the beach on data sheets can provide valuable information for follow-up lessons as well as leaving the site better than you found it.

Objectives

- Students will be able to identify the general habitat requirements of aquatic organisms.
- Students will learn and practice scientific sampling techniques.

Learning Activities

1. Habitat Circles

2. Sampling for Plankton

3. Sampling for Bottom Dwellers

4. Sampling for Swimming Animals

Activity Outlines

1. Habitat Circles

no materials needed

Have the group count off by fours, then have the different numbers form their smaller groups.

Assign each small group one of the basic needs that make up a habitat: food, shelter, space, and water/oxygen.

Form a line by building a chain of repeating units of the four needs: food, shelter, space, water, food, shelter, space, etc. Turn the line into a circle and have everyone face the middle of the circle with his or her shoulders touching.

Have everyone in the circle turn and face right and take one large side step into the center of the circle. They should all end up standing close together looking at the back of the person in front of them.

Have everyone place their hands on the shoulder of the person in front of them and listen carefully. At the count of three, everyone should sit down on the knees of the person behind them while keeping their own knees together to support the person in front of them. When they have all sat down, say "Food, shelter, space, and oxygen or water in their proper balance are the four basic needs of animals. These are what is needed for an animal to have a good habitat".

The circle will probably collapse long before you finish this short speech. When the laughter stops, talk some more about how everything is dependent on everything else in a healthy habitat. When they seem to understand the idea, have them try the lap sit again.

If you get a successfully sitting circle, with each person still remembering what they are supposed to represent, tell them that there is a problem in the habitat. For example, a toxic chemical spill has taken all the oxygen out of the water, or a forest fire has burned all the trees and removed the shelter. After identifying the problem, have the people representing the missing piece try to get out of the circle without having it collapse. (This should be impossible.) When things calm down, ask for more examples of how outside influences can disrupt a habitat and threaten an animal's or a plant's survival.

2. Sampling for Plankton

Materials needed:
plankton net
small glass jars
hand lenses
eye droppers

(While commercially available plankton nets are more effective, the hand-made version described below will allow you to collect some plankton for observation.)

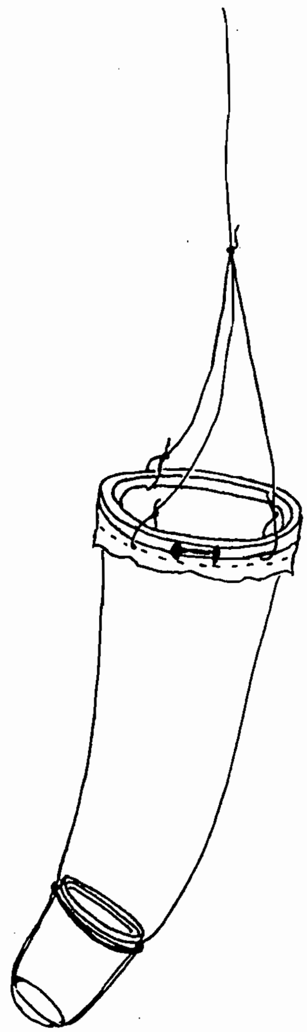
A plankton net can be used in two ways. One method is to tow the net through the water either by boat or someone in waders or boots. Be sure the jar at the bottom of the net is completely filled with water before starting the tow or the net will not submerge. As you tow, keep the net completely submerged, with the top edge of the jar's mouth just below the surface of the water. Make sure the net is streaming out and not hanging limply. Another way to use the net is to slowly pour a bucket of water through the net. One person needs to hold the net out at arm's length while a second person pours the water. With either of these techniques, the plankton will end up concentrated in the jar at the bottom of the net.

To observe the plankton, lift the jar through the net and pour the contents into several small jars for examination with hand lenses. You should get some copepods and other small floating animals and plants.

HOW TO MAKE A PLANKTON NET

Materials:

wooden embroidery hoop - at least 8" in diameter
knee-high nylon stocking
needle
strong thread
thick string or twine
small Jar (baby food) or test tube
rubber band



Embroidery hoops are made up of two circles, one slightly smaller than the other, which fit snugly together. Stretch the end of the stocking around the smaller circle. Put the larger circle over it and tighten it by turning the screw attached to the hoop. There should be about an inch of stocking overlapping. Sew this overlapping piece to the rest of the stocking so that the hoop is securely attached to the stocking. Take small stitches so that the plankton net will be strong.

Cut three one-foot pieces of string or twine. Make three evenly spaced holes in the stocking around the circle. Put a piece of string through each hole and tie it securely to the hoop. Tie the three strings together at the other end. Now attach another string at least 5 feet long to the other three strings. This is the line that allows you to pull the net through the water. Put the small jar inside the toe of the stocking and attach the outside with a rubber band.

3. Sampling for Bottom Dwellers

a) freshwater stream or tidal creek

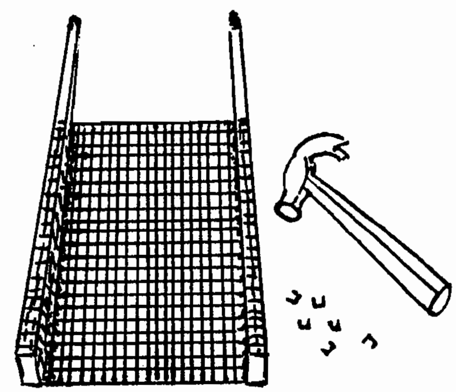
Materials needed:

hand screen or flat-bottomed dip net
flat-bottomed white containers or clear containers with white background material
tweezers or forceps
hand lenses
collecting container

Hand screens are used for collecting animals in fairly fast-moving streams but they also work in small tidal creeks. Wade into the water, holding the screen by the handles with the screen pointing down. Place the bottom of the screen in the water, resting on the bottom. Hold the screen at an angle so that the top is leaning away from the current (downstream in freshwater streams; may be different in a tidally influenced creek). Keep the top of the screen even with, or slightly above, the water surface so that organisms cannot escape over the top. A second person should go about one meter in front of the screen (up current) and turn over some rocks or scrape over the bottom to stir loose the animals, which will be swept into the screen. After a minute or so, rotate or lift the screen forward through the water until it is even with the surface, again so that the animals can't escape. Gently remove them from the screen surface with forceps or fingers and place them in the collecting container with some water for observation.

HOW TO MAKE A HAND SCREEN

Materials needed:
two wooden sticks - 2 1/2 feet in length and one inch thick
square of screen - 2 feet by 2 feet (screen door type)
U-shaped tacks or carpet tacks
hammer



Place the screen flat on the ground and put the sticks on opposite sides of the square. Place the sticks so that the bottom of the screen is even with one end of each stick. The extra wood left at the other end of each stick will serve as handles when you use the screen. Wrap the sticks with the edges of the screen and tack the screen to the sticks with carpet tacks or U-shaped nails. The screen will have to be strong enough to withstand water rushing against it.

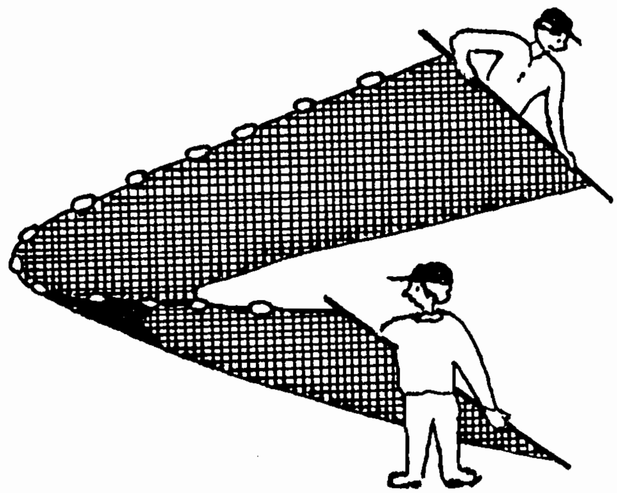
b) shoreline

Materials needed:
large bucket
flat-bottomed white containers or clear containers with white background material
tweezers or forceps
hand lenses
collecting container

Rather than using a net, collect animals by picking up rocks and other solid materials and shaking them around in a bucket of water to dislodge any hiding organisms.

4. Sampling for Swimming Animals

Materials needed:
- bait seine
- collecting containers (5-gallon buckets work well)
- tweezers
- hand lenses
- footwear for wading



A bait seine is designed to catch small fish and grass shrimp, insects, and whatever is floating in the water. The net should be stretched out between two people with the lower edge tilted forward. Move the net in a half circle through the water at a steady pace, keeping the bottom of the net as close to the sediment as possible. When removing material from the net, pay close attention to any plants as they often hide small animals that would have normally escaped the net.

After a Field Trip: Ask if the group thinks that all the different kinds of organisms that live in that habitat were caught. If not, how could they catch the ones they missed? How are the animals adapted to live in their preferred habitat? Was the sampled area good habitat or bad habitat?

The general rule of thumb is that the more species diversity an area supports, the more healthy and productive the habitat. This includes both plant and animal species. For example, in a healthy marsh, there should be a dozen or more different species of invertebrates and fish. Many smaller species will not be found unless carefully collected. Point out that you can't always judge the health of a habitat just by looking at it.

References

Many excellent reference and identification keys are available to help sort out your collected organisms. Check the list at the back of this publication, your bookstore, or the library.

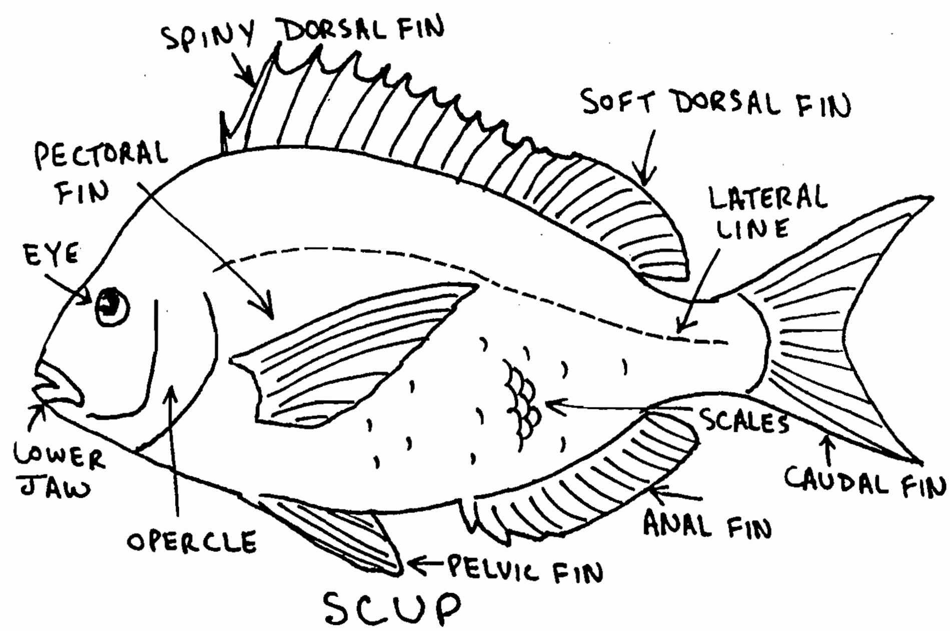
▬ Chapter Six ▬

Fish Science

Background for Instructors

Most people, when asked to name something that lives in water, immediately think of fish. Fish are one of the more visible and more useful (from the human point of view) organisms that live in our waters. There are literally thousands of species of fish on this planet, some which have worldwide distribution and some which are only found in one tiny pond in the middle of one desert. Fish can be quickly divided into two groups; the **pelagic** fish that spend their life swimming in the water column, and the **benthic** or bottom fish that travel along the bottom. This is not to say that pelagic fish don't find food on the bottom or that the benthic fish don't occasionally swim up to the surface in shallow areas, but it is generally very easy to tell the difference between these two types of fish.

The major external parts of a fish are illustrated here. While all fish share the same basic structure, the **adaptations** that have allowed fish to survive in so many extreme **habitats** have drastically changed the outward appearance of the species. Some of the most easily explained adaptations are as follows.

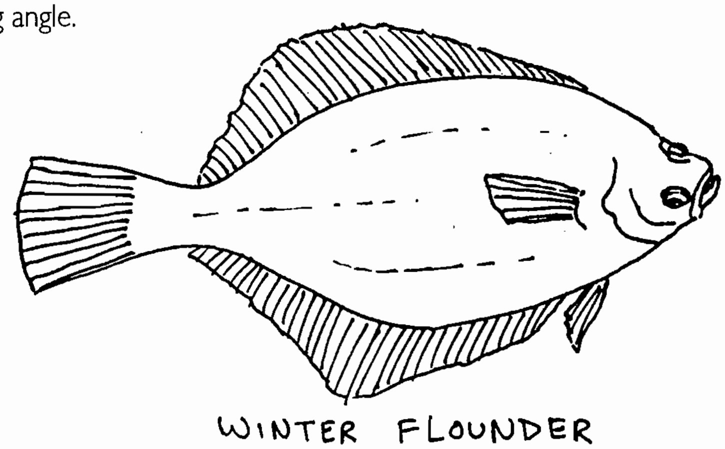


Body Shape

One can tell a lot about a fish by examining the shape of its body. In general, the more streamlined and bullet-shaped a fish is, the faster it swims and the more likely it is to be a predator. The predation part is confirmed by looking at other parts of the fish. Fish that are closer to spherical or which are flattened along one axis or another will tend to be slow movers. An extreme example of a flattened fish is the winter flounder, a flatfish common to Long Island Sound. This fish is so flattened along its vertical plane that it actually has to lie sideways on the bottom and its mouth appears to be attached to its body at the wrong angle.

Scale Size

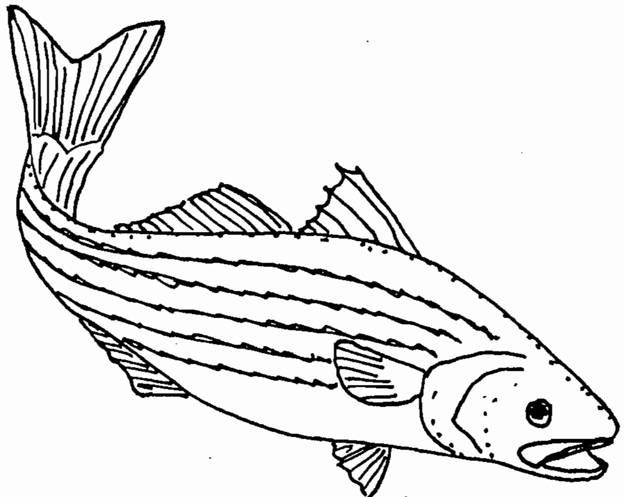
Scales also tell us a lot about how a fish moves through the water. A fish with large scales that feel rough when touched, is almost always a slow-moving, bottom-feeding kind of fish. A fish with large scales that feel smooth or which fall off the fish at a light touch is generally a faster moving fish or one that can move fast when circumstances require, but is not in constant motion. Fish with greatly reduced scales



or with scales that are deeply embedded into their skin are the master movers. These fish, like the tuna or swordfish, are in constant motion and regularly circle the oceans.

Mouth

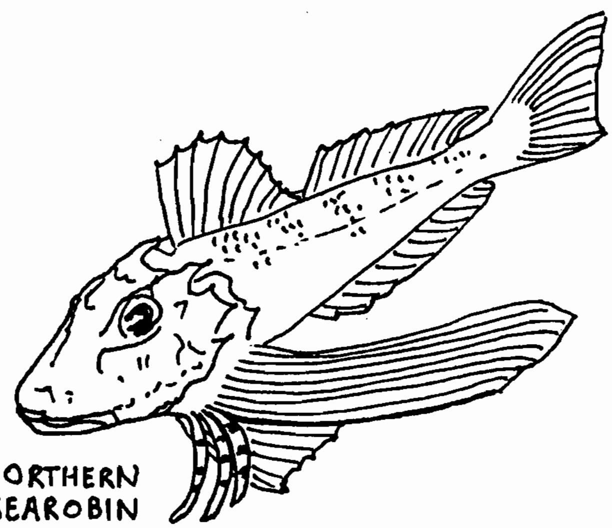
The size and shape of the mouth and teeth tell us what a fish is accustomed to eating. In general, a large mouth indicates a large food item, which means a predator, and a small mouth indicated small food items which means a **scavenger** or an **herbivore**. However, this doesn't always hold true. Fish which live on **phytoplankton**, the one-celled plants floating in the water, will have large mouths inside which there are fine, net-like structures know as **gill rakers** to filter the phytoplankton from the water. The winter flounder, mentioned earlier, has a small mouth but it is a predator that eats worms, amphipods and other small animals that live in the sediment.



The best way to confirm that a fish is a predator is to look inside the mouth for teeth. In general, if a fish has teeth that you can actually see, it is a predator. Different species of fish eat anything from other fish to worms to lobsters and clams to seaweed. You can construct almost an entire **food chain** from fish with phytoplankton the only non-fish component. The position of the mouth on the fish can also tell you something about its feeding practices. Plankton eaters tend to have mouths that point upwards while bottom feeders tend to have mouths that point down or are located low on the front of the fish.

Specialized Fins

Fins tell us a lot about where the fish lives and how it travels. Some bottom dwelling fish have pelvic fins that actually look like little legs that they balance on as they rest on the bottom. Fast moving pelagic fish have greatly reduced the size of their fins to minimize their water resistance and increase their energy efficiency. Many coral reef fish have evolved elaborately decorative fins that are used in displays to protect territory or in courtship. As the fins are more decorative than functional, the fish are obviously slow-moving. Many of these fish have poisonous spines hidden in these decorative fins for protection.

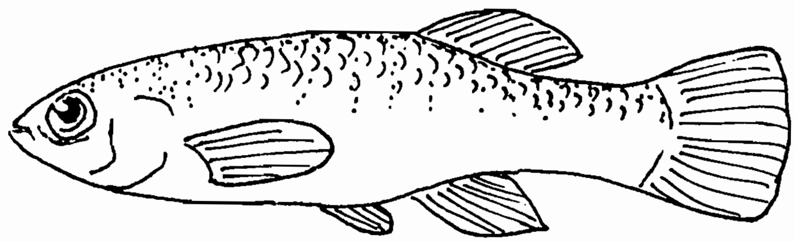


Color

Fish are generally counter-shaded, with their dorsal surface (back) dark in color and their ventral surface (tummy area) pale in color. This coloration acts as a form of camouflage, enabling the fish to better blend with the bottom when viewed from above and to blend with the reflection of light from the sky when viewed from below. Pelagic fish are generally some shade of silver with counter-shading. Bottom dwelling fish are either cryptically colored (real camouflage) or are brightly colored indicating they have some form of self-protection, generally poison, or have a really nasty taste. Deep-sea fish tend to come in shades of black and red both of which are invisible in the lightless environment they inhabit.

Gills

If you have real fish available, exhibit the gills as follows. Pull open the **operculum** and examine the gills inside these flaps. Also, open the fish's mouth and examine the mouth structure and view the gills from that direction. The gills are the fish equivalent of lungs and function by absorbing the oxygen dissolved in the water. Many fish also have long extensions from their gills called **gill rakers**. Fish that eat plankton use the gill rakers to strain their food out of the water.



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Osmoregulation

When we get in the bathtub our skin absorbs water and swells and when we bathe in the sea we often feel dehydrated when we emerge. This is caused by the different concentrations of salts dissolved in the waters. If there is more salt in the water than there is in our cells, the water from our body will want to diffuse (move out) and dilute the saltier water. If there is less salt in the water than in our cells, the outside water will try to diffuse into our cells.

We **osmoregulate** (control the water concentration within our bodies) through the function of our kidneys. However, we are not in constant contact with water, whereas, fish are constantly submerged. Consequently, if a fish had to control the salt concentration in its cells at a level different than the surrounding water, it would require an enormous amount of energy. Freshwater fish dumped into the ocean quickly dehydrate and die while ocean fish dropped in a freshwater aquarium become bloated and drown. Therefore, fish tend to have the same concentration of salts in their cell fluids as is found in the surrounding waters. There are some fish that travel from fresh to salt water and vice versa, like the salmon, shad, and American eel. These fish (**anadromous** if they live in salt water and spawn in fresh water or **catadromous** if they do the reverse) have special organs to survive the transition, but it requires vast amounts of energy.

Buoyancy

Since flesh is denser than water, one would expect a fish to sink. (Most humans float because of our gas-filled lungs and fatty deposits.) To become neutrally buoyant and to avoid having to constantly swim and expend energy to stay afloat, many fish have evolved an **air bladder** that provides flotation in the same way our lungs do. The fish has much greater control over the amount of gas in the bladder than we do over our lungs because the fish does not use this gas as an oxygen supply (except for some African air breathing fish which have evolved the air bladder to this function, somewhere between a gill and a lung). Fish fill their gas swim bladders with a combination of nitrogen and carbon dioxide removed from their blood stream and when the gas in the bladder swells from a change in pressure the fish either absorbs the excess back into its blood or burps it out. Sharks and fish like tunas have no swim bladders and must swim constantly or sink.

Objectives

- Children will be able to identify the various external parts of a fish and how they can be adapted to different habitats.
- Children will understand the concept of osmoregulation and how fish are affected by changes in water salinity.
- Children will learn how fish regulate their buoyancy.

Learning Activities

1. How Fish Cope - Investigating Osmoregulation

2. Mr. and Mrs. Potato Fish

3. Fish Painting (Gyotaku)

4. How Swim Bladders Work - Investigating Fish Buoyancy

Activity Outlines

1. How Fish Cope - Investigating Osmoregulation

Materials needed:
fresh potato slices or lettuce leaves
2 containers
salt
fresh water

Cut a potato into thin slices (if you are artistic, make them look like fish). For a more rapid result, use the lettuce leaves. Half fill the containers with water and place two or three tablespoons of salt in one container. Have everyone feel a potato slice or lettuce leaf, then place half of the slices in each container. Leave the slices alone for about 30 minutes (do the Mr. and Mrs. Potato Fish activity), then feel the slices again. Sometimes it takes longer to have a noticeable effect on the potatoes. If possible, leave the slices soaking overnight for a dramatic difference. Potato slices cannot regulate their water balance and therefore they are altered by their environmental conditions.

Discuss the following questions:

What happened to the potato slices in the fresh water? What would happen to a saltwater fish placed in fresh water? (The potato slice should have become very stiff because its cells have absorbed the maximum amount of water. A fish in these conditions would swell and his cells would burst because plant cells are tougher than animal cells.)

What happened to the potato slices left in salt water? What would happen to a freshwater fish placed in the ocean? (The potato slices should have become very limp because the cells have lost water and become dehydrated. A freshwater fish would become dehydrated and die.)

Adapted from North Carolina Marine Education Manual, Unit Three, Coastal Ecology, *by Lundie Maldin and Dirk Frankenberg, Sea Grant Publication UNC-SG-78-14-C, University of North Carolina Sea Grant College Program, North Carolina State University, Raleigh, NC, 1978.*

2. Mr. and Mrs. Potato Fish

Materials needed:
(for each child or buddy pairs)
small potato (or foam ball or other roughly oval object)
worksheet with parts of a fish
cardboard or construction paper to make fish parts
scissors
stick for mounting "fish" (optional)
real fish (fresh or frozen), one or two species, as examples, or use a model of a fish

Using the real fish as an example, go over the fish anatomy and discuss some of the adaptations of the different parts to fit different habitats.

Divide up the group and have each small group decide where they want their fish to live, what it eats and how it protects itself from enemies. Pass out materials and instruct them to make a fish by placing fins, mouth, scales and eyes on their potatoes in the shape and position that would allow a fish to survive in the habitat they have chosen.

When the fish are finished, bring everyone back in a group and have them examine other fish to see if they can figure out where that fish would live.

Adapted from North Carolina Marine Education Manual, Unit Three, Coastal Ecology, *by Lundie Maldin and Dirk Frankenburg, Sea Grant Publication, UNC-SG-78-14-C, University of North Carolina Sea Grant College Program, North Carolina State University, Raleigh, NC, 1978.*

3. Fish Painting (definitely a rainy day activity)

Materials needed:
fish or other specimens
detergent (dish soap or liquid hand soap)
paper towels
ink (block-print, textile, India, etc.) or tempera or poster paint
soft brushes
paper for printing (newsprint or rice paper work well; needs to be moisture tolerant)
scrap paper for table cover

One of the most common activities in marine education today is fish printing, an adaptation of the Oriental art form of gyotaku which means "fish rubbing." The process, described below, is basically simple and can be adapted to any age/grade and ability level. It is a good follow-up for a collecting trip. It may be used to introduce basic as well as advanced subject-concepts. It is also useful with special populations for whom hands-on activities are particularly beneficial in the learning experience.

A classic example of art form is a flounder print. Flounder make excellent gyotaku subjects because they are flat, have a light mucous coating, and are easily obtained. They also lend themselves well to discussions of animal adaptation such as general morphology, eye migration, coloration, etc.

1. Prepare a fresh, whole, unscaled fish (a completely thawed specimen may be substituted) by washing in household detergent to remove all mucous coating. Rub gently from head to tail to avoid knocking off scales.
2. Dry completely by patting and pressing with paper towels.
3. Cover fish with a thin coat of ink or paint (generally applied from head to tail) with a soft watercolor-type brush or a soft brayer. Do not dilute the ink. Do not ink the eyes at this time unless you use a brayer.
4. Lower paper, right side down, against the fish. Print by pressing the paper against the inked portion. Be careful not to move the paper once it is in position. Don't leave it on until it's soaked. Gently mold the paper around the contours and avoid wrinkling.
5. Remove paper, add eye color with a small brush, and sign the print.

Hints

If you use non-toxic, water-based ink, and only make a quick print or two, you can rinse, filet and eat your fish. You could cook it whole, but the ink taste might be unpalatable.

To make prints with a gutted fish, stuff the body cavity with soft tissue or paper towels to make it appear natural in shape.

You can achieve different effects by applying several colors to the specimen. Color can be mixed and then applied, or mixed on the fish by stroking one color(s) on top of another. Also, all portions don't have to be covered, or covered equally.

For groups, you can obtain 10 to 16 prints from one fish, depending on the enthusiasm with which it is rubbed! Fish may be sponged off between uses to change colors.

The best paper to learn on is inexpensive newsprint. Many people go on to use this technique to decorate T-shirts or other cloth items.

Water-based block-printing ink works well with beginners as it comes off of skin, hair, floors, clothes, etc. It is available in tubes or large cans. India ink, oil-based block printing ink and textile paints may also be used successfully.

Work on a piece of scrap paper. Ink fish, then lift it, remove scrap paper and replace with a clean sheet before printing to avoid picking up any smears.

This information on fish printing is adapted from an article originally published in CURRENT: Journal for Marine Education *and was written by Sally Zimmerman, Education Coordinator, Marine Resources Center, Fort Fisher, Kure Beach, NC, 1978.*

4. Investigating Fish Buoyancy

Materials needed:
(one set for each small group)
large beaker or wide mouth quart jar
sodium bicarbonate (baking soda)
white vinegar
mothballs
food coloring

Have the groups do the following:

1. Fill the jar half full of water and add a few drops of food coloring, 250 ml (1 cup) of white vinegar, 4 or 5 mothballs, and one to two teaspoons of sodium bicarbonate. Be prepared for serious foaming.
2. Observe and record the movements of the mothballs, timing them if a watch is available. (The mothballs should be forming bubbles on their surfaces and rising to the surface of the water. When they reach the surface, the bubbles escape into the air and the mothball sinks again.)
3. When the mothballs slow down or stop dancing, have a discussion with these questions:

- What happened on the surface of the mothballs? (bubbles formed)
- Why did the mothballs rise through the water? What happened to their overall density? (The combination of the mothballs and bubbles had a lower density than the water so they floated. The same thing happens when a fish pumps gas into its swim bladder.)
- Why do the mothballs sink? (Because the bubbles are released to the air and the density increases again. Same thing happens when a fish releases gas from its swim bladder.)
- Bring the discussion around to the idea that when the mothball or a fish manages to change its density, it will change its position in the water column.

For additional information on density, refer to Chapter Two, *Water Wonders*.

Adapted from North Carolina Marine Education Manual, Unit Three, Coastal Ecology, *by Lundie Maldin and Dirk Frankenberg, Sea Grant Publication UNC-SG-78-14-C, University of North Carolina Sea Grant College Program, North Carolina State University, Raleigh, NC, 1978.*

Chapter Seven

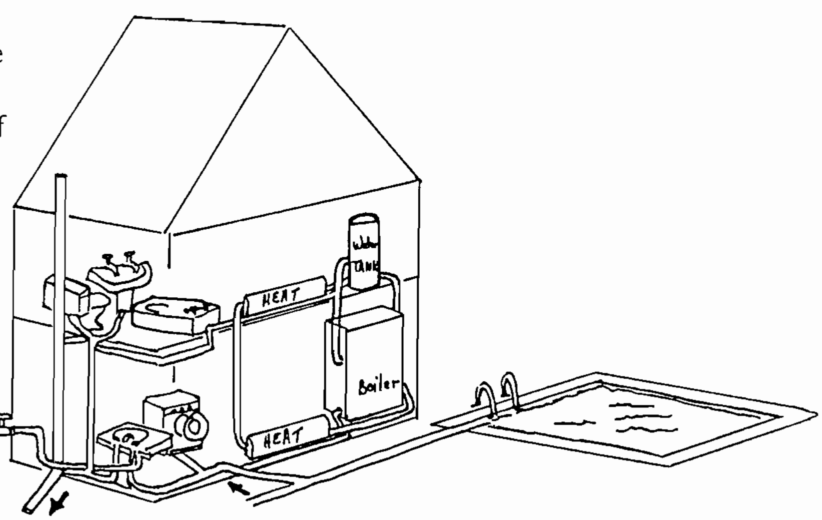
How People Use Water and Long Island Sound

Background for Instructors

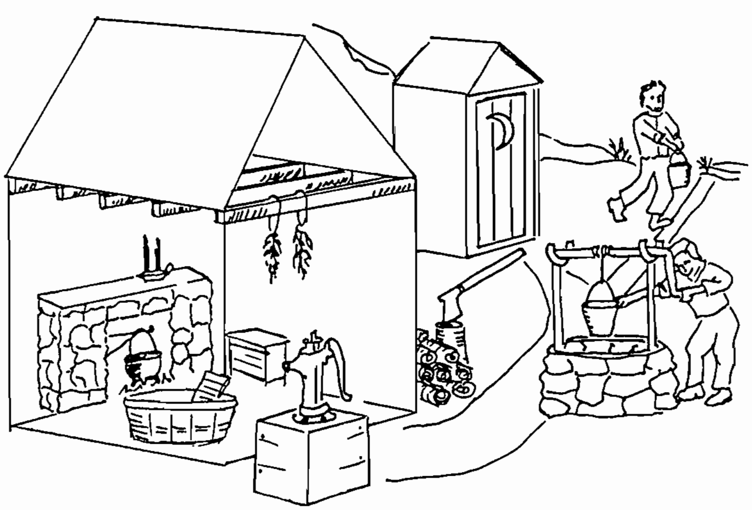
Water is a resource necessary for all life. Water has an endless number of uses, and some of these uses are not compatible. Many people assume that cheap, clean water will always be available. In fact, less than one percent of the world's water is available as fresh, drinkable water. Problems with pollution and major droughts around the country have started changing the way people think about water, but we have a long way to go before we truly appreciate its value.

Long Island Sound is a multiple-use water body, where public recreation, transportation, fisheries resources, and waste disposal—uses of growing importance to the economy—are in direct conflict with each other. Water, especially large bodies like Long Island Sound, is often viewed as a site for waste disposal. Once water is polluted by industry, home consumption, or municipal activities, it is generally disposed of by dumping it back into a water body. Waters that receive the effluent from sewage treatment plants and industrial manufacturing are not aesthetically pleasing and are generally ecologically degraded to some degree.

The value of Long Island Sound to the economy of its surrounding states is on the order of billions of dollars every year generated from the fisheries, the recreational industry, and support services. Many would argue that a dollar value cannot be assigned to the biodiversity, ecosystems, and aesthetic worth of the Sound. Development of the Sound continues as expanding communities demand more housing, industry, and waste disposal sites. It is projected that in the next twenty years, close to nine million people will live in counties bordering Long Island Sound. Is this development compatible with sustaining economically and biologically viable fisheries? Can we maintain the beauty of the Sound sought by countless recreationists? Decisions need to be made about how to balance all the demands on the Sound.



Even how we use water in our homes and communities has an impact on Long Island Sound. When America was being settled and water had to be carried to the house by hand, the average family used about a bucket (five to 10 gallons) of water in a day. Experts currently estimate the average household uses a minimum of 100 gallons of water a day and the quantity may be closer to 300 gallons of water per family per day. This great difference is related to our many changes in lifestyle since those earlier days.



Colonial families used water for cooking and drinking. Chores, such as washing clothes and scrubbing floors, required the extra effort of hauling more water, so they were not done very often. Innovations such as indoor plumbing and washing machines, while making life easier, greatly increases society's demand for water.

The water used in our homes is only a small part of the water we use each day. Most industrial processes require the use of water to make or clean the products we consume. Additionally, swimming pools, skating rinks, gymnasiums, water fountains in public parks, car washes, concrete in building foundations, heating and cooling systems, refrigeration units, and firefighting equipment all use millions of gallons of water each day. Think of what would change in your community if the water supply was suddenly disrupted.

Water supplies for our communities come from two sources: from water diverted from rivers and stored in reservoirs, or pumped from the ground by huge municipal wells. Modern technology allows us to store and transport massive amounts of water over great distances and to remove various pollutants before the water is delivered to the consumer. Water used in Manhattan is piped in from as far upstate New York as Poughkeepsie. Water for New Haven, Connecticut comes from reservoirs in Madison, 20 miles away. Moving water in this manner is not new; the Romans built massive aqueducts 2,000 years ago to supply water to their cities.

Diversion of water from its natural pathways can significantly change local **ecosystems**. If water is held in a reservoir instead of traveling downstream to an **estuary**, the natural mixing of fresh and salt water is altered, changing the plant and animal communities of the estuary. Pumping large volumes of water from wells can lower the **groundwater** level, sometimes completely drying out rivers during droughts.

Objectives:

- Children will understand we depend on water for life and for every day living.
- Children will be able to estimate their individual and cumulative demand on local water supplies.
- Children will understand how some water uses conflict with other uses, forcing difficult decisions to be made.

Learning Activities:

1. One Bucket a Day
2. Water Recreation and Pollution: Redesigning the Sound
3. Setting Priorities

Chapter Ten, "Cleaning Up Polluted Water", also addresses the issues of water use and disposal and should be considered a natural extension of this chapter.

Activity Outlines

1. One Bucket a Day

Materials needed:
five or ten gallon bucket filled with water
several one-gallon containers, like milk jugs
dishpan
dipper or ladle
plastic sheeting or waterproof floor area

Gather the group around the materials and start with a story along these lines. Feel free to embellish or expand the story. You can involve the group by having different children act out the characters in the story and scoop the water for you. This might also speed up the activity.

"Imagine yourself as a pioneer on the wild frontier around 1800. You and your family (mother, father and two or three children) live in a log cabin built on a hill at the edge of a field that your father cleared. At the bottom of the hill is a stream that provides all the water used by your family and all your animals. The animals are walked down to the stream twice a day to get their water, but YOU have to carry the buckets of water up the hill for your family to use. (Have some of the children pick up the bucket of water and carry it a short distance.) Every morning after you bring the water up the hill, your mother uses some to make corn meal mush and hot tea for breakfast (scoop about a half gallon of water out of the pail and put it in the dishpan). After breakfast, your father fills his jug so he and your brothers can take water to the field with them (fill one of the gallon jugs). Mother fills the kettle again to wash the dishes (scoop out another gallon of water). Today is baking day, so some water gets used as Mother makes the bread dough and stews up some fruit to make a pie (add a few more scoops to the dishpan). Lunch is corn cakes and salt beef...and everyone has a drink of water (more scoops of water to the dishpan). After lunch you help weed the garden and need another drink (more water in dishpan). For supper, Mother makes stew (more water) and then washes the dishes from the day (fill another gallon jug). Before bed, you pour water into the wash basin and wash your hands and face, and leave the water for your brothers and sisters (whatever water is left). Tomorrow is washing day and that means you'll have to bring two extra buckets of water up the hill! Just thinking about it makes your arms ache."

Be fairly liberal when pouring out the water, and if you run out in the middle of the day, adjust the story to have the child carry another bucket up the hill (groaning all the way).

After you finish the story, start a discussion about how much water gets used in the students' households in the course of a day. Make sure showers, washing machines, dishwashers, lawn sprinklers, swimming pools/hot tubs, and all the other water amenities of modern society are included. Make a list on a flip chart or blackboard of all the ways water is used in a home. Expand the focus to areas outside the home that use water to serve the children. These can include restaurants, the school, factories that make their clothes, farms where their food is raised, etc. See if they can estimate how much water is connected to their life in the course of a day.

A follow-up field trip to a local sewage treatment facility would visibly demonstrate how the water we use is treated and disposed of.

2. Water Recreation and Pollution: Re-designing Long Island Sound

Materials needed:
charts of Connecticut and Long Island Sound (with rivers) or the water cycle posters made in the earlier module
sheets of land and water uses and pollution symbols
scissors
tape or glue

You can do this exercise as a group or in small teams. It will be more work for you but less time-consuming during the activity if you have already cut up the symbols. Make sure the children understand what the different symbols will do to the water. All symbols must be used on the chart. It is best not to attach any of the symbols immediately, as the groups may want to relocate some after some thought. You can make the activity more true to life by, after the group thinks it has the picture saturated, announcing a population boom of people who want to use the water and giving them another 10 or 12 symbols to try to fit into the picture.

Ask what has been learned by trying to fit all the symbols together on the picture. (There are too many people; pollution and recreation do not mix; people who pollute are ruining their own recreational places.)

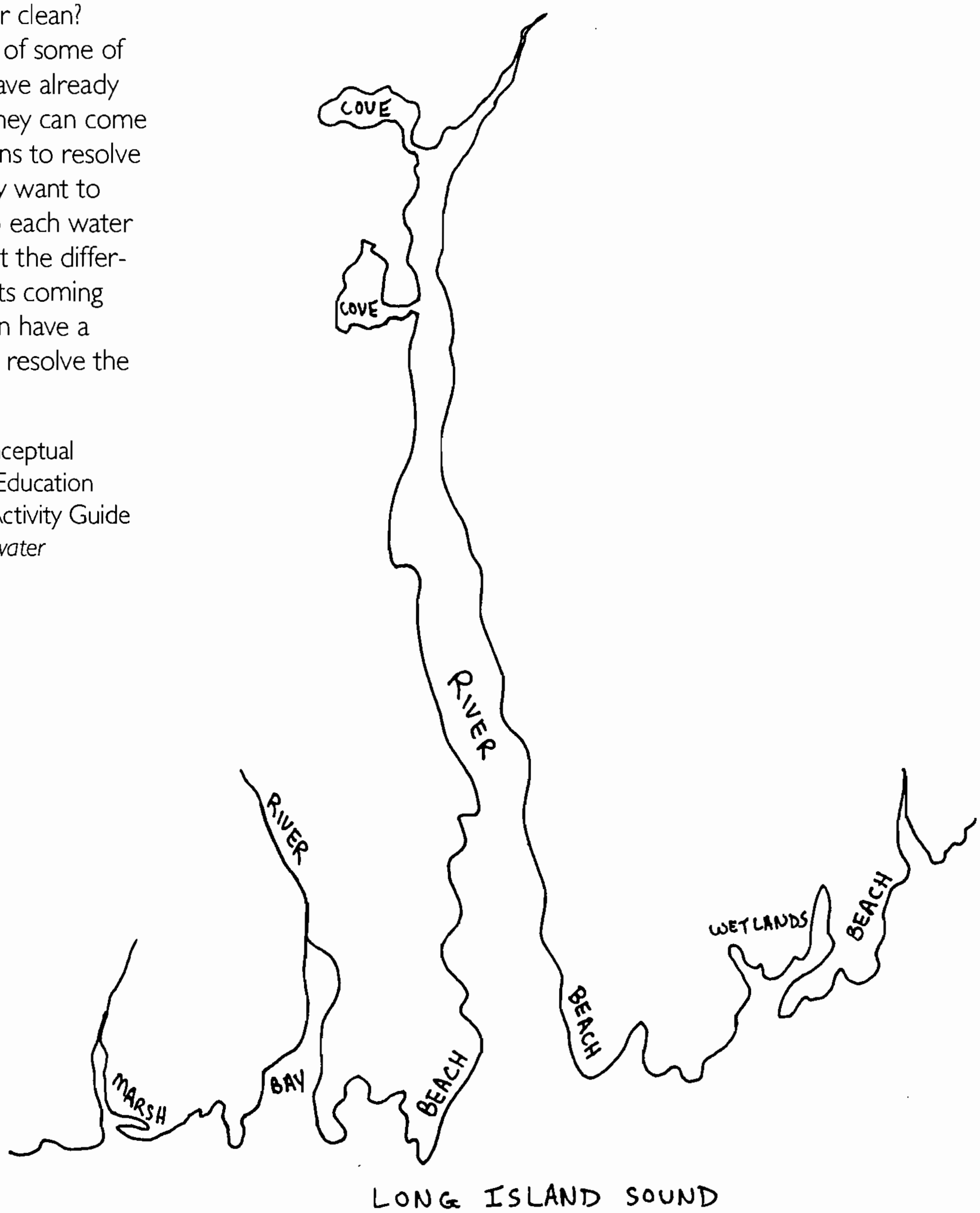
Adapted from Water for Fun, Coastal and Oceanic Awareness Studies Learning Experience 104, *Marine Environment Curriculum Study, Marine Advisory Service, University of Delaware and Population-Environment Curriculum Study, College of Education, University of Delaware, Newark, DE, 1974.*

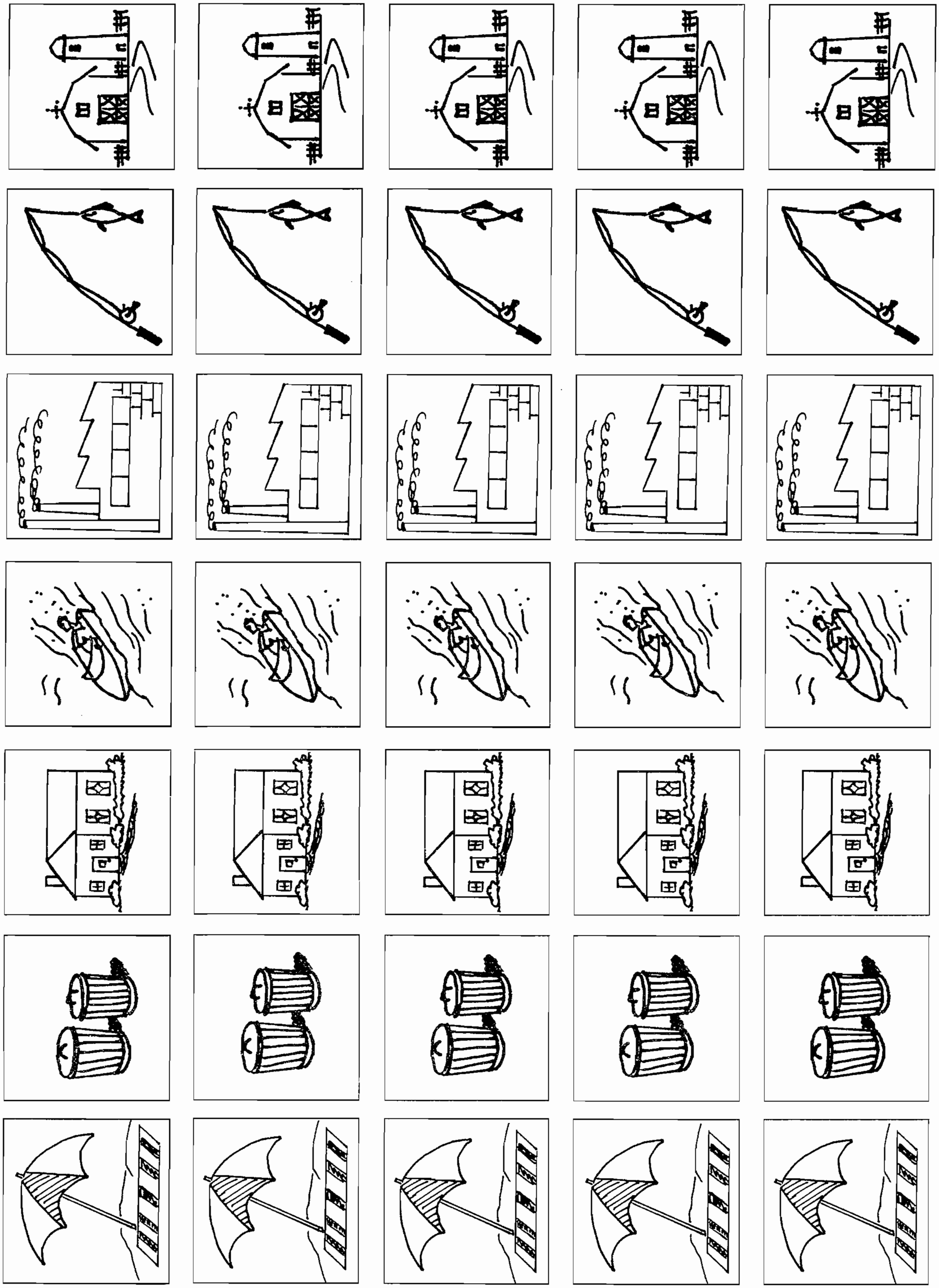
3. Setting Priorities

Give the group the following example: "In a nearby town, No-Name Bay, there are 5,000 people in houses and apartments. The town also has a sewage treatment plant, a factory, a 200-acre farm that raises vegetables and cows, a public park with a beach, and a shellfish industry, which raises oysters and clams. Drinking water comes from a reservoir on the river that empties into the Bay and both the river and the bay are becoming polluted. Each group in town needs clean water but may create polluted water that affects the other users. (Example: the farmer's cows need water for drinking and cleaning the barn, but their manure washes off the field into the river.) Discuss the following questions: How does each group use water? How do they pollute water affecting the other groups? How can these conflicting water uses be prevented/resolved? Who should pay to keep the water clean?

Remind the group of some of the water uses you have already discussed and see if they can come up with any suggestions to resolve the situation. You may want to assign a small team to each water use and have them list the different uses and pollutants coming from each group, then have a debate about how to resolve the problem.

Adapted from A Conceptual Framework for Water Education and Water Education Activity Guide for Grades 9-12. *Freshwater Society, 1981.*



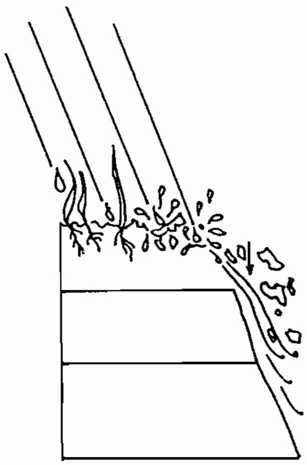


Chapter Eight

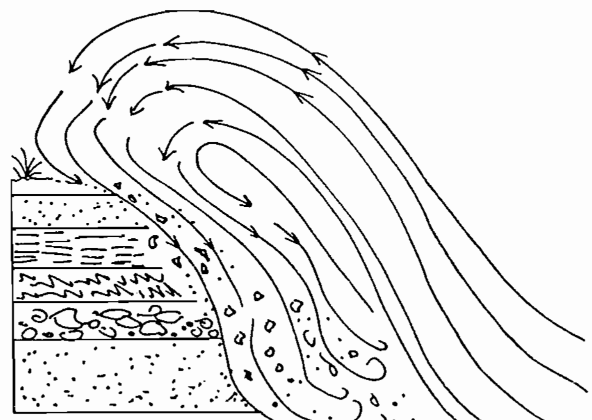
Erosion and Runoff

Background for Instructors

Since the first appearance of liquid water about 4.5 billion years ago, water has literally shaped our planet. In cold climates, water freezing in the cracks and pores of rocks has split the rocks open, making them smaller and exposing new surfaces to the elements. The smaller pieces are broken down further by alternate heating and cooling, while the wind and rain endlessly scour, "weather", and erode their surfaces. Sooner or later, all these processes break boulders into almost microscopic fragments that form the mineral part of soils and sands at the beach.



Splash Erosion



Wave/Tidal Erosion

Running water can literally "wash away" a mountain over geologic time. The action of wearing down or moving of rocks and soil by running water is known as **erosion**. The force of water at the Niagara Falls has worn the edge of the falls back some seven miles over the last 35,000 years. The Grand Canyon was also formed by the action of water over rock and soil. This form of natural erosion occurs very slowly but it definitely causes geologic change.

Much of the erosion occurring in the world today is not part of the slow, natural process of moving water and soil through our environment. It is the result of unsound land uses and practices. Careless agricultural and logging practices, vast expanses of paved areas, or poor design of roadways along hillsides all can lead to man-made erosion with very negative consequences. Consider that while plants need water to grow, the presence of plants help keep water in the soil and that plants and their decomposing remains make up a portion of the healthy top soil needed to grow more plants. If domesticated animals, like cows or sheep, are allowed to graze off all the plants on a hillside, or if entire forests are cut down without replacement, there is nothing to protect the soil from the wind and rain. When the land is bare, winds blow dry soil away (think of the Dust Bowl in Kansas in the 1930's). Rain washes soil (or sediment) into streams, rivers, or estuaries where it can destroy the aquatic ecosystem by covering up the bottom, burying spawning areas and nursery habitat for fish and insects. Suspended sediments prevent light from penetrating the water, keeping aquatic plants from photosynthesizing.

Untoward development along the shoreline often destroys wetlands, which are critical as a buffer for heavy tides or flooding rains. Tidal marshes act like a sponge, absorbing excess water, and as a buffer between the water and the land. When salt marshes are backfilled or paved over, thereby losing their buffering capacity, incoming tides and rains flood the area and storm waves batter the coastline, causing erosion to the surrounding land and stream banks.

Practices that lead to erosion have caused trouble in other areas. In areas where reservoirs supply drinking water, erosion sends silt and sediment into the streams and rivers, then into the reservoirs, filling them with mud instead of water. Where these streams and rivers flow into Long Island Sound, the sediment ends up being deposited in the small coves and embayments or in harbor areas important for commercial shipping and recreational boating, creating the need for massive and expensive dredging projects.

Erosion is not a necessary result of man's land uses. If trees are replaced when they are harvested, grazing lands are replanted and properly managed, agricultural practices are modified to minimize the flow of water over the ground, and roads and buildings are designed properly, erosion can be reduced and valuable resources can be saved.

Objectives

- Children will learn how **erosion** and **sedimentation** damage both the land and the water.

- Children will be able to identify areas that could be impacted by erosion.

- Children will understand the different ways we can control or prevent erosion.

Learning Activities

1. Erosion Demonstrations

2. Erosion from a Fish's Point of View

Activity Outlines

1a. Erosion Demonstration One

Materials Needed:
large basin
wide-mouthed glass jar
tin can with both ends removed
funnel and filter paper or percolator parts
large piece of cardboard or heavy duty aluminum foil
container of humus or potting soil (damp)
container of sand or clay soil (damp)
container of water that sprinkles and pours

Set-up: Set the jar in the basin and place the funnel and filter paper over the jar. Set the tin can into the funnel and place a collar of cardboard or foil around the tin so that water running over its top would be deflected down into the basin. Fill the tin can three-quarters full of the humus or potting soil.

Gather the group around the demonstration and ask them to observe what happens when you sprinkle water over the humus (it should all be absorbed) and then what happens if you rapidly pour about a tinful of water into the set-up (it should all sink in; none will run off into the basin). Keep adding water fairly quickly until some of it runs over the top, down the collar and into the basin. The collar represents a steep, impervious slope, like a paved hillside. This water represents the runoff water. There will also be water dropping through the funnel and into the jar. This water represents the water percolating down to become groundwater.

Have the groups identify where the different parts of water would be going in the real world, then replace the humus with the sand or clay soil and repeat the experiment. A lot more water should run out over the top and into the basin and less make it through to join the groundwater. Ask the group why there are differences between the two examples and which one seems better for the environment.

This activity can be expanded to examine how chemicals, like pesticides and fertilizers, placed on soils can end up in either surface waters or **groundwater**. Place several drops of food coloring on the surface of the soil. Light "rains" should carry the food coloring through the soils and into the "groundwater", while heavy rains should wash the food coloring into the surface waters. You may need to rain for several minutes to force the food coloring through the soils. There should be a noticeable difference in the amount of food coloring passed through the two soil types. Organic matter, like the humus in good soils, tends to bind **nutrients** and chemicals in larger quantities than does sand or other inorganic soils.

1b. Erosion Demonstration 2

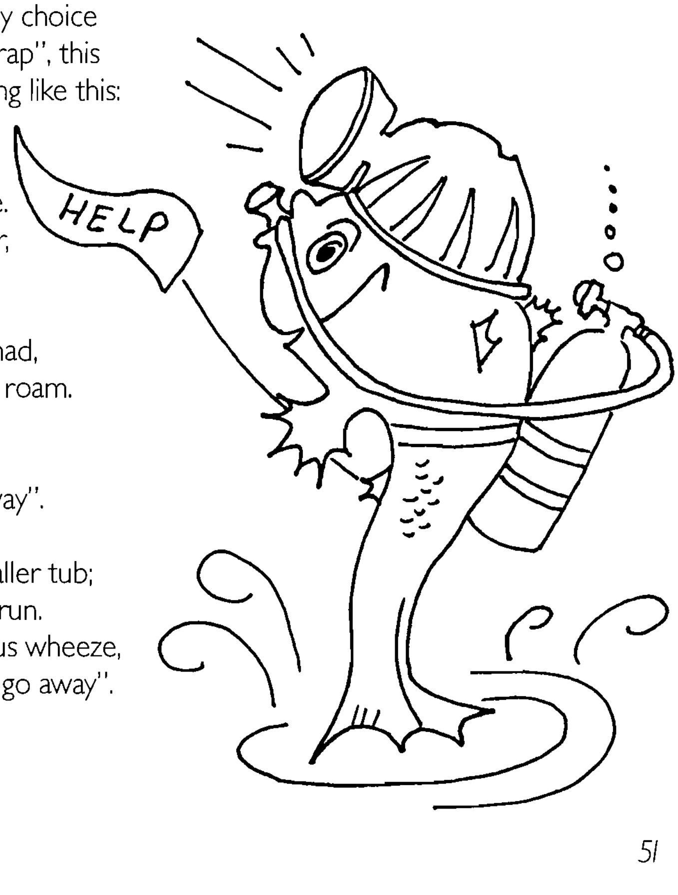
Materials Needed:
Old lasagna pan or disposable aluminum lasagna or turkey roaster pans
Mud
Sand
Water
Paper cutouts of houses or small houses from Monopoly® or Lego® blocks
Toothpicks

Fill one side of the pan with damp mud/dirt, and let dry overnight. Attach paper houses, stores, etc. to toothpicks, and insert the toothpicks on the surface of the dirt (near the edge for that great waterfront property). For added realism, a thin layer of sand can be added to the bare side of the pan once the mud is dry. The group is told that development has stripped this shoreline clear of vegetation to provide maximum number of waterfront houses. Pour water into the sandy side, filling it about half full. Slowly rock the pan, noting the erosion as the waves lap against the mud bluffs. For added impact, sprinkle "rain" on the mud-community. The result is eerily similar to the evening news' pictures of the southern California coast during El Niño.

2. Erosion from a Fish's Point of View

Materials Needed:
story
fish puppet or other fish prop

Gather the group, and introduce them to the fish (my choice for fish name of the summer is "Fresh Fish"; if you can "rap", this can be even better). The fish's story should go something like this:



"Well, I'm Fresh Fish and my buddies agree
that we don't mind soil when it's where it's meant to be.
We have soil in our marsh, it's where we get our fodder,
but we don't like mud when it gets into our water."

"You know, some soil's not so bad, but a lot makes us mad,
because it's ruining our homes, we got nowhere else to roam.
Your mud's clouding up our waters,
burying eggs that's our sons and daughters,
so we'd really like to say, "Just take your mud and go away".

"Every time you add more mud, this fishing hole's a smaller tub;
our plants get no sun - we've got no food, nowhere to run.
We need oxygen to breathe and your mud just makes us wheeze,
so once more we'd like to say, "Just take your mud and go away".

"Like people like their homes clean - looking sharp and looking mean.
Your mud messes up our water, so we can't live like we oughter.
We can't do anything about it, but you can go and scream and shout it.
Tell the world you heard Fresh Fish say, "Just take your mud and go away!"

OR: If you have no sense of rap (obviously I don't if you tried to use the one here), you can give it to them straight:

"Hi, I'm Fresh Fish and I've got a bone to pick with all you humans who keep letting all this sediment and mud and stuff wash into my marsh. You know, I've seen a lot of things come and go, but this sediment situation is just getting worse and worse.

First of all, all this stuff washing into the marsh is making it fill up! The water's getting shallower, my favorite deep hole doesn't exist any more, and there's just not enough room for all the neighbors anymore. Of course, you probably solved that problem for us this spring after that last big storm. Me and the wife had just laid all our eggs in a nice little nest and then the storm brought in all this mud and buried the place. Somehow I don't think any of this year's brood is going to hatch.

On top of wiping out this year's family, all this mud is making the food situation around here pretty grim. The little plants floating in the water and the bigger ones attached to the bottom...well, the ones on the bottom got buried, and the ones in the water can't get enough sunlight to survive. It's so darn dark down here now we need headlights to keep from running into each other!

And another thing, all your mud is making it awfully hard to breathe. For some reason the mud is sucking up the oxygen in the water and clogging up our gills. If the water gets too much warmer, there's not going to be enough oxygen in it for all of us and somebody's going to die — or maybe all of us!

Look at it this way guys...you don't like it, or anyway your mothers don't like it when you bring soil and mud into the house. You call it dirt then, right? And your mother makes you spend all that time cleaning your room and washing stuff? Well, we feel the same way about our marsh because it's our home, so we'd really appreciate it if you would help us keep it clean by stopping all that erosion and keeping the mud out of our waters. Thanks! Now go out and do something about it!"

Chapter Nine

SPILL! Demonstrating Disaster

Background for Instructors

Petroleum is one of three naturally occurring liquids on this planet but its chemical structure is such that it is a substance that does not dissolve in or mix well with water. Petroleum is used for many things in our society; it is an energy source, a lubricant, and a raw material in many synthetic products, including plastic and rayon. Petroleum also becomes a very nasty pollutant when it is released into either our surface or ground waters. In these days of declining oil supplies and increasing awareness of man's impact on other portions of the **ecosystem**, greater efforts are being made to prevent major oil spills.

In spite of these efforts, oil continues to be released into our surface water. Transportation accidents like the *Exxon Valdez* and the *North Cape*, offshore oil drilling operations, pipeline leaks, accidents during the transfer of oil from tankers to storage tanks, and leaks improperly maintained vehicles all add oil to the environment. It is estimated that only about 20% of the oil entering our waters is from large, disaster scale, spills. The vast majority of oil releases are small amounts spilled during day to day activities or from naturally occurring oil seepage. Oil enters our **groundwater** from leaking underground storage tanks, and from do-it-yourselfers pouring their used motor oil out on their driveway or down the nearest storm drain.

Big Oil Spill Stirs Water Safety Fears
New York Times, Feb. 21, 1988
Long Island's ... st recorded underground petroleum spill, 800,000 gal. of leaded gasoline....

Experts Seek Source of Oil Spill in River, The Hartford Courant, July 7, 1991

Tugboat Pilot in Thames Oil Spill Missed Warning Lights: 27,000 gal. home heating oil spilled in Long Island Sound, The Hartford Courant, Dec. 24, 1992

As past disasters have demonstrated, a major oil spill to surface waters has a devastating impact on the natural ecosystem. Shorebirds and other coastal wildlife are especially vulnerable to oil spills because such spills tend to occur in shallow, semi-enclosed coastal areas where these organisms are primarily located and where spilled oil is concentrated along the shoreline.

The extent of an oil spill and the associated damage is dependent on the type and quantity of oil involved, prevailing wind and water conditions and the variety and abundance of life in the area of the spill. While initial damage appears overwhelming, natural forces are capable of cleaning up these spills over a period of years. Acute, high-level exposure to petroleum products wreaks obvious havoc, but low-level, long-term exposure will reduce an organism's ability to feed and reproduce, decreasing its overall chances of survival.

Of course oil is only one of the many chemicals used every day in our homes or at industrial sites. Cleaning fluids, pesticides and hundreds of other chemicals, are all highly toxic when they end up in the water after being improperly discarded or accidentally released or spilled into the environment. The impact of oil or other toxic chemicals released into our groundwater is less apparent because there are no pictures of oiled wildlife and beaches. However, because of the inability of groundwater to cleanse itself, the pollution of our drinking water supplies and the whole water cycle by chemical contamination of groundwater could have more long-term consequences than a spill like the *Exxon Valdez*.

Objectives
- Children will be able to see how pollution moves when introduced into a water body.

- Children will learn how to evaluate the impact of pollution on the environment.

Learning Activities
1. Evaluating an Oil Spill - Surface Waters

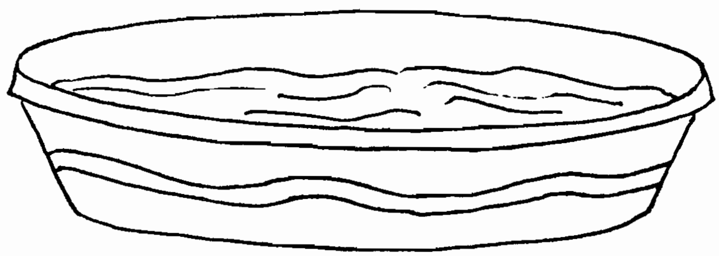
2. Evaluating an Toxic Spill - Groundwater

These activities take about an hour each.

Activity Outlines

1. Evaluating an Oil Spill - Surface Waters

Materials needed:
wading pool or large container marked to resemble an **estuary** (you should be as detailed as possible)and half filled with water
wood shavings or confetti (or for those who don't mind big cleanups, dyed vegetable oil)
small fan or other method of simulating wind
impact evaluation cards for the "experts"
pens or pencils



Divide the group into buddy teams or pairs and assign teams to each of the following impact areas: plant life, animal life, landscape, and human activities.

Around the "field site," quickly outline the following story: the group is now a group of environmental impact experts that have been called in to estimate the impact of the spill on the a) plant life, b) landscape, c) animal life, and d) human activities of the area. Assign the specific areas to be examined by handing out an impact evaluation card to each group. Tell the groups to work on the assumption that anything the "oil" touches will be covered with oil or chemicals.

Release the "oil" from a likely point in the "estuary." Use the fan to simulate wind and slowly and gently tip the pool or pan to simulate tidal action. Have your environmental "experts" start their investigations.

After the spill has been completely dispersed, or a reasonable time period has gone by, get the group back together to report on their impact findings. Some questions to be considered:

- What areas would be most affected by the spill?
- What factors dispersed the spill? (wind, current, etc.)
- How would different weather or water conditions affect the spill?
- How could we keep the spill from spreading?
- Who should be responsible for cleaning up the spill?

As a variation, or in a second run of the activity, have substitutes for standard oil spill cleanup equipment available and have the group figure out how best to use the materials to protect critical areas or clean up the spill, (thick, fuzzy yarn for oil booms, dish detergent for dispersal agent, small squares of paper towel for absorbent work, etc.). This may lead to an interesting debate about what defines a "critical" area, if they have to choose between, say, protecting a beach, a salt marsh and the local harbor.

Adapted from OBIS Oil Spill, *Outdoor Biology Instructional Strategies Trial Edition, Set II, Lawrence Hall of Science, University of California, Berkeley, CA, 1975.*

2. Evaluating an Oil (Chemical) Spill - Groundwater

Materials needed: one set for each small group
2 clear plastic containers with flat bottoms (like a shoebox)
wood block 1" thick to prop up end of container
food coloring (red, green or blue)
powdered lemonade mix (with or without sugar)
sprinkling can or spray bottle of water to make "rain"
plastic drinking straw cut in 3" lengths
wide range pH paper or pH testing kit
enough clean sand to fill container with 1" thick layer

NOTE: Be careful about the sand you use. Sands with a high carbonate content will neutralize the citric acid from the lemonade powder and the experiment will not work as expected. To avoid this, you can purchase high silica sand at a building supply store or aquarium sand from a pet shop.

One term that may need definition is the word "**plume**". When groundwater is polluted, the pollution spreads out from the point of contamination in a three-dimensional teardrop shape. This spreading form is known as the "plume".

Divide into groups of four or five, give each group their materials, and have them follow these directions:

Work Sheet

To examine a visible plume:

1. Layer some sand in your container so it is no more than one to two inches deep at the deepest end. Place the end of the container with the deepest sand on the wood block.

2. Place five or six drops of food coloring on the surface of the sand at the raised end (representing a chemical spill).

3. "Rain" on the contaminant with the spray bottle, making sure that the spray is light enough that the food coloring seeps into the sand rather than running off over the surface. Make sure erosion is not occurring in the upper sand. Keep "raining" until the food coloring can be seen in the sand at the bottom of the container.

4. After about five minutes, the food coloring "plume" should be visible on the bottom of the container. Have the groups draw the shape of their plume on a blackboard or piece of poster paper. Keep raining for a few more minutes, then let the container sit for about a half-hour. After this time, check the shape of the plumes again and add to the first picture (the plumes should be broad and fan-like, narrowing toward the point of origin).

To examine an invisible plume:

1. Fill the second container with damp sand to a depth of about one inch. Smooth off the top of the sand so that one end is deeper than the other. (Wet sand causes the "contaminant" to travel faster.) Raise the deeper end on the wooden block.

2. Make a shallow hole in the upper end of the sand and add one teaspoon of powdered lemonade mix to the hole. Cover the hole with sand.

3. Lay out 12 pieces (1" long) of **pH** paper on the table. These strips will be used for testing the sand to locate the contaminant plume.

4. With the spray bottle, "rain" on the upper end of the box so that the sand gradually becomes saturated. Add water slowly so there is no runoff and no erosion. Keep watering until you think the contaminant has been carried through the sand and down to the other end of the box.

5. Using the pieces of plastic straw, remove a plug of sand from the container and drop it on a strip of pH paper. If the pH paper indicates a drop in pH (more acidic conditions) you know the plume of contaminated groundwater has been found.

6. Record the location and results of each test plug. Take at least 12 samples, using a fresh piece of straw every time or the sample may not be accurate (or the straws can be washed out between samples). After the experiment, the straws can be washed and dried for future use.

Discussion Questions: (for both experiments)

- What makes the contaminant travel away from the place it was originally buried?

- Why did the contaminant move in the direction it did?

- What factors underground in the real world might influence the direction of the contaminants?

- How many samples would be needed to know exactly where the contaminant plume is located?

- If there were a real contamination site in your neighborhood, how would scientists test for groundwater contamination?

Impact Challenge Card #1: Landscape

Follow the spill and estimate its impact on the landscape. Use a length of string to measure the area the spill covered.

Estimates: Water ______ sq. meters (length x width)

Land ______ sq. meters (length x width)

Where did most of the "oil" end up? Why?

How might the underwater landscape be affected?

How did the spill change the general appearance of the landscape?

Impact Challenge Card #2: Plant Life

Follow the spill and estimate its impact on plant life.

How many different types of plants were affected?

Which plants were hardest hit by the spill? Why?

How might an oil spill affect land plants?

How would animals that eat aquatic plants be affected?

Impact Challenge Card #3: Animal Life

Follow the spill and estimate its impact on animal life.

How many different types of animals were covered with oil?

Which animals were hardest hit by the spill? Why?

Which animals do you think would be capable of escaping from a spill?

Which animals might not be able to escape?

How might an oil spill affect animals that live under the rocks in the water?

Impact Challenge Card #4: Human Activities

Follow the spill and estimate its impacts on human activities.

How might an oil spill affect fishing and other recreational activities such as swimming, water skiing, surfing, diving, etc.?

How might boats, docks, breakwaters and other water structures be affected?

How might drinking water or food be affected by an oil spill?

Chapter Ten

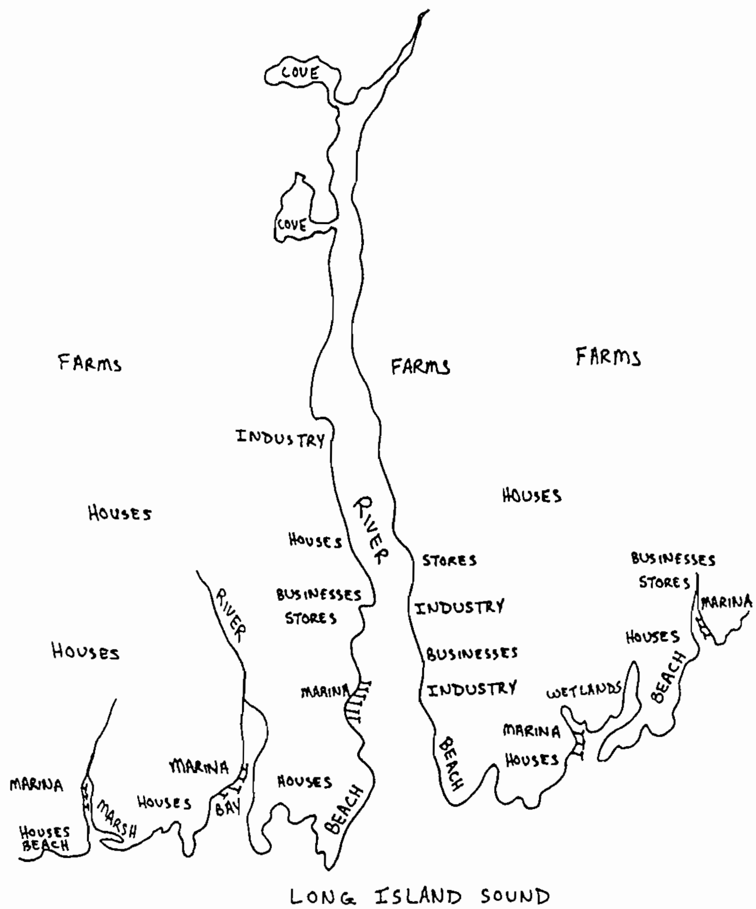
Cleaning Up Polluted Water

Background for Instructors

Long Island Sound is considered the most significant water resource in Connecticut. Growing concern in the 1970's regarding the declining health of Long Island Sound resulted in widespread support to target sources of pollution and other forms of degradation and to plan efforts for cleanup and restoration. In 1985, the Long Island Sound Study (LISS) was launched to comprehensively study the impacts various forms of pollution contribute to the environmental problems facing Long Island Sound. The study recognized five major pollutants that adversely affect the water quality of the Sound: nutrients, pathogens, sediment, toxic contaminants, and floatable debris. Cleanup of polluted waters is an expensive and daunting task and our aim should be preservation and conservation of our water resources to allow their continued and varied use.

Pollutants entering Long Island Sound are classified as either point or nonpoint sources of pollution. **Point source pollution** is easy to identify, for example, sewage pipes directly dumping effluent into the Sound. There are 44 sewage treatment plants on the shores of Long Island Sound with another 42 on the rivers that empty directly into the Sound. The total amount of wastewater discharged from these facilities is over one billion gallons each day.

Nonpoint sources of pollution are more difficult to measure. Because of this difficulty, their effects are more insidious. Rain water running over parking lots collects oil, gas, antifreeze, and other chemicals on the surface of the pavement. This contaminated water then drains to a stream or storm drain, which ultimately leads to the Sound. Activities demonstrating some of the sources and impacts of **nonpoint source pollution** are located in the chapters on erosion and toxic spills.



Excess **nutrients** have been found to contribute to the most pressing issue in the Sound. While nutrients are essential for supporting marine life, too many nutrients, particularly nitrogen, can lead to **hypoxia** (low dissolved oxygen levels). Excess nitrogen promotes algal blooms. Bacteria use oxygen to decompose this overabundance of algae when it dies. As bacteria continue to feed and reproduce, oxygen concentrations drop to dangerously low levels for other organisms.

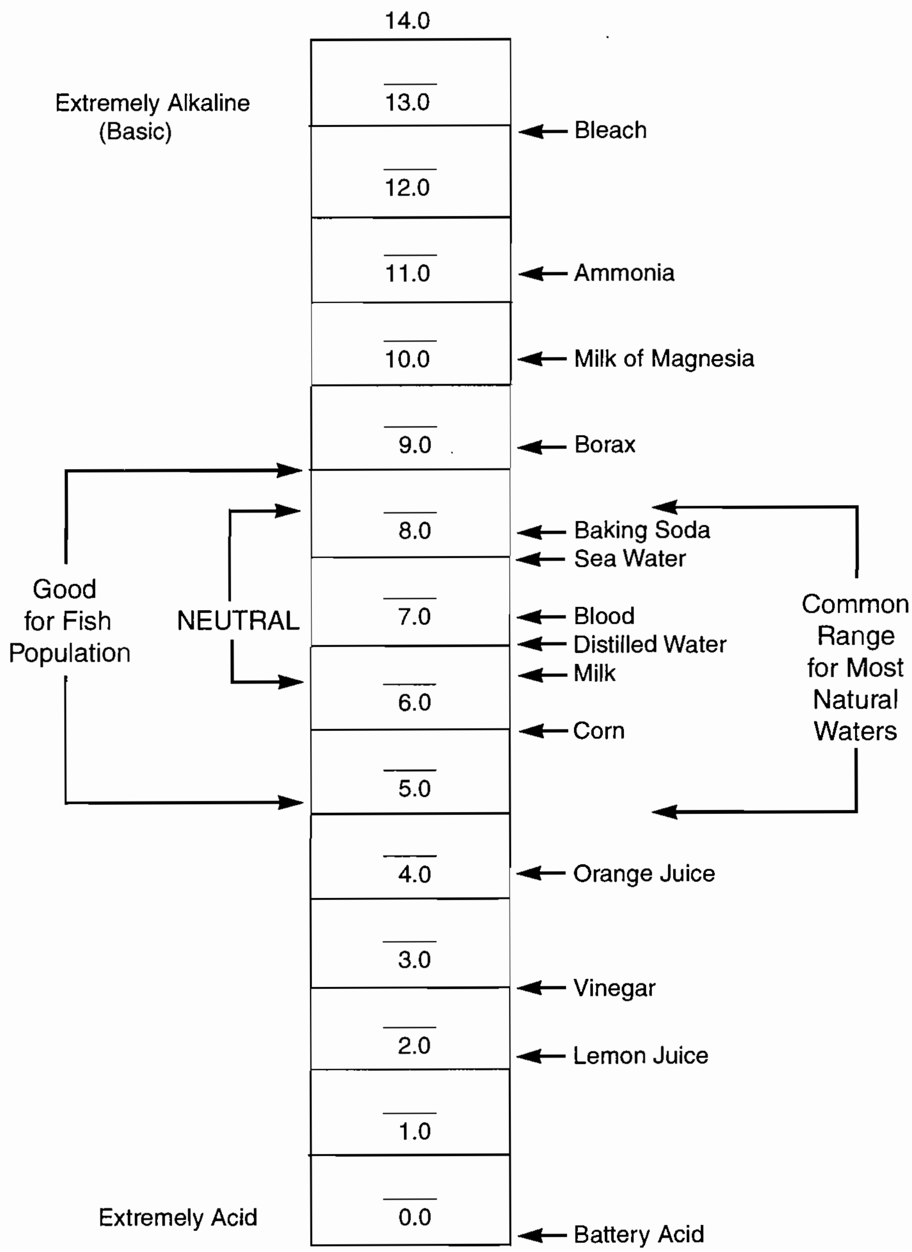
Hypoxic conditions are especially prevalent during the summer months following spring algal blooms. Benthic or bottom-dwelling organisms suffer most because the dead algae settle to the bottom and there is limited mixing with oxygenated surface water. Most of the human-supplied nitrogen comes from sewage treatment facilities, the rest from sources as diverse as acid rain, lawn fertilizer and car exhaust.

Pathogens include disease-causing viruses, bacteria, and microorganisms. They are responsible for water-borne illnesses such as hepatitis and dysentery. Swimming areas and shellfish beds are often closed when pathogenic organisms are detected in local water samples. Pathogens generally enter the Sound through inadequately treated sewage wastes and fecal material (manure or "poop") from domestic and wild animals and birds.

Excess sediment from natural and manmade **erosion** can cloud waters with suspended particles, blocking **photosynthesis** in plants and choking filter feeders such as shellfish. Major sources of sediments include unsound construction and logging practices. These activities disturb the vegetation's holding capacity of the soil, thereby allowing the runoff of sediments.

Toxic contaminants need not be present in large quantities to greatly impact the Sound. Mercury, lead, DDT, and petroleum products are a few examples of contaminants responsible for negatively impacting marine life. While some contaminants have immediate lethal effects, others are slow and insidious, affecting long-term reproductive potential, for example. **Bioaccumulation** is an important associated concept. This refers to the increasing concentration of poisonous substances up the **food chain**. The amount of contaminants ingested exceeds the amount excreted. This has serious implications for marine species that humans consume.

pH SCALE



One form of water pollution that is often overlooked is acid rain. Chemical contaminants from air pollution are washed from the sky by rainfall and end up in our streams, rivers, lakes, and oceans. Much of this contamination is in the form of nitrates and sulfates released through the burning of fossil fuels (coal and petroleum). When these substances mix with water they form nitric acid and sulfuric acid and their addition to water bodies lowers the **pH** of these waters. Fresh waters acidified by acid rain can experience pHs as low as 3.0. This low pH can have adverse effects on aquatic life because most organisms thrive at a pH of 7-8. Long Island Sound does not experience lowered pH due to acid rain because the salts act as a buffer system. However, the pollutants in acid rain contribute nutrients, adding to the hypoxia problem in the Sound during the summer.

Floatable debris constitutes what most people term "garbage"—plastics, cigarette filters, cans, glass, paper. While aesthetically detracting, "floatables", such as plastic bags, can be ingested by marine life and prove potentially fatal. Many animals can become entangled in debris, like six-pack plastic rings, hindering their ability to feed, reproduce, grow, or escape predators.

This activity can take about 40-60 minutes depending on the length of the initial discussion and the time allotted for the cleanup attempt.

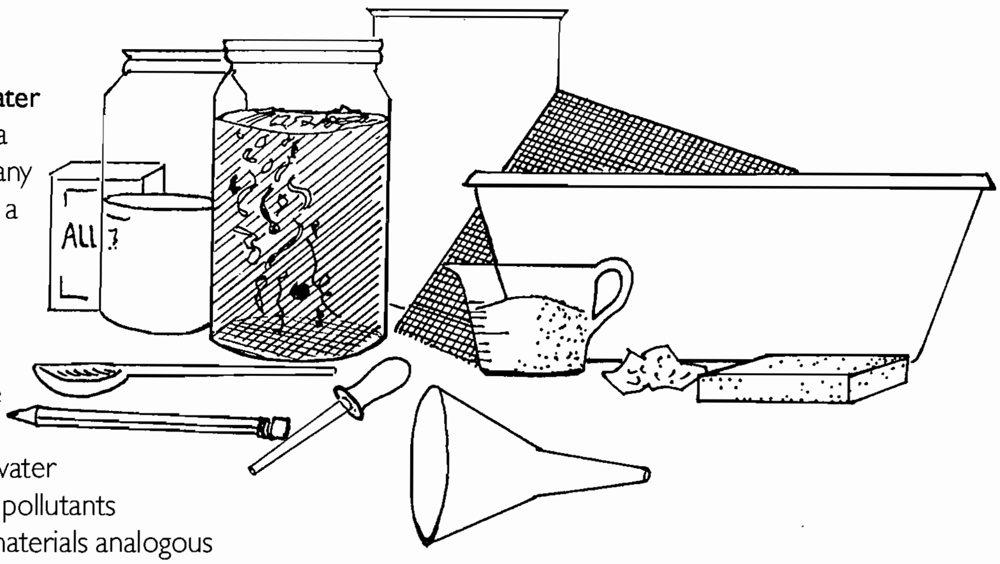
Objectives

- Children will learn different techniques used to remove pollution from water.

- Children will understand that it is not possible to clean up some forms of pollution.

Learning Activity

I. Cleaning Up Polluted Water



Activity Outline

I. Cleaning Up Polluted Water

While water pollution is a popular topic these days, many children have no more than a subjective awareness of the sources of pollution and how water must be treated to remove pollutants. In this activity the children observe various pollutants being dumped into a jar of clean water and then try to remove the pollutants with a variety of tools and materials analogous to those used in real water pollution clean-up situations. By limiting both the materials available for clean-up and the time for the task, the experience is made more life-like. This activity is best done in small groups of no more than six, near a sink and a supply of running water.

Materials needed: (for each small group):

I copy of "Water Pollution Cleanup" worksheet (pg. 67-68)
I pen or pencil
I wash basin or dishpan
I piece screening or mesh 6" square small wad of cheesecloth or aquarium filter fiber
I small sponge
I or 2 eyedroppers or pipettes
I or 2 spoons
I empty quart jar
I quart jar half full of clean water
3/4 cup filter sand or clean beach sand
I container for waste removed during cleanup process (quart-sized cottage cheese or sherbet containers work well)
2 funnels, medium to large sizes
I tablespoon alum (used for pickling, check spice section of grocery store)

Instructor will need:

- as many quart jars half filled with clean water as there are small groups
- labels or grease pencils to mark jars
- measuring spoons
- small aquarium pH testing kit or pH paper
- "pollutants" (real pollutants indicated in parentheses)
  - 3 tablespoons vegetable oil (petroleum)
  - 2 tablespoons leaf litter (sewage, organic wastes)
  - 1 teaspoon dirt (sediment)
  - 2 drops plant fertilizer (fertilizers and nutrients)
  - 5 drops dish detergent (detergents or general chemicals)
  - 1 drop food coloring (pathogens, toxic chemicals, heavy metals)
  - assorted litter: small pieces styrofoam, paper, plastic (floatable debris)
  - 1 teaspoon vinegar (acid rain)

Preparation

Gather the required materials, placing the equipment for each group in their dishpan. Prepare enough polluted water samples for each group but one by placing the indicated amounts of pollutants into jars half full of clean water. Keep the prepared samples out of sight until the activity starts. Prepare the last sample in front of the children for greatest visual impact.

Before starting the activity, you may want to check the pH of your clean water. In some areas, tap water already has a low pH, making the impact of adding vinegar to the water to represent acid rain much less dramatic. If this is a problem, try using distilled water, or adding a little baking soda to the water.

Starting the activity

Assign small groups then ask the class to list different things that are polluting our rivers, lakes, and Long Island Sound. Write the list on a flip chart or blackboard for reference. The list should eventually include at least: trash, petroleum, sewage, toxic chemicals, other chemicals (including detergents and fertilizers), sand or dirt (from erosion), and acid rain. You may have to ask some leading questions to get a complete listing.

When the list is complete, take the half jar of clean water, measure the pH, then, referring to the list on the board, add the analogous pollutants from the Materials List. Cap the jar, shake it up, measure the pH of the water, and announce that, working in their groups, they will have 20-30 minutes to clean the water sample to the best of their ability. Before passing out the water samples, go over the ground rules listed on the work sheet, and the list of clean-up materials available, have each group choose a recorder, and take five minutes to discuss the activity and come up with a "plan of attack." Pass out the clean-up materials, re-emphasizing what the groups have available. After these initial discussions, pass out the polluted water samples.

While the groups are cleaning their water samples, visit each group to answer questions and offer suggestions while avoiding giving specific directions. Encourage the groups to think before acting on an idea. Do not allow groups to obtain additional cleaning materials and be careful about allowing innovative groups to request paper towels, etc.

When their time is up, have each group place their materials back in the dishpan and bring their labeled jar of "clean" water to a central location for comparison and discussion.

Discussion

Have the group decide which jar of water looks the cleanest. Measure the pH of that sample. Have a spokesperson from each group describe briefly what techniques they used on their sample. Compare these techniques to real-life techniques used in water treatment plants. Many communities in Connecticut get their drinking water from reservoirs or rivers and must treat it before piping it to consumers. In water treatment plants, the water is passed through a screen to remove debris. The water then enters large settling tanks and alum, or similar chemicals, is added, causing fine particles to clump together and sink to the bottom of the tank. The water is then drained from the top of the tank and passed through sand filter beds to remove any remaining particles. In a final step, chlorine is usually added to kill bacteria and fluoride is sometimes added as a public service. Sewage treatment plants have similar setups, but slightly different techniques, as described in the LISS Fact Sheet "Wastewater Treatment".

Ask which pollutants were the hardest to remove. Most of the solid material should have been removable with the filter materials provided. Oils and detergents lay over the surface of the water and could be removed by skimming the water with a spoon or a sponge or an eyedropper. The acid rain, fertilizers and toxic chemicals could only be effectively "removed" with one available technique — dilution with clean water. This is the reason most polluters discharge their wastes into streams, for the dilution effect.

Ask if they think the dilution got rid of the pollution. Remind them that there was only one drop of food coloring added to the water sample. Discuss bioaccumulation of pollutants through the food chain.

Some children may think that we could clean up all our water by running it through a water treatment plant. Point out that this is not practical. The only way to keep our waters clean is to keep people from putting pollutants into them. Also note the large amount of waste that was created by cleaning up their water samples and ask the children how they think this material must be treated.

This activity tends to work best for groups that work well together and cooperate during the clean-up. Pollution is everyone's problem and everyone must work together if we are going to successfully clean up our planet.

This activity was adapted for Long Island Sound from one developed by Hudson River Sloop Clearwater, Inc.

Work Sheet

Water Pollution Cleanup

While Connecticut's rivers and Long Island Sound have become cleaner since Congress passed the Clean Water Act in 1970, there are still a lot of pollutants entering our waters. Many cities, factories, and other sources still dump wastes into rivers and the Sound. There are laws against water pollution, but they are hard to enforce, so polluters often break these laws and get away with it. Even when polluters are caught and have to clean up their pollution, it is often not an easy task.

Today you are going to try to clean up polluted water. Your group has a sample of polluted water and some equipment you can use to try to remove the pollutants from the water.

Before You Start

Before starting your cleanup project, your group should take a few minutes to plan your procedure. Choose one person in your group to be the recorder. The recorder should write down your group's cleanup plan. If you change your plan or add more steps, the recorder should add them to the plan.

You will have fifteen minutes to get as much pollution as possible out of your group's sample of water. Please keep the following in mind:

1. Do all pouring over the basin to avoid accidental spills.

2. The only clean water available is the half-jar with your cleanup equipment. Think hard how you can use this limited amount of clean water. You cannot use clean water from any other source.

3. Waste removed from the sample should be collected in the appropriate container.

4. At the end of the fifteen minutes, your group should have at least one half bottle of "clean" sample to compare with the results of the other groups.

DON'T HURRY! Take the time to think about each step of your cleanup project, about what kind of pollutant you are trying to remove, and what tools you have available.

	What Was Tried	Pollutants Removed
Step 1		
Step 2		
Step 3		
Step 4		
Step 5		
Step 6		
Step 7		

Glossary

absorption—one substance taken into another

adaptation—characteristic of an organism increasing its survival in its habitat

adsorption—one substance adheres to another

air bladder—fish organ providing buoyancy

anadromous—fish migrating from seawater to freshwater to spawn

benthic—organisms living on or in the bottom surface

bioaccumulation—progressive concentration of toxic substances up the food chain

biosphere—area of earth and its atmosphere inhabited by life

carnivores—animals feeding on meat

catadromous—fish migrating from freshwater to seawater to spawn

condensation—formation of liquid water from gas or vapor

consumers—organisms unable to produce their own food and must eat other organisms

decomposers—organisms feeding on dead matter and breaking it down into nutrients

density—amount of mass per unit of volume

ecosystem—community of organisms and their physical environment

erosion—wearing away of soil by natural forces (wind and water) and human activities (logging and agriculture, for example)

estuary—water body where meeting and mixing of freshwater and saltwater occurs

evaporation—loss of moisture in the form of water vapor, change of liquid water into water vapor (gas) form

first-order consumers—organisms feeding on plants; herbivores

floatable debris—waterborne debris, ie., garbage

food chain—sequence of organisms feeding successively upon the next, starting with plants, which are eaten by herbivores, which are eaten by carnivores, cycling through to decomposers

food web—all interconnected food chains

gill rakers—structures used by some fish species to strain plankton from the water

groundwater—water found beneath the surface of the earth

habitat—place where an organism lives

herbivores—organisms feeding on plants

hypoxia—low levels of dissolved oxygen in water

limnologist—scientist who studies lakes and ponds

moraine—accumulation of rocky material transported and deposited by glaciers

nonpoint source pollution—nonlocalized source of pollution, e.g., rain water picking up oil from parking lots

nutrients—substances essential to living things

oceanographer—scientist who studies the ocean

operculum—a protective lid or covering to a body opening

osmoregulation—physiological control of water concentration in an organism

pathogens—disease-causing viruses, bacteria, and micro-organisms

pelagic—organisms inhabiting open water

pH—measure of acidity; 0 is most acidic, 7 is neutral, and 14 is most alkaline or basic

photosynthesis—creation of carbohydrates by plants using sunlight, carbon dioxide, and water

phytoplankton—plants (usually very small) passively drifting near the water's surface; basis of the food chain

plume—teardrop-shape spreading of a contaminant in groundwater

point source pollution—obvious source of pollution discharge, e.g. sewage pipe

polar—molecules having both positively and negatively charged ends

precipitation—condensation of water vapor to rain or snow

primary producers—organisms capable of making own food, e.g. plants through photosynthesis; the base of the food chain

receiving waters—large water systems, usually lakes or oceans, into which streams and rivers empty

rocky intertidal—rocky habitat subject to intense wave action and exposed at low tide

salt marsh—vegetated land periodically covered by salt water

sandy beach—flat open habitat experiencing tidal action

scavengers—organisms feeding on dead matter

second-order consumers—animals feeding on first-order consumers; carnivores

sedimentation—accumulation of sediment in waterways resulting in clogging of water systems

solution—substance dissolved in water

spring tides—highest high tide and lowest low tide occurring twice monthly during full and new moons

subtidal zone—habitat constantly submerged, supporting benthic and pelagic communities

suspension—particles are mixed throughout a liquid, but not dissolved

thermal sink—moderation of nearby land temperatures by large bodies of water

thermal stratification—temperature differences at different depths in the water

third-order consumers—organisms feeding on second-order consumers

tidal flats—flat sandy or muddy areas exposed at low tide

transparency—ability of light to pass through water, a solution, or solid

transpiration—evaporation of water in plants through pores in the leaves

watershed—entire area of land and accompanying water draining to a large water body

zooplankton—animals (usually small) drifting passively in the water column

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Appendix 1: Adapting Activities to Childhood Development Stages

The purpose of any educational program, formal or informal, should be to help children grow and develop along pathways that will lead to their becoming fully functioning and productive members of their society. Planning such a program requires experiences that begin "where children are" and are designed to move them forward to more mature expressions and experiences. Good educational programming should respect children for who they are and what they can do as well as challenging them to imagine who they might become and what they might do. In other words, good educational programming is both grounded in the here and now and focused on the future.

The *Long Island Sound in a Jar* activity guide has been developed for your use with these points in mind. It is hoped that children participating in any or all of these activities will get: a better understanding of the dynamic interaction of the earth, its ecology, and its inhabitants; to discover the explorer, scientist, and inventor within themselves; an opportunity to interact successfully with others.

Planning for Success

A quality educational activity should be tailored to the changing characteristics and needs of the target audience. The audience for the *Long Island Sound in a Jar* curriculum is school-age children, Kindergarten through Junior High. It is important for the instructor to note that during this period of time, children pass through three distinct developmental stages. The first stage occurs between the ages of about 5 to 7, the second spans ages 8 to 10, and the third stage covers ages 11 to 14. Keep in mind, however, that the age ranges just mentioned are approximate. Although all children pass through the same stages, they do so at different rates. What is important to know is that, as children move through these stages, their abilities, interests, activities, and priorities change. The following chart outlines important features and characteristics for each developmental stage of the school-age child. Knowing about and planning for the developmental differences in children will take you a long way in presenting effective and fun educational activities.

Also keep in mind other essential elements of high quality school-age programming:

1. A Teacher/Leader who:
   - listens to and talks with children in meaningful conversations as individuals and in groups;
   - gets involved in the children's projects, games, and activities rather than directs or dominates them;
   - treats all children with respect, showing no favoritism based on sex, race, religion, ethnic background or social status and encourages the same behavior in children;
   - encourages responsible independence in children;
   - has the courage to admit that an activity is a dud and can switch gears and re-engage children's interest and energy.

2. Activities that:
   - foster a positive self image and a sense of independence;
   - encourage children to think, reason, question and experiment;

- enhance physical development, encourage cooperation and promote a healthy view of competition;

- encourage sound health, safety and science practices as well as a creative and wise use of leisure time;

- create awareness of the community and world at large and provide direction for children's involvement in it;

- are, at most, 15 to 20 minutes in length and encourage diverse types of responses from the children, i.e., listening, observing, measuring, writing, recording, reporting. (Note: This means that if you have 30 minutes, expect to present at least 2 different activities.)

3. Strategies for Handling:

   a) Misbehavior

   - Identify and clearly communicate the expectations, rules, and limits for participants' behavior for each module and learning activity.

   - Have a response plan for dealing with misbehavior redirection from unacceptable to acceptable behavior: one-to-one talk; problem-solving strategies; group discussion; removal.

   b) Mixed aged/mixed ability groups

   - Provide opportunities for older children to help younger ones.

   - Group children by interest or in other ways and not by age or ability.

Final Thoughts

Don't be afraid to tinker with the curriculum. Do whatever you need to do in order to make it a vital part of yourself and your students. The only request is that you keep the curriculum developmentally appropriate, experientially based (hands-on activities), and factual.

Dr. Maureen T. Mulroy
Human Development Specialist
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Individualizing Activities

Young School-age (5 - 7 years)	Middle School-age (8 - 10 years)	Older School-age (11 - 14 years)
Experimentation is the key to successful activities. Let them use their bodies, ideas and materials in new and different ways. There is no right or wrong way.	Skill development is most important. Learning how to use "real" tools, equipment and materials is of great importance. They want time to practice new skills but don't want to get bogged down with rules.	Coordinating and combining well-learned skills and abilities into new routines and rule-regulated activities is of interest to this group. This age child places great emphasis on precision and perfecting.
Experience and not a finished product is what is important to this age group.	Although interested in making and doing "real" things, they are not interested in making masterpieces or in perfecting skills.	Completed projects, finished products, works of art are core issues. They enjoy seeing other "artists" or "scientists" working and sharing "tips of the trade."
Incorporate fantasy, pretend and dramatic play in as many aspects of an activity as possible.	Need to use "real" toys in their play and are apt to include all sorts of sound effects while involved in play. They enjoy involving others in their play and are able to "go with the flow" of changing ideas and input.	The imagination is channeled into adult expressions such as making documentaries, poetry or short story writing. These children are ready to take a script and make it come alive via acting, directing and scenery construction.
Emphasize the use of the senses. Activities that require them to use their ears, eyes, nose, mouth and skin are right on target! Think about combining two or more senses.	Learning about how we sense rather than the actual sensations is more interesting. They enjoy models, diagrams and experiments involving the human body and its functions.	Emotional responses to sensory stimulation is very typical. They respond to the beauty of images, words, movements, etc. It is not unusual for them to "cry for no reason." Also be ready for experimental behavior to enhance sensory stimulation, i.e. drug and alcohol use.
Activities that reenact the routines and events of their known world (home and school) will be sought and enjoyed.	Who, What, When, Where and Why are the questions this group thinks are important. They are eager to translate newly-acquired information into stories, articles and trivia games to be shared with family and friends.	Global awareness and interest in people from around the world are of great importance.

Young School-age (5 - 7 years)	Middle School-age (8-10 years)	Older School-age (11 - 14 years)
Fostering friendship skills of sharing, helping, taking turns working with another person are very appropriate.	Friendship groups are formed around common interests. It is not unusual for them to have "secret" handshakes, passwords and languages. Any activity that teaches a new or "out of the ordinary" skill will be a hit. Be ready for in/out group fighting and "pecking order" arguments.	Having a best friend and being part of a group are key concerns. They welcome opportunities that help them meet members of the opposite sex. They enjoy administering surveys and collecting data that puts them in touch with the ideas and attitudes of their contemporaries.
Finding appropriate ways of channeling emotions and their behavioral expression are necessary and important. Help children to use words rather than actions to express their feelings.	This group likes to think that they are really "cool" and don't have emotions. They will dare and double dare each other to prove their coolness. They need assistance in recognizing the appropriateness of feelings and in finding ways to verbally express concerns, fears and affections.	Finding different ways of expressing feelings and ideas is of great interest. Exposure to poetry, dance, art and communications training as alternate means of expression is a good idea.
Children learn who they are via what they can do! Help them see how far they have come since they were preschoolers and show them what they have to look forward to as they continue to grow and learn.	These children need to learn about who they are and what they can do by interacting with their peers. They need to see that each person in their group has important information and experiences to share and that they can retain their identity while still being part of a group.	Interest in the physical self tends to be the primary focus of this age group. It is, however, important that they see themselves as being social, emotional and intellectual beings. Meeting men and women from a wide variety of careers and backgrounds is a great way of seeing the possibilities that reside within themselves.

Appendix 2: Additional Background Reading

The following columns were chosen from a series written by Connecticut Sea Grant Extension Educators, Chester Arnold, Nancy Balcom and Heather Crawford, which ran bi-monthly in *The Connecticut Post* between 1991 and 1996. They are intended to complement the activities presented in *Long Island Sound in a Jar*, provide background information and generate classroom discussion. They are reprinted here with permission and may be reproduced for educational purposes.

The Urban Sea: Connecticut's Great Resource

Chester Arnold
*April 7 & 21, 1991**

Long Island Sound is THE natural resource of Connecticut. The state of New York, our partner in the use and management of the Sound, can boast of a long list of impressive and important water bodies, including two Great Lakes, the Hudson River, Great South Bay, and New York Harbor. Not so, Connecticut. Long Island Sound, with a little help from the Connecticut River, defines and dominates our state.

A wise-cracking colleague of mine likes to say that without the Sound, Connecticut would be "just a small boring corner of Iowa." While I do not subscribe to this theory (insulting to both Connecticut and Iowa alike, I imagine), it is true that without the influence of this great expanse of water to our south, Connecticut would be a vastly different place. Inspiring in its beauty and a bit overwhelming in its complexity, Long Island Sound has been the backdrop for almost all of the important historical events shaping the history of our state. Today, it continues to be a major, if less visible, factor in our economy, our public health, our collective identity, and our quality of life.

Long Island Sound is surrounded by people, earning it the nickname of "The Urban Sea." This is not surprising, given that as a nation, we have a strong tendency to flock to the shore, with our coastal counties sporting a population density of 341 persons per square mile, approximately six times the U.S. average. Here in the LIS area, we make that figure look like some thing from the Alaskan tundra, with a population of 2,300 people per square mile in the coastal counties surrounding the Sound. If we further narrow our view to only the coastal towns, the figure grows to almost 4,000 people per square mile — 62 times the national average!

By this measure, the Sound is almost surely the most urbanized major water body along America's coast, with the heavily populated western areas of the Bronx, Queens, Westchester, Nassau, Fairfield and New Haven counties giving way only grudgingly to the more rural areas in eastern Connecticut and along the north shore of Long Island. In fact, this has always been the case, relatively speaking. When European settlers first arrived here in the 1600's, they found what is believed to be the heaviest concentration of Native Americans on the continent. The easy living provided by the bountiful waters of the Sound and the rivers of the area was the principal reason for this gathering of the tribes.

The lives of the new settlers also revolved around the Sound, which became the major highway for transportation. A reproduction of a pre-colonial map that I have labels the Sound as "The Devil's Belt," a romantic first nickname that I have no explanation for, but is presumably navigation-related. Bridgeport, New Haven, New London, Middletown, Hartford — all grew and prospered because of their location at natural harbors or otherwise strategic spots along the Sound or Connecticut River.

During the 1800's, the Sound came into its own as a reliable food source, and the fame of LIS oysters spread far and wide. I have not come across any nickname for the Sound during this period; perhaps, as a no-nonsense work site, the Sound had no need of one. Toward the end of the nineteenth century and into the twentieth, the railroad opened the eastern half of Connecticut's shoreline to visitation from the multitudes of New York and Boston. Soon, Connecticut's coast sprouted a crop of opulent resorts, and the Sound became known as "The American Mediterranean" from the late 1800's until the outbreak of World War I.

At the same time that tourists were Mediterraneanizing, the industrial revolution was picking up steam and transforming large areas of the shoreline and surrounding areas. From the standpoint of transportation and waste disposal, the coast is an ideal industrial site, and the shores of the Sound were no exception. This trend culminated in the 1950's and 1960's, when Connecticut, in particular, turned its collective back on the Sound in terms of uses other than industrial and transportation. Meanwhile, the improved transportation routes opened up much of the Sound area to the joys of commutation, and galloping suburbia was born.

In the last 15 years interest in the Sound has revived. Now more than ever, people want to work, play, and live in close proximity to Long Island Sound. The water pollution implications of this paradox are as obvious as they are ironic. The same qualities that attract people to the Sound — beautiful beaches, clean water, fresh seafood — are the very things being threatened by our loving excess of attention.

In other words, what we want is "The American Mediterranean: The Sequel", while what we got is "The Urban Sea". This basic conflict, overlain onto the natural complexity of the Sound, gives rise to the many issues, problems, and programs that are the subject of this column.

* Editor's Note: This column is condensed from the first two columns of On Long Island Sound, a feature that appeared periodically in *The Connecticut Post* between 1991 and 1996.

Salt Marshes: Enjoy 'Em While You Can!

Chester Arnold
July 28, 1991

This may not have come up in conversation recently, but in terms of geological time, we live in a rare Golden Age of salt marshes. Salt marshes, or coastal wetlands, occupy the low ground surrounding bodies of salty water. This spiky green fringe grows slowly, in the relatively narrow zone subject to periodic inundation by the tides.

In geologic eras when sea level is rising or falling rapidly, the salt marsh plants can't keep pace with the rapidly changing conditions at the water's edge. During the last 4000 years, however, most of New England has been experiencing a gradual rise in sea level, creating perfect conditions for the proliferation of marshes.

Coastal marshes are critical components of the Long Island Sound ecosystem. The marsh habitat provides a home for a host of birds, mammals, and reptiles (not to mention insects), and its salt water channels provide shelter for many species of young fish. The plant material of the marsh eventually finds its way to the Sound, becoming a key building block of the estuary's immensely productive food web. Wetlands even get into the environmental protection racket, providing a goodly amount of water treatment through uptake and removal of toxic materials, organic compounds, and nutrients from contaminated water.

Unfortunately, man has created a Reign of Terror smack in the middle of the Golden Age. What nature has provided, man has been busy taking away. Experts estimate that only about half of Connecticut's coastal marshes existing prior to European settlement remain intact today. The rest have been either removed through dredging, or turned into more buildable acreage through addition of fill.

The destruction of coastal wetlands is another environmental tragedy that began in ignorance rather than malevolence. The level of regard that our ancestors had for marshes is hinted at by the term historically used for them — swamps. Swamps were smelly, insect-ridden wastelands that could best be made useful by filling them in — progressive reasoning at the time, and reasoning that led to dramatic alterations in our coastline. The extent of these alterations might surprise you. The next time you pass New Haven on I-95, consider that virtually all the land as far as you can see to either side — asphalt, concrete, and otherwise — was originally salt marsh, right up to the town green.

During the 1950's, the importance of salt marshes (in fact, all marshes) began to be realized. For a number of years, the voices of coastal ecologists were easily drowned out by the rumble of busy payloaders and backhoes. Slowly, however, the need to protect salt marshes began to sink in, and laws protecting the marshes from various depredations began to sprout up in New England during the 1960's and 1970's.

In Connecticut, the culmination of growing legal protection for coastal wetlands came with the passage of the state Coastal Management Act in 1979, which made it illegal to dredge or fill salt marsh. Like all laws, however, it took some time before the transition was made from paper to reality. And, while wholesale destruction of coastal wetlands has stopped in the state, it is probably fair to say that due to lack of enforcement manpower, small pieces of marsh continue to be illegally nicked out of the coastline now and then.

Although salt marshes now enjoy protected status, debates on the preservation of critical coastal habitats continue. The latest battleground is the tidal mudflat, the zone just seaward of the marsh. Should all mud flats be protected, including ones that are already seriously polluted and therefore environmentally damaged?

Questions like this carry us beyond the black and white of preservation and destruction into the gray area of restoration.

Oyster Industry Rebounding

Nancy Balcom
May 3, 1992

I just hung up the telephone after talking with another caller interested in aquaculture in Connecticut. As the state Extension contact for the Northeastern Regional Aquaculture Center (NRAC), I get a lot of inquiries along those lines.

Just what is aquaculture? Officially, it is the cultivation of aquatic animals and plants for commercial or recreational purposes — aquatic farming, so to speak. In Connecticut, there are currently two forms of aquaculture: bottom culture of oysters and clams, and farm-raised finfish production (for food, bait, restocking or fish for fee programs). In 1981, Connecticut became one of the first states to formally recognize aquaculture as a form of agriculture and farming. The General Statutes define aquaculture as the "farming of the waters of the state and tidal wetlands and the production of protein food, including oysters, clams, mussels and other molluscan shellfish on leased, franchised and public underwater farm lands."

As a result, the shellfish industry is regulated by the Department of Agriculture, Aquaculture Division, headed by John Volk and based in Milford. However, finfish farming, being relatively new, was basically overlooked in the definition of aquaculture, and is overseen by the Department of Environmental Protection, which also runs three state-owned hatcheries.

By far, shellfish are THE foundation of Connecticut aquaculture, and the Eastern oyster industry is the primary reason why Connecticut is one of the largest aquaculture states, in terms of production and value. Presently, 25 shellfish firms employ around 425 individuals. While current levels of oyster production do not come near to matching production levels during the industry's heyday in the late 1800s, production is rebounding with a vengeance, due to the combined efforts of the state and industry. In 1991, 540,000 bushels of oysters valued at more than $26 million were landed, as well as 1.2 million pounds of hard clams, valued at $3.8 million.

Have you ever seen what appear to be tree branches sticking up out of coastal waters here and there? You are looking at markers for shellfish grounds. There are 52,000 acres of shellfish grounds currently under cultivation (as compared to 88,000 acres in 1890).

Since aquaculture implies "farming" which in turn implies manipulation, a brief background on oyster reproduction and shellfishing operations is necessary. Oysters spawn in the water column, where sperm and eggs mix. The resulting planktonic larvae need a hard substrate upon which to settle and attach. Once the attached larvae or "spat" attain the size of a quarter, they are considered seed oysters, and are collected and transplanted to better grow-out beds.

While other states must rely on hatchery-reared seed oysters, Connecticut is blessed with bountiful natural spawning grounds—in particular, 3,000 acres off Stratford and Bridgeport. These state-owned seed beds have been enhanced with more than 1.2 million bushels of "cultch" or oyster shells, to provide the hard substrate preferred by settling oyster larvae. Since 1988, the state has invested $4 million into planting cultch, in an effort to revitalize the oyster industry.

Once the oysters reach market size (depending on the classification of the grow-out waters), they are either harvested directly for market or are first relayed to other grounds in clean waters for a period of depuration or self-cleansing. These efforts are all carefully regulated to ensure the protection of public health.

The aforementioned NRAC is one of five regional centers established by Congress five years ago. NRAC develops and sponsors regional research and extension projects in support of the aquaculture industry in the northeastern U.S. Funded by the U.S. Department of Agriculture, NRAC is currently housed at UMASS Dartmouth, and represents aquaculture operations from Maine to West Virginia. Members of its committees are drawn from universities, extension and industry.

Growing in leaps and bounds, aquaculture is becoming increasingly important both in Connecticut and nationwide. The shellfish and finfish produced are prime examples of the fine "Connecticut Grown" products we have for our consumption in this state. Ask for them!

Sport Anglers Need to be Conservation and Quality-Minded

Nancy Balcom
June 14, 1992

Fishing season has been in full swing for awhile now. Hundreds of thousands of Connecticut residents take part in this traditional recreational pastime—trying their luck and testing their skills against unseen adversaries. Landing that first fish is an unforgettable milestone. I remember the first bluegill I caught with my grandmother some 25 years ago as vividly as I remember landing my first bluefin tuna six years ago.

Unfortunately, the reality is that many fish stocks are depleted, victims of their own popularity. State and federal fishery management regulations are in a constant state of flux, in an effort to try and keep pace with the problems of overfishing, restore a balance and rebuild the stocks. Fishery management is an inexact science. It is exceedingly difficult to manage something you can't see and that is constantly moving. As new information becomes available or old information is re-evaluated, management regulations change, frustrating commercial and recreational fishermen and resource managers alike. Meanwhile, the competition between recreational and commercial fishermen for the same fish stocks continues to grow.

Recreational landings greatly exceed commercial landings for a number of species in Long Island Sound. In the case of scup, recreational landings have been 22 times greater than commercial landings. Since many of the more popular fish species are overfished, expand your horizons. Try sampling less-utilized species, such as sea robins or skates. What the heck, you might find out they're downright tasty!

One of my concerns is how anglers handle the fish they catch. Fish are extremely perishable critters and can spoil rapidly if proper precautions aren't taken. You wouldn't buy a fish that was obviously in poor condition, so why would you want to spend time fishing and bring home fish in sub-optimal shape?

Fish start to spoil the moment they die. They are a veritable breeding ground for bacteria. There are three simple things to remember—quick kill, clean and ICE, ICE, ICE! The quick kill prevents the fish from flopping around, an activity that promotes bruised flesh and reduces quality. Gutting eliminates the party life of the bacteria harbored in the digestive track. Thorough icing is most important. Crushed ice works best because it completely surrounds the fish for faster and more efficient cooling. The end result: high quality fish that smell fresh, not fishy, that will tantalize your palate.

Many anglers live by the adage "take only what you need, leave the rest for another day," which thankfully has replaced the "slay the fish" mentality, a practice that led to a tremendous waste of fish. In addition, with conservation on their minds, more anglers are participating in catch-tag-and-release fishing programs. Anglers can obtain tags from programs such as the National Marine Fisheries Service Cooperative Shark and Game Fish Tagging Programs, the American Littoral Society, and the Billfish Foundation. Each tag comes with a simple data card, which the angler fills out and returns to the program after a fish has been tagged and released. If the fish is recaptured, the tagger is notified.

What are the benefits to participating in tagging programs? There is the excitement of finding out when and where "your" fish was recaptured. You contribute to the conservation of the resources. The data also help fishery biologists learn more about the movements and growth rates of fish stocks; knowledge that is used in combination with other information in making management decisions.

Unfortunately, some anglers and commercial fishermen fail to return tags, thinking the data will be used against them, either in making management regulations more restrictive or by giving information to their "enemies." While management decisions are never based solely on tag return data, every piece of information adds to the basic understanding of fishery resources. And, by the time a fish is recaptured, the tag returned, and the information processed and publicized, you can be sure that school of fish is nowhere near where it was before! There are many faster, high tech ways to help anglers and commercial fishermen alike to determine where the fish are. Think too, of the tagger's disappointment, who never hears that one of his/her fish was recaptured—less than a year or maybe 10-15 years later!

So, cast your line into the Sound and reel one in this summer. But keep in mind the others who'll come after you, who wish the same opportunity, privilege and pleasure.

Comparison of Spills Shows Luck on our Side

Heather M. Crawford
February 21, 1993

Pop quiz time! What do the Shetland Islands north of Scotland and Long Island Sound have in common? The answer, unfortunately, is that both have been the site of a major oil spill within the last three months. In both cases, a vessel carrying oil went where it shouldn't have been and ran aground. A comparison of the two spills shows just how lucky we were on this side of the Atlantic.

In the early morning hours of December 21, 1992, a tugboat delivering a barge loaded with No. 2 home heating oil to New London got lost, strayed outside the channel, and ran aground on Black Ledge at the mouth of the Thames River. The collision put a hole in the hull and cracked it in three places. A distress call went out and within two hours the barge was surrounded by containment booms. Within five hours, the remaining cargo had been transferred to another barge. By Tuesday evening the barge had been refloated and was being towed off for repair.

The barge had a cargo capacity of about one million gallons. More than 25,000 gallons of oil eventually escaped into the water from the 39,000 gallon tank that was ruptured, but the release of the remainder of the cargo was prevented. Number 2 fuel oil is a light grade that rapidly degrades or evaporates with exposure to waves and sun. Most critical habitat areas were protected from contamination with oil-absorbing booms so the total environmental impact is expected to be slight to moderate. Some commercial lobster and clam operations in the area lost gear and animals to oil contamination. Oil also traveled to Niantic Bay much faster than anticipated, threatening local scallop restoration efforts, but the tugboat firm will be expected to pay compensation for economic and environmental damages.

Things did not go so smoothly in the North Atlantic. On January 5, 1993, a tanker carrying over 22 million gallons of heavy crude oil lost engine power and the crew abandoned ship. The tanker went aground at the north end of the Shetland Islands during a heavy gale and began to break apart. The weather conditions were so bad that no type of containment or oil recovery measures were possible. Several days later the tanker split into thirds, releasing the entire cargo. Oil spread down the coast of the island and was also blown inland by near-hurricane force winds. Everything: seals, birds, salmon farms, local sheep herds and pastures were soaked with oil. Residents of the island have been breathing windborne oil for weeks on end. While the tanker company will have to pay for cleanup and damages, simply assessing the total damage could take years.

Long Island Sound managed to dodge the oil spill bullet this time, thanks in part to favorable weather conditions, but also because of the Long Island Sound Oil Spill Contingency Plan. This plan was mandated by a federal act passed after the 1989 grounding of the oil tanker, the *Exxon Valdez*. It includes everything: a detailed inventory of available personnel and equipment; models of water movement; a mapped inventory of critical habitats and environmentally sensitive areas; and full-blown training exercises. The plan is supposed to help all the state, federal and local agencies responsible for responding to an oil spill act in an integrated manner. The New London spill was the first test of this plan and, while a couple of small glitches did surface, the plan did its job.

It's a good thing it did work, since there's an estimated two and a half BILLION gallons of oil transported through Long Island Sound each year. Some spills could be eliminated by requiring double hulls on tankers and barges, an industry standard environmentalists have been screaming about for years. But until someone figures out how to eliminate operator error or mechanical failure from the whole oil transportation system, the chances of another spill, in Long Island Sound or anywhere else in the world, are pretty high.

Common Phrases Anchored by Nautical Origins

Nancy Balcom
June 27, 1993

Summer's here, which makes me think of a hammock, some good books and total laziness. It's a time when life shouldn't be too taxing and I think column-writing (and reading) falls into that category. Therefore, this column is not about an earth-shattering subject. It's about words—and their nautical origins.

Many words, phrases and sayings in daily use originated during the era of sailing ships. The meanings of these phrases, once very specific to sailing and sailors, have become obscured or more generic over time.

For example, take the word "posh." Today, this means the best accommodations. Aboard British vessels that sailed between India and Britain through the stifling Red Sea, it was preferable to have a cabin on the shaded side of the ship. These highly prized cabins cost extra and those who paid for them had their tickets stamped "POSH," meaning "port out, starboard home."

Do you "get the point?" This phrase originated at the court-martials of British officers. The verdict was indicated by the placement of a sword in front of the officer—if the hilt was placed towards him, he was "not guilty" but if the blade pointed to him, then he would "get the point."

Have you been accused of being a "stick in the mud?" This term for a non-progressive person was originally used to describe pirates who were hanged on the docks of London and their bodies buried in the mud of the Thames River. Did you "let the cat out of the bag?" Today, this expression means to say something you should have kept to yourself. During the time of sailing vessels, it brought fear to any sailor guilty of a crime. He faced a brutal whipping with a cat o'nine tails.

A novice seaman would become familiar with the names and uses of all the ordinary ropes on a vessel during his first voyage. When he was discharged, the captain would mark his papers "knows the ropes." Today, this phrase means familiarity with all aspects of a task.

Are you "aboveboard" in your business dealings? Pirates had the rather sneaky habit of concealing most of their crew below decks, making their vessels appear less threatening to merchant ships loaded with treasure. These hidden pirates were used to help capture the merchant ships. Honest captains kept their crews "above board."

"Hands off!!" Sailors were considered a rough group of men and were not allowed to carry weapons except when in battle. They were permitted to keep one knife in their kit bags. However, if that knife was ever drawn against another sailor in anger, British Admiralty law dealt the aggressor a harsh punishment—the man would lose his hand.

Sometimes the best way to describe a strained relationship between two people is to say they are "at loggerheads." In sailing terms, the "loggerhead" was a tool used to spread hot pitch in the seams between the planks of a vessel. It was a hot and dangerous job, sometimes leading to hot tempers. If a fight broke out, the loggerhead was often used as a weapon.

Do you like to hang around the water cooler to get the office "scuttlebutt?" Ships had an open cask of water which was set out where men gathered for a drink of water and the latest news. The cask was called a scuttlebutt.

Not everyone hangs on "to the bitter end" these days. In nautical terms, "bits" were vertical wooden beams through which the anchor cables passed. If all the ship's cables were run out, the small amount that remained on board was referred to as "the bitter end."

"Not by a long shot" had its origins in naval warfare. Unlike our current ability to launch missiles long distances towards targets unseen, battles between sailing ships were up close and personal. The cannons used had an effective range of 50 yards or less. Anything in excess of this distance was considered "a long shot."

These are just a few of the expressions we commonly use that were born at sea. I could continue but I won't. So, keep your shirt on, you son of a gun. Remember that the tie that binds is squared away. I can tell by the cut of his jib that he should be deep sixed. In the doghouse and feeling blue? Well, I've had a windfall and I'm going to leave you high and dry. Don't get carried away!

Introduced Species Mask Native Ecosystems

Nancy Balcom
August 8, 1993

Recently I had the opportunity to serve as guest speaker on a Connecticut River "green" cruise. As we cruised along, someone remarked about the "pretty purple flowers" along the shoreline. I felt compelled to tell the group that those colorful flowers were actually a biological pollutant in disguise—an introduced aquatic species called purple loosestrife. This non-native plant is setting down a lot of roots here, choking out native wetland plants like cattails that provide marsh animals with food and shelter. (Sometimes the swan turns out to be an ugly duckling.)

Connecticut has its share of biological pollutants which subtly or dramatically change the local ecosystem, or have been here so long we don't know what the natural system even looks like. Some, like the gypsy moth caterpillar and the zebra mussel, are very damaging to the environment and the economy.

Some invaders have been part of the local scenery so long, it's hard to imagine them NOT being there. In Long Island Sound, notable examples are the common periwinkle and the green crab. The periwinkle was deliberately introduced to eastern Canada in the 1840s by European settlers as a familiar food item from home. This little snail, less than an inch long, is now the predominant marine organism of the New England rocky coastline. Scientists believe that this snail dramatically changed our coastal ecosystem, competing for space and food with the native critters. If this snail was introduced to New England today, rather than 150 years ago, it would be considered an environmental disaster.

The green crab was also transplanted from Europe in the early 1800s. A consumer of plants and animals, it now holds a significant role in the local happenings of the rocky shore, both as predator and prey.

"Fouling" organisms are particularly unwelcome, attaching to anything that's in the water. Sea squirts from Asia and California are making Long Island Sound their home, much to the chagrin of boat owners and fishermen. Sea squirts are animals with grape-like, elongated or vase-shaped bodies with two projecting spouts. When prodded, they often oblige with a squirt of water, thus their name. They have no food or bait value for humans or marine organisms, but they may be crowding out blue mussels, which do serve those purposes.

The spongy green seaweed commonly referred to as "deadman's fingers," a native of Asia, arrived in 1957. It attaches to hard surfaces like oysters and scallops with a "holdfast," damaging shellfish beds. This seaweed is also called the "oyster thief" because larger plants can become buoyant and drift away with their cargo of oysters attached.

How do invader species "invade?" Well, some are deliberately introduced—like the periwinkle and the brown trout. Others arrive accidentally, hitching rides on ship bottoms or fishing gear. They can be carried in ballast water or packing containers, released by bored home aquarists or escape from researchers. The walking catfish of the South literally fell off the back of a truck and landed near a drainage ditch.

The plague of zebra mussels in the Great Lakes has riveted attention on ballast water—water pumped aboard empty or partially loaded ships to improve their stability. Millions of gallons of ballast water from ports worldwide, along with countless marine cargo, are discharged weekly into the Sound alone. Some organisms survive the transoceanic trip, but continued survival in the new world is not assured. Conditions have to be just right for the newcomer, and most times they aren't, which is why there hasn't been a wholesale mixing of aquatic species worldwide. New Coast Guard regulations require the exchange of ballast water at sea by ships heading to the Great Lakes. More may follow regarding coastal port discharges.

Opinions on the effects of introduced species vary as widely as the species themselves. Anglers welcome the introduction of additional gamefish. Scientists lament the changes in the local ecology and food chain. Utilities want to barr the door against damaging species like zebra mussels. While increased regulatory attention may dramatically slow the number of invasions that occur, they will nevertheless continue. Who knows what species will "rule" the Sound in 100 years?

Winter's Roads Lead to Pollution

Heather M. Crawford
January 23, 1994

I'm sure I am NOT the only person in the state of Connecticut at this time who would desperately like to fast-forward through winter this year. Skiers and other fans of arctic pastimes may love this opportunity to play in their own state. Meteorologists may be thrilling at "one of the most active winter weather patterns since 1978-79." I, however, wish to be on a nice, warm beach, and the frozen version I see everywhere these days is not improving my attitude.

I am, of course, referring to our roadways. It doesn't take a lot of imagination to break a beach down into some major component parts: sand, salt, and water. Things like sunscreen, jellyfish and shells can be considered seasonal accessories. Travelling on almost any road in Connecticut this winter will bring you into contact with all the same major parts, accessorized for this season with mittens, ice-covered tree branches and downed power lines. The difference is that summer beaches are enjoyable and winter roadways definitely are not!

Another major difference between beaches and roads is that the same components that combine to create an ecosystem we love at the beach can be quite destructive when introduced into other ecosystems via our road-ways. Road sand and salt are two major ingredients in the brew of pollutants contributing to "non-point source" water pollution, also known as "polluted runoff," "toxic runoff," or "pointless pollution." These general terms distinguish the complex mix of pollutants that are washed from the land into the water with every rainstorm or snowmelt from pollutants that enter the water via the discharge pipes of industry or sewage treatment plants.

Many nonpoint source pollutants are materials that seem harmless or minor when considered individually, but when combined become a significant source of water pollution. One example of nonpoint source pollution frequently used when discussing Long Island Sound is fertilizer (nitrogen) applied to the average residential lawn or garden. The runoff from an individual yard might seem too miniscule a quantity of nitrogen to worry about, but when it is multiplied by the millions of yards in the Long Island Sound watershed, the total is staggering.

In a similar manner, most people consider the use of sand and salt a messy, but effective and harmless way to keep roads open during winter storms. The problem is that neither sand nor salt are truly harmless when they end up in small streams and ponds. Some sand, or sediment, would enter such systems naturally. When sand quantities are increased to the levels that wash off roadways after a winter storm, it can bury the bottom of a stream, smothering the resident animals and plants. It also changes the shape of the stream in a way that may lead to flooding within the watershed.

The atoms that make up salt — sodium and chloride — are normally found in extremely low concentrations in fresh water systems. Adding too much salt to fresh water systems is sort of like poisoning the fish and other inhabitants. In addition, too much sodium in drinking water can cause human health problems. This is one reason for the signs you see along the roads indicating a public drinking water supply watershed. Many communities restrict the use of road salt in these watersheds to keep sodium out of their water supply.

We use a LOT of sand and salt on our roads. Average figures for state roads alone are slightly under 85,000 TONS of salt and 294,000 TONS of sand per year. That's enough sand to make a sand castle ten stories high and covering a football field! While some of the sand will be swept up and collected from the roadways in the spring, much of it ends up going over road embankments or down storm drains and washing into the nearest pond or stream.

Since I'm not about to suggest that there's no need to clear the roads after a snow or ice storm, I'm not sure there is a solution to this dilemma. We'd save a lot of personal and societal frustration if we recognized that Mother Nature and Old Man Winter sometimes want us all to stay home with a cup of cocoa and a good book rather than hitting the road. Until everyone gets snow days from work as well as school, we at least need to recognize that fighting that pair has environmental as well as economic impacts.

Remember Sound during clean-up

Heather M. Crawford
April 17, 1994

FINALLY — after the winter that wouldn't end — spring is here and we can do everything that was impossible when snow and ice dominated the landscape. Getting out of work while the sun is still in the sky is even more incentive to "just do something". This annual rush of excess energy (a physiological reaction to the extra light from lengthening days) is my explanation for the activity known as "spring cleaning". I can't think of a more reasonable excuse for why I suddenly feel like washing my windows and digging out my compost heap. If you feel the spring cleaning urge, you can help protect Long Island Sound by keeping the following few tips in mind.

• When cleaning up the sand left from the running battle for safe streets this winter, don't just sweep it back into the street. Excess road sand washes into storm drains, then out into wetlands and streams, where it buries both plants and animals. Consider recycling the sand by screening excess debris out of your sweepings and storing it for use next winter. You can also spread a thin layer on your lawn to adjust soil texture, or when planting landscaping plants that prefer well-drained soils. Because this sand may contain very small quantities of heavy metals from the roads, it is not a good idea to use it in vegetable gardens.

• Spring cleaning in the yard is a good time to start a compost pile. All the leftover leaves, plant stems, old mulch and dead grass raked out of corners make a great base for a pile. You can add grass clippings, bush trim-mings and other yard waste all spring and summer. By next spring you'll have a free supply of soil enhancer to use on your lawn, in land-scaped areas or as pot-ting soil. Compost piles recycle nutrients and organic matter on-site, preventing problems in local waters and Long Island Sound.

• If spring cleaning means whipping the lawn into putting green-perfect shape, think carefully before applying chemicals. Many of the problems in the Sound, as well as inland ponds and lakes, are linked to excess nutrients (fertilizer) and toxic chemicals (pesticides) that are improperly applied to residential lawns and gardens. Have your soil tested (kits are available at your local Cooperative Extension office) to see how much fertilizer you really need. Consider skipping spring lawn fertilization. Grass uses spring nutrients to grow big, healthy blades that you'll just have to cut. Fertilization later in the year produces good root systems for a healthy lawn.

Scout your lawn regularly for insect or weed problems. If you catch a problem early, it can be controlled with spot treatment and you won't need to use chemicals on the whole lawn.

• If you'd rather work on the car instead of the yard, think twice about where your car fluids go. Wash cars on the grass instead of in the driveway to keep the soap suds and road gunk from going straight down the storm drain and heading for the Sound. If you use a bio-degradable cleaner, the microbes in the soil will break it right down. Never EVER dump motor oil, antifreeze, or other car fluids on the ground or down the storm drain. They are all highly toxic and will kill plants and animals and contaminate drinking water in very small quantities. Motor oil must be recycled and most garages have collection facilities.

• When cleaning inside the home, please remember that what goes down your drain doesn't magically disappear; it goes into your septic system and groundwater or to the sewage treatment plant and then out into a river or the Sound. Neither septic systems nor sew-age treatment plants are set up to remove chemicals. Read the labels on your cleaning supplies; if something is hazardous to you, it's even worse for aquatic ecosystems. Follow directions carefully; using more than the recommended amounts won't make things cleaner, it just wastes money and increases the chance of water pollution.

Never dump leftover chemicals down the drain or on the ground; share them with friends or take them to a hazardous waste collec-tion site. If your town doesn't have one, use some of your springtime energy to convince them that a hazardous waste collection day would be a great way to celebrate Earth Day next year as well as helping to protect Long Island Sound.

Change Scale for a New Look at the Sound

Heather M. Crawford
July 10, 1994

The temperature is up, the humidity is up and the south side of Connecticut turns into a parking lot on weekends — it must be summer again. This is the time of year during which Long Island Sound plays a huge role in both the state economy and the vacation or weekend plans of thousands of families. Everyone has their favorite reason for heading for the Sound: boating, swimming, fishing, sunbathing, windsurfing or birding to name just a few. But there's a lot of exciting stuff going on in and around the Sound in the summer that people rarely see.

There are two big reasons why things aren't easily seen at the shore: scale and location. When most people look at the shore they see the big pieces of the picture: sand, sky, water and maybe some marsh and rocks for variation. Looking in-depth at any one of these pieces can be like looking at a whole new world.

For example, a beach isn't a beach without sand, but how many people really look at sand? Change your perspective and scale by examining the individual grains in a handful of sand and you find that the simple sand is actually tiny particles of dozens of different minerals mixed with shell fragments and plant debris.

Sand varies in color along the same beach. I have seen red or purple patches of sand on several beaches along the Connecticut shore. This sand is actually composed of tiny fragments of garnet and an iron-bearing mineral. If you look closely you can see what looks like tiny gem crystals and iron filings instead of quartz or granite. Run a magnet over this sand when dry and the iron leaps out and attaches itself (fairly permanently) to the magnet.

The same trick of changing your perspective applies to looking at the water in the Sound. Some people just think, "oh, the water looks kind of blue (or brown or green or murky and disgusting) today" without thinking about what makes the water that color. If they do think about it, they assume the color is caused by "pollution" or "chemicals" of some kind. In fact, the colors of the Sound are as varied as the sands on the beach.

Right now, the waters of the Sound are teeming with life. The phytoplankton (one-celled plants) are taking advantage of the extended sunshine to grow and multiply. Each species of phytoplankton (and there are hundreds) is a slightly different color, ranging from brown to gold to green and red; many of them have slightly different nutrient requirements. Occasionally, one species will have a population explosion, or "bloom," that will appear to change the color of the water.

Phytoplankton, because of their small size and high nutritional value, make a perfect baby food. Many of the animals in the Sound take advantage of the warmer temperatures and increased food supplies of summer to spawn and get the next generation off to a good start. Clams and oysters, worms and starfish will all be broadcasting their eggs into the water shortly and their young will become part of the zooplankton (microscopic animals) community for several weeks before settling to the bottom and transforming into their adult shapes. If you were to draw a fine-meshed net through the waters of the Sound in July and August, you might catch the very early makings of a fine seafood stew.

There are so many other small secrets in and around Long Island Sound that can be discovered by a curious explorer with a little patience, a bucket and a hand lens. It can be fascinating to watch barnacles feed, figure out how mussels stick together in their clumps or check out the animals growing on the seaweed blades. Just remember two rules of exploration etiquette: return any animals you examine to as close to where they came from as possible, and don't try to take live animals home. Enjoy the summer and the next time you get to the beach, open your eyes and see what you can see!

Sound has Good, Bad News

Heather M. Crawford
August 21, 1994

This has been a "good news - bad news" kind of summer for Long Island Sound watchers. For every sign of progress towards protection or restoration of the Sound, there's another indicator that we are a long way from having the problems "under control."

The bad news is that our annual bout of hypoxia, the condition where the amount of dissolved oxygen in the deeper waters of the Sound drops to levels that do not adequately support life, is severe. I knew the Sound was in trouble this year when I heard they were closing Hammonassett Beach due to "sludge" in the water. The sludge turned out to be masses of phytoplankton, matching the conditions of the Sound during the first recorded major hypoxic event in 1987. That year, researchers described the phytoplankton blooms as making the surface of the Sound look like "chocolate pudding."

Animals living in any water body require oxygen levels of at least five parts per million to live comfortably. When dissolved oxygen levels drop below this level, mobile animals swim off in search of better living conditions and stationary animals either close up and wait out the episode or struggle to survive in inhabitable conditions. The most recent field surveys indicate that the deeper waters in the western half of the Sound currently have oxygen levels between two and three parts per million.

Hypoxic water extends from the East River down the central axis of the Sound to New Haven with two lobes extending even further east along the shores of the Sound. A picture of the hypoxic zone makes a good ink blot test for how people see the condition of the Sound. So far I have heard people describe the shape as looking like a cat crouched to pounce on unsuspecting prey, some sort of well-flattened road kill or a figure holding its arms up in surrender.

Unfortunately, unless a REALLY big weather system moves through our region (like a hurricane) there will be little relief from hypoxia until early September. Each year around that time the Sound's waters "turn over" and surface water is mixed to the bottom, carrying with it the precious oxygen. Scientists don't really understand what starts the turnover process each year but suspect it occurs when surface water temperatures equal or exceed the average daily air temperature. If that's true, humans aren't the only ones hoping the current fall-like weather will continue!

The good news for this summer is actually occurring above the waters of the Sound. The osprey, or fish hawk, one of the species of predatory birds decimated by the use of DDT several decades ago, has been making a comeback. The osprey re-population of Connecticut has been aided by helpful humans putting up nesting platforms in likely habitat areas along the coastline. This summer was really significant because ospreys nested AND raised young (not a common occurance in the first year of occupation) in three brand new areas.

One successful nest was located in the Quinnipiac Marsh area of North Haven. This nest was both the first documented use of this marsh area for osprey nesting and the nest located furthest inland. At Gulf Beach in Milford, timing was everything. The Department of Environmental Protection chose the area to build a marsh observation platform and the osprey also decided that it would be a good place to raise chicks. Consequently, there were comfortable benches and an elevated platform for prime viewing of the first osprey residents in Milford. The third nest was all the way west in Greenwich on the once again appropriately named Eagle Point. Since there were no documented nests with young west of Branford before this year, these three represent an enormous expansion of osprey breeding territory. Successfully nesting ospreys also indicate an adequate food supply to support these fish-loving predators, negating the continuing cries of "the Sound is dying." Long Island Sound is not dead — it is not even dying — but sometimes it isn't very healthy. We all need to keep working, in all the different ways possible, to speed its recovery and prevent future problems.

Temperatures Help Foster Varied Sea Life

Heather M. Crawford
July 9, 1995

When people have asked me what I most like about Long Island Sound, I've always responded with something like, "oh, I just love the variability - I always find something different every time I'm near the water." Then I had to sit down recently and actually describe how Long Island Sound varies over the course of a year, and I realized that the variability I enjoy is a crucial component of what makes Long Island Sound unique. From both meteorological and ecological points of view, the Sound is in a constant state of change.

One of Connecticut's more colorful authors, Mark Twain, is credited with commenting that if you don't like New England weather, all you have to do is wait fifteen minutes, implying that by then something different (not necessarily better) would be going on. There may be a little hyperbole here, but this comment is not far from the truth. Southern New England and Long Island Sound lie in one of the most dynamic marine climatic belts on Earth. Due to our location roughly halfway between the North Pole and the Equator, during the course of the year Long Island Sound waters experience both arctic and tropical conditions. Shifting between these two extremes creates the distinct four seasons that native New Englanders often find themselves missing if they move to other regions of the country.

Due to this extreme temperature range, over the different seasons of the year Long Island Sound is hydrodynamically connected to different ecosystems. During the winter, water temperatures (30 degrees F in February/March) are similar from Chesapeake Bay to northern Nova Scotia, connecting the Sound to the Arctic. During summer months, a continuous band of warm surface water (72 degrees F) runs from Cape Cod to Florida and the Caribbean and the Gulf Stream also swings close to shore, ferrying both tropical water and its inhabitants to the Sound.

Add to this wide range of surface water temperatures three deep water basins that are both cooler in summer and warmer in winter than the surface waters, and Long Island Sound becomes an area that provides year-round habitat for animals from both tropical and arctic ecosystems. Lobsters and winter flounder are two examples of boreal (arctic) species that reach the extreme southern end of their habitat range in the Sound. Both survive the warmer months by migrating into the deeper, cooler waters of the Sound. With the ongoing problem of depleted oxygen supplies (hypoxia) in the deeper waters during summer months, this temperature escape mechanism becomes less effective, adding another stress to two economically important and already stressed fisheries.

On the other end of the spectrum, there are warm-water species, like the blue crab, which thrive in the Sound's shallow waters during the summer and retreat to deeper waters to escape the coldest water temperatures of winter. True tropical species, such as spotfin and barracuda, are brought north by the Gulf Stream and spotted on a fairly regular basis in the Sound in late summer months, but cannot survive the winter cold.

Still other species take advantage of the Sound on a seasonal basis. From the north, seals travel to the Sound as a winter retreat, taking advantage of its relatively ice-free shores and plentiful fish. From the south, some tropical species use the Gulf Stream as a seasonal transportation system. For years, in the fall, there were reports of temperature-shocked sea turtles washing up on the north shore of Long Island. It was assumed that they had mistakenly traveled north and been caught off-guard. Researchers finally found out that the turtles come north deliberately, summer in the Sound to take advantage of the rich food supply, then swim the length of the Sound and head south along the shore in the fall.

So think twice about water temperature the next time you go swimming or wading. Even if you think the water feels a little chilly or a little too much like a bathtub, many of the other animals swimming around you are happy with the temperature just the way it is.

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