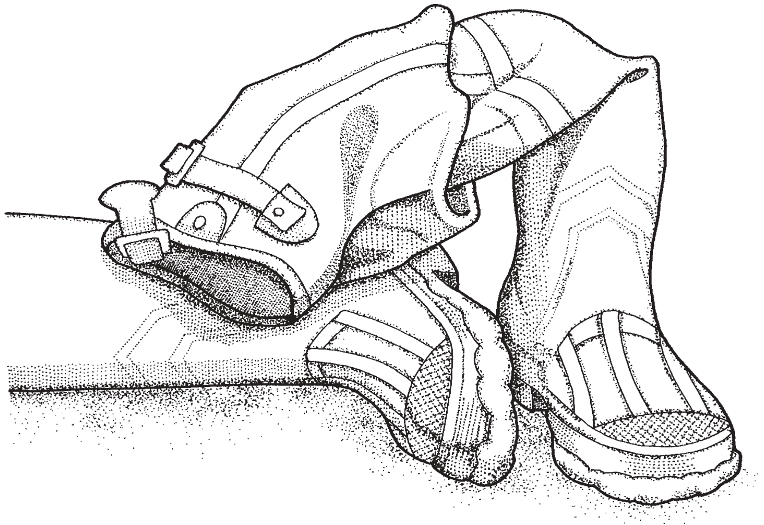


Taking An Estuary Field Trip - Activity 1

By all means, take your class to an estuary near you. Your possibilities are endless. Here are a few ideas to get you started.

Things to Do on a Field Trip

1. Focus on changes. Look for signs of natural change (eroding bluffs, sedimentation, evidence of wave action). Look for signs of human influence. Take along someone who has seen the changes happen.

2. Focus on estuary life. Observe and identify. Examine the sediment (maybe with a shovel and sieve). Check an ecology textbook for field study techniques that your class could employ. Try a beach seine. Collect and observe plankton. Compare several sites or habitats. Return all organisms to a habitat in which they can survive.

3. Focus on quantifying. You can count a population, study waves, profile a beach, monitor water quality. . .

4. Customize a "Scavenger Hunt" to help focus attention. Ecological concepts, historical perspectives, geological formations, inspirational objects or events could be included. (See the "Copies and Overheads" section for an example.)

5. Make your own site-specific field guide.

6. Observe and create. Do some exploring, then try the writing activities on pp. 97-101. Instead of writing, you could draw, paint, sculpt, or compose.

7. Invite an "expert" to join you: wildlife biologists, fisheries biologists, historians, geologists, marine biologists, poets, artists, and naturalists could be a valuable resource on a trip.

8. Don't hesitate to contact your local marine science center for suggestions.

9. Look through the curricula listed in the Resources section for other field trip ideas.

✓ Pre-trip Checklist

1. **Visit the site**
   When will the tide be high? low?
   Is it a public beach? Do you need permission to use the beach?
   Are there bathrooms?
   Are there hoses or faucets for clean up?
   Is there protection from adverse weather?
   Is there a phone for emergencies?
   Is the access steep or dangerous?

2. **Define trip objectives and activites.**
   Do they match the coursework?
   Do they match the site?
   Will the school support it?

3. **Arrange transportation**
   Are buses available for the whole day?
   If not, can car pooling be arranged?
   Do you need to supply a map?
   Is emergency transportation available?

4. **Class preparation**
   Do they know their responsibilites?
   Do they know what equipment to bring?
   Has acceptable behavior been agreed to?

5. **Arrange assistance**
   Do any parents want to help?
   Are college students available?

✓ Trip Checklist

1. **Enthusiasm-** Field trips are enjoyable!

2. **Emergency Numbers and First Aid Kit**

3. **Communicate responsibilites**
   – Introduce goals, expectations, boundaries, equipment.

4. **Communicate Mandatory Behavior**
   – Tread lightly! Your presence in the estuary will damage the site. Please minimize that damage.
   – Observe, don't collect.
   – Fill in all holes.
   – Return rocks to exact positions.
   – Return animals to appropritate tide zone.
   – Collect marine debris.

5. **Equipment needs will vary, but here are some suggestions:**
   – for observing
   jars (plastic)
   shovels
   sieves (for benthic organisms)
   trays
   – for measuring
   Field Notebooks, pencils
   Meter stick, measuring tape, thermometer, monitoring equipment
   – for identification/recording
   Field guide to habitat. (See Resources)
   Binoculars
   Microscopes, magnifying glasses
   Video cameras, cameras
   Clipboards and data sheets
   – for cleaning
   Water source, hose, and sprayer
   Buckets, brushes
   Plastic bags for storing wet items

✓ Student Checklist (Absolutely required!)

1. **Old shoes or snug boots.**

2. **Rain and cold weather gear.**

3. **Extra socks, shoes, and sweatshirt.**

4. **Bag for wet clothes.**

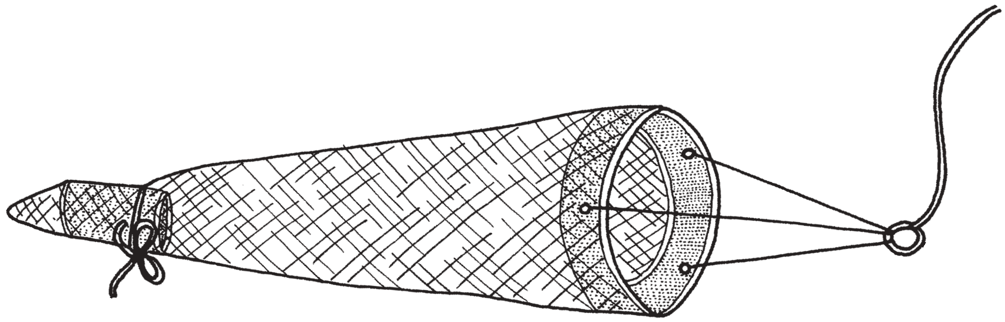
5. **Food and beverage.**

Possible Field Trip Sites

County	County Parks & Rec. Phone Number	Sample of Public Facilities	Habitat
Whatcom	(360) 733-2900	Semiahmoo Co. Park	Sand Beach
		Birch Bay State Park	Sand Beach
		Larrabee State Park	Rock, Gravel
Skagit	(360) 336-9414	Padilla Bay Reserve	Mudflat
		Skagit Habitat Mgt. Area	Mudflat, Wetlands
		Washington Park	Rock, Gravel
		Deception Pass State Park	Rock, Gravel
Island	(360) 679-7373	City Beach	Sand, Mud
		Fort Ebey State Park	Sand, Rock
		Point Partridge Rec. Area	Rock
		Libbey Beach Co. Park	Rock
		S. Whidbey Co. Park	Sand, Rock
Snohomish	(425) 388-3415	Kayak Pt. Co. Park	Gravel
		Mission Beach Park	Gravel
		Howarth Park	Sand, Gravel
		Olympic Beach Park	Sand, Gravel
King	(206) 296-4232	Richmond Beach Park	Sand
		Golden Gardens Park	Sand
		Carkeek Park	Sand, Gravel
		Discovery Park	Sand, Gravel
		Alki Beach Park	Sand
		Lowman Beach Park	Gravel
		Dash Point State Park	Gravel
		Redondo Co. Park	Gravel
		Saltwater State Park	Gravel

For More Information

WA Parks and Recreation Commission	(800) 233-0321
WA Dept. of Ecology	(360) 407-6000
WA Dept. of Fish and Wildlife	(360) 586-2762
WA Dept. of Natural Resources	(360) 902-1004



Plankton Study - Activity 2

Plankton are free-floating organisms which play a vital role in the marine world. Though they are small, they are the foundation of the marine food web; the critical "first step" in the flow of energy through the system.

Biologists consider any organism which drifts with the currents and tides a plankter. Most are microscopic, though some (jellyfish, for example) may be large enough to see. *Phytoplankton* are photosynthetic, single-celled algae. Animal plankton are called *zooplankton*.

Nearly all marine animals go through a planktonic stage. These juveniles, "temporary" plankton one might say, are called *meroplankton*. Those animals which remain plankton their whole lives are called *holoplankton*.

Plankton are not evenly distributed around the world. Open oceans are relatively unproductive and lack the nutrients plankton need to flourish. In contrast, coastal areas, including estuaries, support an abundance of plankton and associated marine life. Puget Sound is especially fertile due to an upwelling from the ocean floor. Rivers are also constantly contributing nutrients from the land. The number of plankton in coastal water defies imagination. One study in England estimated 4.5 billion (4,500,000,000) phytoplankton in **one liter** of water! Such tremendous production is important for the entire marine system which depends on plankton, not only for its energy, but also for most of its oxygen.

Plankton Sampling

A net for collecting plankton can be as simple as a nylon stocking held open by a wire ring or tuna can with the bottom cut out. With a film canister or small jar in the toe and three lengths of string for a leader, your net is ready to use. Fine mesh cloth such as silk can be used instead of the stocking for a more effective net.

Commercially made nets come with varying sizes of mesh ranging from 5m to 1000m (m=micrometer, or 1/1000 of a milli-meter). A very fine mesh (8m or

0.008mm) is necessary for catching the smaller phytoplankton, while a larger mesh (100μ or 0.1mm, for example) is useful for zooplankton. Nets are available from Research Nets, listed in the resource section.

Plankton is often collected by dragging the net behind a boat. If the current is strong enough, the net can be held from a bridge or pier. Attach your net to a stick and you can wade at your nearest beach, moving the net back and forth in front of you as you walk. Transfer the plankton to a container with a water tight lid for transport. Keeping your plankton cool (in a refrigerator or on ice) and allowing air exchange will prolong their life, but remember the population will change as they consume each other.

Observation

A dissecting scope is excellent for observing live plankton. Place a small amount of your sample in a glass petri dish. You may want to dilute the sample with estuary water if your sample is too crowded.

1. Watch for different types of movement. Some animals dart through the water with a jerky motion. Others glide or spin. For some, cilia may be the only body part that moves.

2. Identify the different types of plankton in your sample. The accompanying plankton guide should be useful. To identify something not included in the guide, check the books listed in the References section.

3. Draw what you see. Try to guess what the various body parts are called. Identify which are phytoplankton and which are zooplankton.

4. Estimate the size of different plankton. Compare relative sizes of phytoplankton and zooplankton.

5. For a more detailed look at your plankton, use a compound microscope and glass slide.

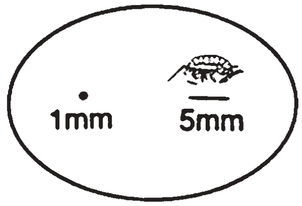
Questions

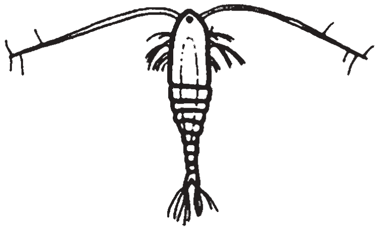
1. Which plankton forms are common in your sample? Which are rare? What do you think might be the reason for this?

2. Why are there more plankton in Puget Sound than in the middle of the Pacific Ocean?

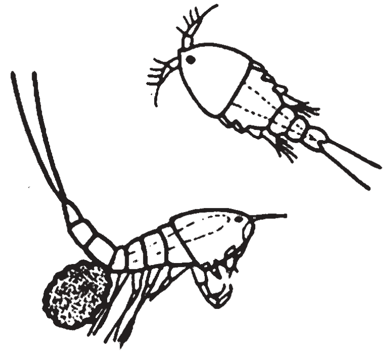
3. One study in England found 4.5 billion phytoplankton in a liter of water. Does your sample have that many? What might affect the number of plankton caught in a single sample?

Plankton Guide

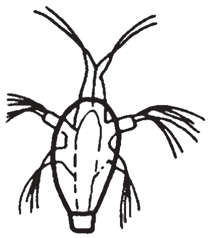




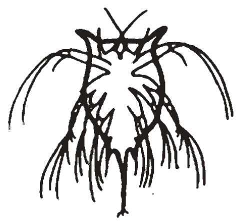
Copepod (calanoid) .5-2mm



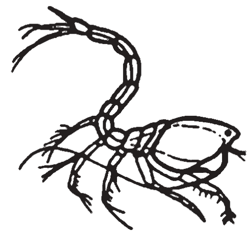
Copepod (harpacticoid) .5-2mm



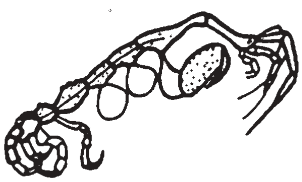
Copepod (nauplius) .2-.5mm



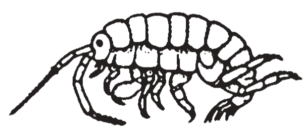
Barnacle nauplius .5-1mm



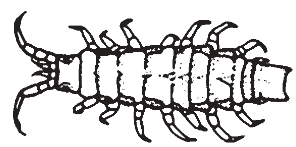
Cumacea 1-2mm



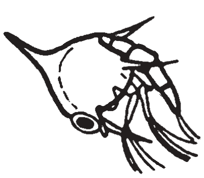
Caprellid amphipod 4mm



Amphipod (gamarid) 1.5-10mm

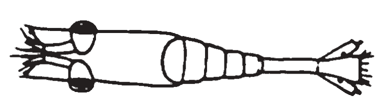


Isopod (*Idotea*) 1-20mm



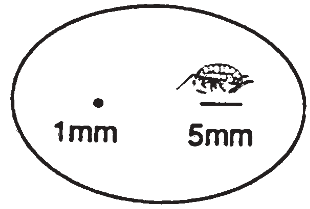
Crab Zoea 2mm

Hermit crab Zoea 2-4mm

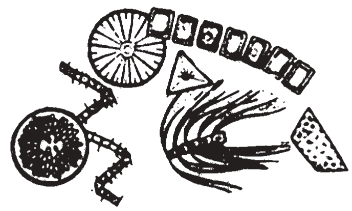


Shrimp Zoea 4mm

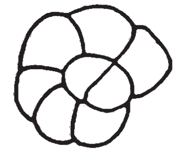
Plankton Guide



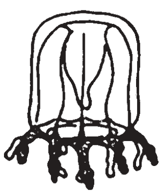
Dinoflagellates .05-.5mm



Diatoms .025-.3mm

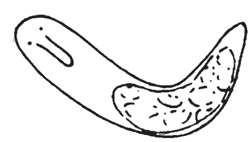


Foram .6mm

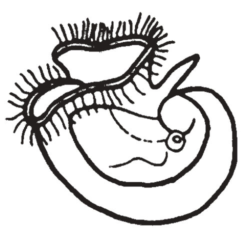


Hydroid medusa 2-10mm

Ctenophore (comb jelly) 4mm

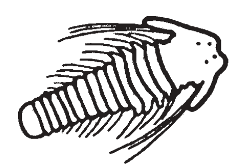


Nemertean larva .5-4mm

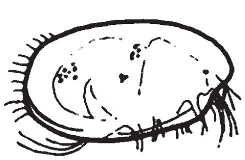


Snail veliger .5mm

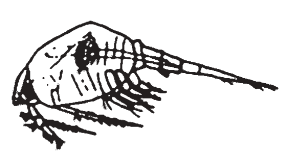
Juvenile nudibranch 2-4mm



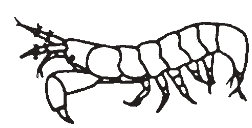
Polychaete larva .5-4mm



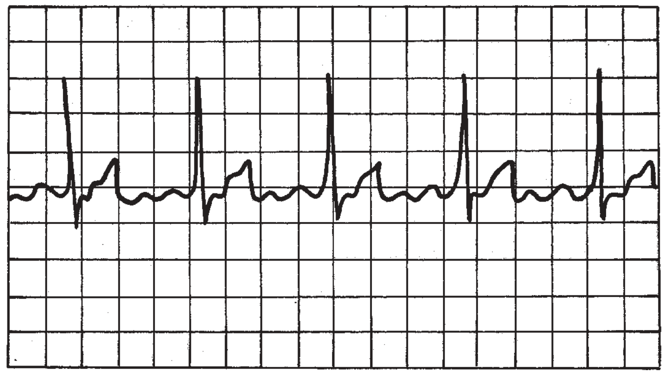
Ostracod .5mm



Leptostracan 3-4mm



Tanaid 1.5mm



Water Quality Monitoring - Activity 3

Introduction

Water monitoring is a systematic measurement of parameters that indicate water quality. This section describes eight tests which give information about the health of a body of water: temperature, salinity, dissolved oxygen, nitrates, phosphates, pH, turbidity, and coliform bacteria.

After following these activities, you should understand the purpose of these tests, know how to run accurate water quality tests, become familiar with sources of water pollution, and see how these parameters relate to human and non-human uses of estuaries. For example, you may find that your estuary water may not be safe for swimming or shellfish harvest.

Monitoring is a fundamental tool of research. When studying a particular system, researchers begin by carrying out a baseline study, a broad assessment of many different variables. They do this for several reasons. The results are important for the comparison of future data. To assess the damage done by an accident such as a toxic spill, it is important to have an idea of what was in the water **before** the spill.

Researchers also use baseline studies to determine which topics they should investigate further. If a baseline study shows an unexpected high level of coliform bacteria, then the researcher may want to design a study to determine why.

These activities are valuable as "one shot" field studies or classroom labs. Taking a set of measurements once from one site gives a small picture of conditions in the estuary. If possible, monitor several sites. This will give a larger picture and demonstrate the great variability within the system. The salinity at the mouth of a stream will not be the same as the salinity upstream or further out in the bay. Understanding what is happening in an estuary at a given moment, however, is not necessarily a complete picture. It is much more accurate (and interesting) to follow an estuary over time -- to take a "moving picture."

Estuaries undergo daily, seasonal and long-term changes that can only be assessed with periodic monitoring. Salinity might change drastically over the course of a single tide. Nutrients such as nitrogen vary seasonally as varying amounts are added to the water and used by organisms. Human activities such as dredging or dumping may permanently alter the characteristics of an estuary.

Though your class may not be able to carry on an extended monitoring program, it is possible to share your results with other schools. Your study area might be an estuary near your school, or it could be Padilla Bay. Your results could be compared to those of other researchers through an organization such as GREEN (Global Rivers Environmental Education Network -- in the Resources section). You may be able to join with other classes who are a part of a coordinated monitoring program in Puget Sound. Check with your local marine science center or the Breazeale Interpretive Center at Padilla Bay for information about such programs.

If you intend to compare or coordinate your results, it is essential that your monitoring be standardized, that is, follow the exact same procedures as other researchers. Different monitoring techniques may yield slightly different results. Be sure to check with the other schools or organizations to be sure your techniques match theirs as closely as possible.

Keep in mind the limitations of water monitoring. The individual activities give a small piece of information about the estuary water. They do not prove very much by themselves. Taken together with the other small pieces, they tell a little more. The estuary is a complex place with hundreds of interacting chemical and biological processes. It is difficult to draw definite conclusions about cause and effect from the results of one test.

The following monitoring activities include a short description of the parameter, how that factor is important in an estuarine system, and a description of monitoring procedures. For more detailed information, see the Resources section. *Puget Sound Project: The Changing Sound*, from the Poulsbo Marine Science Center, offers a complete set of student work sheets and monitoring directions that you may wish to use.

Warning: Many water quality tests involve toxic chemicals that must be handled and disposed of properly. Be sure to use proper lab safety equipment and procedures. All hazardous wastes should be collected and disposed of properly. (Call 1-800-RECYCLE for hazardous material information.)

Questions

1. List four reasons researchers monitor water quality.

2. As a group, create a list of local, state, and federal agencies that might currently be monitoring water quality in a body of water near your home or school. (Soil Conservation Service, County Health Department, Department of Fisheries, etc.) Call each agency and ask: 1) if they are monitoring, 2) what they are measuring, 3) why, and 4) what methods they are using.

WATER MONITORING DATA SHEET

SCHOOL: DATE:

RESEARCHERS:

TIME:

TIDE:

AIR TEMP:

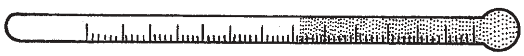
WEATHER:

WATER COLOR:

WIND:

OTHER:

SITE NUMBER DEPTH	1	2	3
DISSOLVED OXYGEN (mg/l) & (% sat.)			
FECAL COLIFORM (colonies/100ml)			
pH units			
TEMPERATURE (^{o}C)			
SALINITY (ppt)			
TOTAL PHOSPHATES (mg/l)			
NITRATES (mg/l)			
B.O.D. (mg/l)			
TURBIDITY (m)			



Temperature

Though temperature is simple to measure, it is important. Many other characteristics of water depend on temperature. Cold water holds more oxygen than warm water. The rates of metabolism and photosynthesis increase as water temperature rises. Organisms are limited to certain temperature ranges and may be more susceptible to disease or poisoning from toxins when the temperature rises.

Human activities can upset the temperature balance in an estuary. Many industries use water for cooling purposes and release large amounts of warmed water. Though they may not add chemical pollutants their thermal pollution may be just as harmful to organisms.

You'll find that many of the other monitoring procedures in this section include measuring temperature. Because cold water is denser than warm water, many bodies of water have distinct layers of water of different temperatures, with the warmer water on top and the colder water on the bottom. The area between the warm and cold water is called the thermocline and you may have noticed it while swimming in a lake or in Puget Sound. Because of the thermocline, it is important to take temperature readings from several depths at any location.

Procedure

1. Obtain a water sample. Commercially produced sampling devices are readily available from biological supply companies (see References) or you can construct your own.

2. Because the sample temperature may change quickly, immediately insert an alcohol-filled Centigrade thermometer into the sample.

3. After about 2 minutes (long enough for the thermometer to stabilize), read the temperature.

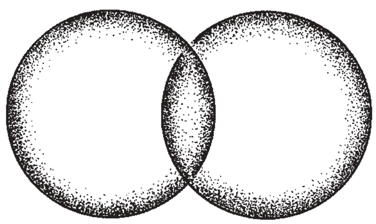
4. Record your location, depth, and temperature reading.

Questions

1. Why is water temperature important to the organisms living in it?

2. Did the water temperature at your site vary with the depth? Why?

3. When might you expect the temperature at your site to be different? Why?



Dissolved Oxygen

For estuary organisms, oxygen (O_2)is one of the most important chemicals dissolved in water. It is necessary for respiration and its abundance (or scarcity) often determines which organisms can live in an area. It can enter the water directly from the air by diffusion, or is supplied by the photosynthesis of plants.

Many things affect the amount of O_2 dissolved in water:

1. Temperature -- Cold water holds more O_2 than warm water,

2. Aeration -- Water stirred by currents and winds picks up extra O_2 ,

3. Photosynthesis,

4. Plankton growth -- Plankton blooms caused by excess nutrients deplete the O_2 when the microorganisms die and decay,

5. Organic matter -- It takes O_2 to decompose organic matter.

Organic matter can come from many sources: decaying estuary organisms, urban and agricultural runoff, sewage treatment plants, and industrial wastes (dairies, lumber mills, paper plants, food processing plants, etc.).

Once in the estuary, organic matter is decomposed by organisms such as bacteria and fungi which use up a lot of oxygen. Normally, the decomposers deal with organic matter at a reasonable rate and the system can replenish the oxygen supply. When excessive amounts of organic matter are added, however, oxygen levels can be depleted and other organisms can be affected. Fish kills are often the result of the sudden discharge of too much organic matter for the system to handle. A low oxygen level may limit the number of different organisms living in an area and very low levels may eliminate nearly all the organisms there.

Procedure

There are many ways to measure dissolved oxygen (DO). The method you choose may depend on your budget, time allowance, or how much you want to emphasize chemical principles.

Dissolved oxygen meters are available, but are expensive. Many companies offer an inexpensive dissolved oxygen test kit. You can follow the same method (known as the Winkler technique) without purchasing a kit if you have access to lab equipment and some readily available chemicals. Whichever method you choose, be sure to carefully follow the manufacturer's instructions.

Here are a few tips to insure that your results are as accurate as possible.

1. It is best to sample several depths at each site, for example: 0.5 meters below the surface, mid-column, and 0.5 meters above the bottom.

2. When collecting the samples, try to prevent extra oxygen from entering the sample through bubbles. Siphon the water from one container to another rather than pouring, and allow the bottle to overflow to eliminate any atmospheric oxygen. Place the stopper or lid on carefully so that no air bubbles remain in the bottle.

3. Remember to record the water temperature when you collect the sample. Other useful information might be: date and time, location, weather, tide, depth of collection.

Questions

1. Design experiments to test how DO is affected by: a) temperature, b) salinity, and c) organic matter.

2. When measuring DO, you were required to either complete the measurement immediately or fix the oxygen before storage or transportation. What might make the DO levels change if you don't take these precautions?

3. What changes to the watershed could be made to increase the DO at your site?

Follow-up

Biochemical Oxygen Demand (BOD) is a measure of how much oxygen is consumed by microorganisms, and is an indicator of dissolved organic matter. This standard test is used at sewage treatment plants and some industries to make sure they aren't "polluting" the water with too much organic matter. If during your monitoring you discover a site with unusually low DO, you may wish to test the nearest water *source* for organic matter. The source may be a stream, river, or drain pipe which is contributing organic matter to the estuary.

You can perform a BOD test by filling 2 bottles with sampled water. Determine the DO for one bottle. Completely wrap the second bottle with black tape and incubate it in a dark place for 5 days (68°F). After 5 days, determine the DO for the "black" bottle.

$$BOD = DO^1 - DO^2$$

DO^1 = DO of first sample
DO^2 = DO of incubated sample

This measure is the amount of oxygen which was consumed over a five-day period.

Coliform Bacteria

A healthy, balanced estuary is teeming with bacteria, minute organisms that enter into the many biological processes from digestion to nutrient cycling. Bacteria are essential members of a functioning ecosystem. Too many of the wrong kinds of bacteria, however, can mean trouble.

A sudden input of large numbers of bacteria can deplete the oxygen supply affecting sensitive animals such as fish. Certain pathogenic (disease causing) bacteria can accumulate in invertebrates such as shellfish and cause human illnesses.

Coliform bacteria normally grow in the intestinal tracts of mammals, humans included. They are present in large numbers in human sewage and have thus become an indicator of contaminated water. They can enter water systems in several ways: directly from boats, from septic tanks which are not working properly, from sewage treatment plants, and from pets and livestock (cows in a stream or inadequate storage and spreading of manure). Treatment plants which process both household sewage and runoff from storm sewers are often overloaded during periods of heavy rain. Raw sewage and runoff are then combined and released untreated into the water supply.

The presence of coliform bacteria is not a problem in itself. In fact, coliform bacteria generally do not reproduce outside of the digestive tract. They may indicate problems, however, since they indicate the possible presence of harmful bacteria and the contamination of water by sewage. That contamination is often accompanied by a concentration of toxic, heavy metals and an overload of organic matter.

State and Federal agencies have set standards for safe levels of fecal coliform bacteria. Though they vary depending on location, the following guidelines may be useful when comparing your own results.

Intended Use	Maximum No. of Fecal Coliform
Drinking Water	1/100 ml
Water Above Shellfish Beds	70/100 ml
Primary Contact Recreation (such as swimming)	1000/100 ml
General Recreation Surface Water	2000/100 ml

Procedure

The presence of coliform bacteria can be determined by using a Millipore Sterile Filtration Apparatus. (See Resources section.) This technique involves filtering a 0.5 ml water sample using a vacuum pump system and a sterile filter and then incubating the filter in a special bacterial growth medium. The medium contains a dye which turns green when coliform bacteria break down the sugar, lactose, into a compound called aldehyde. Each bacterium cell in the sample grows into a green colony which is easy to recognize and count.

Follow the manufacturer's instructions carefully, being especially aware of using sterile techniques when handling bacteria. Though highly unlikely, there may be pathogenic bacteria present in your sample. Be sure to WASH YOUR HANDS after this activity.

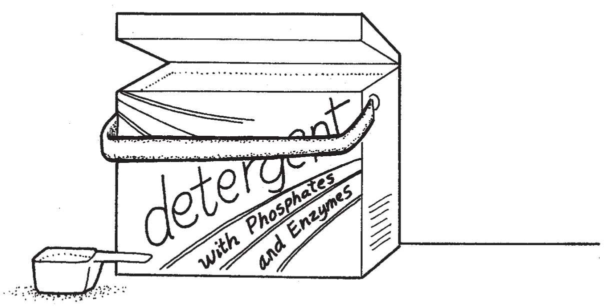
When you have counted the coliform bacteria in your 0.5 ml sample, convert your results to the number of coliform bacteria present in 100 ml. Then you can compare your sample to the guidelines above.

Questions

1. Are coliform bacteria harmful to humans?
2. Why do researchers measure coliform bacteria levels?
3. Is your house on a septic system or municipal sewage system? How might this sewage get into the surface water (ditch, stream, lake, wetland, river)?
4. What should you do if your test results indicate a high level of coliform bacteria in the water at your site?

Follow-Up

See the activity, Drawing Your Own Water in Activity 7, "What You Can Do for Estuaries."



Nitrates and Phosphates

Nitrates and phosphates are two of the many nutrients that plants need for growth. They are present in varying amounts throughout the year in Puget Sound and their availability is one factor that determines the rate of plant production. Sunlight and temperature also affect plant growth. Any of these factors can limit growth if in short supply. For example, phytoplankton growth is slow in November and December due to short days and cloudy weather even if the plants have plenty of available nutrients from winter rain runoff. In spring, longer days coupled with availability of nutrients that accumulated during the winter cause a huge increase in production. In mid-summer, sunlight is adequate but there is often a shortage of nutrients after the rapid growth of spring.

Though nutrients such as nitrates and phosphates are necessary for a productive system, too much of these can be a problem. Over-fertilization can cause too much growth of certain plants. This bloom clouds the water, and depletes the nutrients needed for a healthy, balanced system. Human activities such as fertilizing lawns, washing clothes, and raising livestock often cause an excess of nitrates and phosphates entering the watershed.

Procedure

Many companies offer test kits for measuring nitrates and phosphorus in water. The following descriptions refer to the Total Phosphate Test Kit and Low-range Nitrate Test Kit from the HACH company. The method you choose may be slightly different.

Measuring Total Phosphorus

1. Be sure to carefully follow the instructions which accompany your test kit. It is important that the glassware for this test be soaked in diluted HCl (hydrochloric acid) and rinsed thoroughly with distilled water. This removes any phosphate detergent film which could disrupt the test.

2. After carefully obtaining your water sample, add potassium sulphate and sulfuric acid and boil for 30 minutes. Add demineralized water to keep it from boiling dry. This procedure makes all the phosphorus in your sample available to the reagent in the next step.

3. When the sample has cooled, add sodium hydroxide and the "PhosVer III" reagent, mixing thoroughly.

4. Compare your sample with an untreated water sample using the "comparator box." Rotate the color disk until a combined color and density match is obtained. Read mg/L phosphate as total phosphate.

Measuring Nitrate

1. You must use demineralized water during the nitrate test because any other water, including distilled, contains ammonia (NH_3) ions that will disrupt this test. Carefully follow the instructions accompanying your test kit.

2. Fill the color-viewing tube with your collected sample water and add "NitraVer 6" reagent. Stopper and shake for 3 minutes.

3. After 30 seconds you will see particles of cadmium metal settling to the bottom. Pour the sample into the second color-viewing tube, leaving the cadmium particles behind. (Discard the cadmium in a toxic waste container).

4. Add "NitraVer 3" reagent to the sample and shake. Wait 10 minutes for the reaction to be completed. (During the wait, rinse the first tube and fill it with your original water sample).

5. After 10 minutes, place both tubes in the comparator, hold it up to a light source and rotate the disk to obtain a combined color and density match. Read the mg/L through the scale window. To convert this reading to mg/L Nitrate (NO_3^-) multiply the reading on the scale by 4.4.

Questions

1. In the Puget Sound region, in what season would you expect to find the highest level of nutrients in the water? the lowest? Why?

2. How can high levels of nutrients be harmful to aquatic systems?

3. How can "fertilizing lawns, washing clothes, and raising livestock often cause an excess of nitrates and phosphates entering the watershed?" (see p. 81)

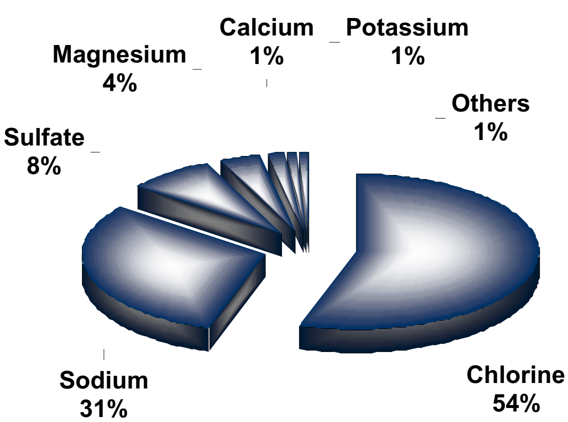
4. Are there any human activities in the watershed above your sampling site that may elevate your readings?

5. Are there any chemicals or reagents used in these tests that could be hazardous? How can they be disposed of properly?

Salinity

Saltiness is the most obvious characteristic of sea water. An estuary is less salty than the ocean, but how diluted is it? And what difference does that make to the plants and animals there?

Sodium chloride is the table salt that we are all familiar with and it is an important element of sea water. It is not the only salt, however. In fact, nearly all the known elements are dissolved in sea water. Animals and plants need these salts for growth and reproduction.



The most common elements in sea water

People get required salts through the food they eat. Organisms living in salt water get these elements directly from the water. In the ocean, most organisms have the same concentration of salts inside their cells as in the outside water. *Osmosis* (molecules moving through a membrane from an area of higher concentration to an area of lower concentration) regulates this balance. In fresh water, organisms rely on physiological adaptations to keep the salt levels inside their cells **higher** than the fresh water outside. Though most organisms can adjust to small changes in salinity, a drastic change can be lethal.

Estuary organisms face a constant fluctuation in salinity as tides and fresh water flow interact. Salt water is denser than fresh water, so the organisms often have to deal with "layers" of different salinities. Because of this *stratification*, it is important to take samples from varying depths when testing for salinity.

Salinity is usually measured in parts per thousand. That means that sea water, with about 35 parts per thousand salt has 35 grams of salt for every 1000 grams of water. The symbol $^{0}/_{00}$ means parts per thousand. (You know the symbol % which means parts per hundred, or per*cent*.)

Humans can affect the salinity of bodies of water as they develop and utilize shoreline areas. Farmers' dikes keep salty tides from coming up into sloughs that were once saltmarshes. Pumping large amounts of fresh water from underground aquifers may result in sea water intrusion as salt water moves in to take up the empty space. This has threatened many fresh drinking water supplies. Irrigation upriver reduces the fresh water flow into an estuary, making it saltier.

Procedure

Most researchers use a salinity meter to measure salinity most accurately. Since salt water conducts electricity better than fresh water, a salinity meter can determine the conductivity of a solution, and then convert conductivity to salinity. These meters can be expensive but are reliable and easy to use. If you don't have access to a salinity meter, you can also calculate salinity using a hydrometer, available at aquarium stores.

About The Hydrometer

A hydrometer is a hollow glass tube with a scale printed on the top. It works on the principle that increased salinity results in increased density. Things are more buoyant (they float higher) in saltier water. The hydrometer will float higher in saltier water and the water surface will be lower on the printed scale. Unfortunately, cold water is also denser than warm water, so the temperature affects the buoyancy at the same time.

To determine the salinity of your sample you will need to take the measurement on the hydrometer and correct it for temperature. Since the hydrometer chart is based on water at 15°C, you need to determine what the water density would be at this temperature.

1. Obtain water samples from various depths.
2. Pour about 450 ml of your sample into a container such as a 500 ml graduated cylinder.
3. Measure and record temperature (centigrade).
4. Measure density with the hydrometer. (Look at the point where the water line crosses the scale.)
5. Correct the density using Chart 1, the Density-Water Temperature Chart. (For example: Your sample was 5°C with a density of 1.0100. Find the 5° column. Go down that column to the 1.0100 line. The chart reads -9. Subtract .0009 from 1.0100 to get your corrected density of 1.0091).
6. Use this new, corrected density to determine salinity on Chart 2, Salinity/Corrected Density Chart.

Questions

1. Why does fresh water float on salt water?
2. Why do some organisms living in salt water need a strategy to avoid dehydration?
3. Convert 35 parts per thousand (0/00) to percent (0/0).
4. What human activities can alter the salinity of coastal waters?
5. A salinity meter and a hydrometer can both be used to determine salinity, though they measure different properties of salt water. What are these properties?

Follow up

Check salinity at different places in the estuary you are monitoring. Check right after a heavy rain and after a long dry spell. Check a site at low tide and again at high tide.

When would you expect the salinity to be higher or lower?

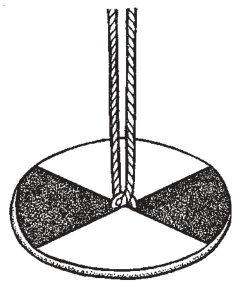
DENSITY - WATER TEMPERATURE CHART

Observed Density	TEMPERATURE OF WATER																			Observed Density
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	Diff.	
1.0000	-3	-4	-5	-5	-6	-6	-6	-5	-6	-5	-5	-4	-3	-2	-1	0	1	3	4	1.0000
1.0010	-4	-5	-6	-6	-6	-6	-6	-6	-6	-5	-5	-4	-3	-2	-1	0	1	3	4	1.0010
1.0020	-4	-5	-6	-6	-7	-7	-6	-6	-6	-6	-5	-4	-3	-2	-1	0	1	3	5	1.0020
1.0030	-5	-6	-6	-7	-7	-7	-7	-6	-6	-6	-5	-4	-3	-2	-1	0	1	3	5	1.0030
1.0040	-5	-6	-7	-7	-7	-7	-7	-7	-6	-6	-5	-4	-3	-2	-1	0	1	3	5	1.0040
1.0050	-6	-7	-7	-7	-8	-7	-7	-7	-7	-6	-5	-5	-4	-2	-1	0	1	3	5	1.0050
1.0060	-6	-7	-8	-8	-8	-8	-8	-7	-7	-6	-6	-5	-4	-3	-1	0	2	3	5	1.0060
1.0070	-7	-7	-8	-8	-8	-8	-8	-7	-7	-6	-6	-5	-4	-3	-1	0	2	3	5	1.0070
1.0080	-7	-8	-8	-8	-9	-8	-8	-8	-7	-7	-6	-5	-4	-3	-1	0	2	3	5	1.0080
1.0090	-8	-8	-9	-9	-9	-9	-8	-8	-7	-7	-6	-5	-4	-3	-1	0	2	3	5	1.0090
1.0100	-8	-9	-9	-9	-9	-9	-9	-8	-8	-7	-6	-5	-4	-3	-1	0	2	3	5	1.0100
1.0110	-9	-9	-10	-10	-10	-9	-9	-8	-8	-7	-6	-5	-4	-3	-1	0	2	3	5	1.0110
1.0120	-9	-10	-10	-10	-10	-10	-9	-9	-8	-7	-6	-5	-4	-3	-1	0	2	3	5	1.0120
1.0130	-10	-10	-10	-10	-10	-10	-9	-9	-8	-7	-6	-5	-4	-3	-2	0	2	3	5	1.0130
1.0140	-10	-11	-11	-11	-11	-10	-10	-9	-8	-7	-7	-6	-4	-3	-2	0	2	3	5	1.0140
1.0150	-11	-11	-11	-11	-11	-10	-10	-9	-8	-8	-7	-6	-4	-3	-2	0	2	3	5	1.0150
1.0160	-11	-11	-12	-11	-11	-11	-10	-10	-9	-8	-7	-6	-4	-3	-2	0	2	4	6	1.0160
1.0170	-12	-12	-12	-12	-12	-11	-11	-10	-9	-8	-7	-6	-5	-3	-2	0	2	4	6	1.0170
1.0180	-12	-12	-12	-12	-12	-11	-11	-10	-9	-8	-7	-6	-5	-3	-2	0	2	4	6	1.0180
1.0190	-13	-13	-13	-13	-12	-12	-11	-10	-9	-8	-7	-6	-5	-3	-2	0	2	4	6	1.0190
1.0200	-13	-13	-13	-13	-13	-12	-11	-11	-10	-9	-7	-6	-5	-3	-2	0	2	4	6	1.0200
1.0210	-14	-14	-14	-13	-13	-12	-12	-11	-10	-9	-8	-6	-5	-3	-2	0	2	4	6	1.0210
1.0220	-14	-14	-14	-14	-13	-13	-12	-11	-10	-9	-8	-6	-5	-3	-2	0	2	4	6	1.0220
1.0230	-15	-15	-14	-14	-14	-13	-12	-11	-10	-9	-8	-6	-5	-3	-2	0	2	4	6	1.0230
1.0240	-15	-15	-15	-14	-14	-13	-12	-12	-10	-9	-8	-7	-5	-3	-2	0	2	4	6	1.0240
1.0250	-16	-15	-15	-15	-14	-13	-13	-12	-11	-9	-8	-7	-5	-4	-2	0	2	4	6	1.0250
1.0260	-16	-16	-16	-15	-15	-14	-13	-12	-11	-10	-8	-7	-5	-4	-2	0	2	4	6	1.0260
1.0270	-17	-16	-16	-15	-15	-14	-13	-12	-11	-10	-8	-7	-5	-4	-2	0	2	4	6	1.0270
1.0280	-17	-17	-16	-16	-15	-14	-13	-12	-11	-10	-9	-7	-5	-4	-2	0	2	4	6	1.0280
1.0290	-18	-17	-17	-16	-16	-15	-14	-13	-12	-10	-9	-7	-5	-4	-2	0	2	4	6	1.0290
1.0300	-18	-18	-17	-17	-16	-15	-14	-13	-12	-10	-9	-7	-6	-4	-2	0	2	4	6	1.0300
1.0310	-19	-18	-18	-17	-16	-15	-14	-13	-12	-10	-9	-7	-6	-4	-2	0	2	4	7	1.0310

SALINITY - CORRECTED DENSITY CHART

(Density at 15ºC. - Salinity in parts per 1,000)

Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity	Density	Salinity
0.9991	0.0	1.0048	7.1	1.0101	14.2	1.0158	21.4	1.0211	28.6	1.0266	35.8
.9992	.0	1.0047	7.2	1.0102	14.4	1.0157	21.6	1.0212	28.8	1.0267	35.9
.9993	.1	1.0048	7.3	1.0103	14.5	1.0158	21.7	1.0213	28.9	1.0268	36.0
.9994	.3	1.0049	7.5	1.0104	14.6	1.0159	21.8	1.0214	29.0	1.0269	36.2
.0995	.4	1.0050	7.6	1.0105	14.8	1.0160	22.0	1.0215	29.1	1.0270	36.3
.9996	.5	1.0051	7.7	1.0106	14.9	1.0161	22.1	1.0216	29.3	1.0271	36.4
.9997	.7	1.0052	7.9	1.0107	15.0	1.0162	22.2	1.0217	29.4	1.0272	36.6
.9998	.8	1.0053	8.0	1.0108	15.2	1.0163	22.4	1.0218	29.5	1.0273	36.7
.9999	.9	1.0054	8.1	1.0109	15.3	1.0164	22.5	1.0219	29.7	1.0274	36.8
1.0000	1.1	1.0055	8.2	1.0110	15.4	1.0165	22.6	1.0220	29.8	1.0275	37.0
1.0001	1.2	1.0056	8.4	1.0111	15.6	1.0166	22.7	1.0221	29.9	1.0276	37.1
1.0002	1.3	1.0057	8.5	1.0112	15.7	1.0167	22.9	1.0222	30.0	1.0277	37.2
1.0003	1.4	1.0058	8.6	1.0113	15.8	1.0168	23.0	1.0223	30.2	1.0278	37.3
1.0004	1.6	1.0059	8.8	1.0114	16.0	1.0169	23.1	1.0224	30.3	1.0279	37.5
1.0005	1.7	1.0060	8.9	1.0115	16.1	1.0170	23.3	1.0225	30.4	1.0280	37.6
1.0006	1.8	1.0061	9.0	1.0116	16.2	1.0171	23.4	1.0226	30.6	1.0281	37.7
1.0007	2.0	1.0062	9.2	1.0117	16.3	1.0172	23.5	1.0227	30.7	1.0282	37.9
1.0008	2.1	1.0063	9.3	1.0118	16.5	1.0173	23.7	1.0228	30.8	1.0283	38.0
1.0009	2.2	1.0064	9.4	1.0119	16.6	1.0174	23.8	1.0229	31.0	1.0284	38.1
1.0010	2.4	1.0065	9.6	1.0120	16.7	1.0175	23.9	1.0230	31.1	1.0285	38.2
1.0011	2.5	1.0066	9.7	1.0121	16.9	1.0176	24.0	1.0231	31.2	1.0286	38.4
1.0012	2.6	1.0067	9.8	1.0122	17.0	1.0177	24.2	1.0232	31.4	1.0287	38.5
1.0013	2.8	1.0068	9.9	1.0123	17.1	1.0178	24.3	1.0233	31.5	1.0288	38.6
1.0014	2.9	1.0069	10.1	1.0124	17.3	1.0179	24.4	1.0234	31.6	1.0289	38.8
1.0015	3.0	1.0070	10.2	1.0125	17.4	1.0180	24.6	1.0235	31.8	1.0290	38.9
1.0016	3.2	1.0071	10.3	1.0126	17.5	1.0181	24.7	1.0236	31.9	1.0291	39.0
1.0017	3.3	1.0072	10.5	1.0127	17.6	1.0182	24.8	1.0237	32.0	1.0292	39.2
1.0018	3.4	1.0073	10.6	1.0128	17.8	1.0183	25.0	1.0238	32.1	1.0293	39.3
1.0019	3.5	1.0074	10.7	1.0129	17.9	1.0184	25.1	1.0239	32.3	1.0294	39.4
1.0020	3.7	1.0075	10.8	1.0130	18.0	1.0185	25.2	1.0240	32.4	1.0295	39.6
1.0021	3.8	1.0076	11.0	1.0131	18.2	1.0186	25.4	1.0241	32.5	1.0296	39.7
1.0022	3.9	1.0077	11.1	1.0132	18.3	1.0187	25.5	1.0242	32.7	1.0297	39.8
1.0023	4.1	1.0078	11.2	1.0133	18.4	1.0188	25.6	1.0243	32.8	1.0298	39.9
1.0024	4.2	1.0079	11.4	1.0134	18.6	1.0189	25.8	1.0244	32.9	1.0299	40.1
1.0025	4.3	1.0080	11.5	1.0135	18.7	1.0190	25.9	1.0245	33.0	1.0300	40.2
1.0026	4.5	1.0081	11.6	1.0136	18.8	1.0191	26.0	1.0246	33.2	1.0301	40.3
1.0027	4.6	1.0082	11.8	1.0137	19.0	1.0192	26.1	1.0247	33.3	1.0302	40.4
1.0028	4.7	1.0083	11.9	1.0138	19.1	1.0193	26.3	1.0248	33.4	1.0303	40.6
1.0029	4.8	1.0084	12.0	1.0139	19.2	1.0194	26.4	1.0249	33.6	1.0304	40.7
1.0030	5.0	1.0085	12.2	1.0140	19.4	1.0195	26.5	1.0250	33.7	1.0305	40.8
1.0031	5.1	1.0086	12.3	1.0141	19.5	1.0196	26.7	1.0251	33.8	1.0306	41.0
1.0032	5.2	1.0087	12.4	1.0142	19.6	1.0197	26.8	1.0252	34.0	1.0307	41.1
1.0033	5.4	1.0088	12.6	1.0143	19.7	1.0198	26.9	1.0253	34.1	1.0308	41.2
1.0034	5.5	1.0089	12.7	1.0144	19.9	1.0199	27.1	1.0254	34.2	1.0309	41.4
1.0035	5.6	1.0090	12.8	1.0145	20.0	1.0200	27.2	1.0255	34.4	1.0310	41.5
1.0036	5.8	1.0091	12.9	1.0146	20.1	1.0201	27.3	1.0256	34.5	1.0311	41.6
1.0037	5.9	1.0092	13.1	1.0147	20.3	1.0202	27.4	1.0257	34.6	1.0312	41.8
1.0038	6.0	1.0093	13.2	1.0148	20.4	1.0203	27.6	1.0258	34.7	1.0313	41.9
1.0039	6.2	1.0094	13.3	1.0149	20.5	1.0204	27.7	1.0259	34.9	1.0314	42.0
1.0040	6.3	1.0095	13.5	1.0150	20.6	1.0205	27.8	1.0260	35.0	1.0315	42.1
1.0041	6.4	1.0096	13.6	1.0151	20.8	1.0206	28.0	1.0261	35.1	1.0316	42.3
1.0042	6.6	1.0097	13.7	1.0152	20.9	1.0207	28.1	1.0262	35.3	1.0317	42.4
1.0043	6.7	1.0098	13.9	1.0153	30.0	1.0208	28.2	1.0263	35.4	1.0318	42.5
1.0044	6.8	1.0099	14.0	1.0154	30.2	1.0209	28.4	1.0264	35.5	1.0319	42.7
1.0045	7.0	1.0100	14.1	1.0155	30.3	1.0210	28.5	1.0265	35.6	1.0320	42.8



Turbidity

Turbidity refers to the number of particles suspended in water, or how cloudy the water is. Clear water has low turbidity. Cloudy water has higher turbidity.

Life in estuaries depends on phytoplankton and plant production for much of its energy. Plants, in turn, depend on sunlight for photosynthesis. When the water is too turbid, too much light is diffused, not enough reaches the plants that need it, and production decreases. Too many suspended solids reduce the growth of invertebrates such as clams and oysters. Egg development is slowed or stopped when water contains too much silt. Eelgrass doesn't grow at the mouth of a large river where turbidity is too high.

High turbidity can have several causes. Rivers naturally carry large amounts of silt, clay, and detritus from their watersheds. Moving water carries more suspended solids than still water, so waves and tides can cause turbidity. Human activities such as logging, dredging, farming, and construction result in more particles entering the water. Large numbers of phytoplankton can cause turbidity -- which may be a sign of a healthy, productive environment, or a sign of over fertilization.

Turbidity is often measured with a device called a Secchi disc. It consists of a weighted disc that is lowered into the water until it disappears. This "vanishing point" is the point at which there are so many suspended particles diffusing the light between the disc and the viewer that the disc can no longer be seen. The vanishing point will be deeper in water with fewer particles and shallower in more turbid water.

Procedure

The Secchi disc has two sides -- one white and one with alternate white and black quadrants. The side you choose is a matter of personal preference. Try them both and decide which is easier for you to see. The rope should be marked at 0.25 m intervals and should not stretch.

1. Lower the disc into the water and record the depth at which the disc disappears.
2. Slowly raise the disc and record the depth at which it reappears.
3. Record both observations and calculate the average.

Note: In currents, the disc may hang at an angle, resulting in the line actually being longer than the depth. Make your readings with the line hanging straight down.

Direct sunlight may obscure your view of the disc, so try to lower the disc into a shaded spot.

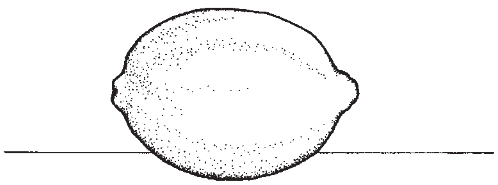
Questions

1. Padilla Bay no longer has a river emptying into it. How do you think the turbidity in Padilla Bay compares with the turbidity in Skagit Bay, the present mouth of the Skagit River? Where would you expect to find more eelgrass?

2. How might an increase in turbidity affect productivity in an estuary?

3. List two human and two natural causes of increased turbidity.

4. What are some factors that can cause inaccurate secchi disc measurements?



pH

The pH scale is a measure of the amount of hydrogen ions in a solution (please read the discussion of pH on pages 26-28 in the "Ecology" section. The pH of water is an important chemical factor determining which organisms can survive in an area. Though sea water is naturally buffered against drastic changes in pH, an estuary is faced with constantly changing fresh and salt water interactions and is often influenced by human activities. The presence of a water treatment plant or industrial effluent may change the pH enough to affect the organisms living nearby.

The "p" in pH stand for "potential." "H" stands for hydrogen. A pH of 1 stands for 10^{-1} grams of hydrogen ion (H^+) per liter. A pH of 7 stands for 10^{-7} grams H^+. The pH scale ranges from 1 to 14, with 1 being very acidic (having the most H^+), 7 being neutral (having equal H^+ and OH^-), and 14 being the most basic. Since the number of the pH scale refers to an exponent of 10, a change in just one number on the scale indicates a change of 10 times the acidity. So a solution of pH 6 has 10 times the number of H^+ as a solution of pH 7. A pH of 5 indicates 100 times the H^+ of pH 7, and pH 4 is 1000 times more acidic than pH 7.

Most organisms have a specific pH tolerance. Some species have a broad tolerance and can survive large pH changes. For others, however, even a slight change of pH can be limiting. Like temperature, oxygen, and salinity, pH is one more way to measure the health of a system.

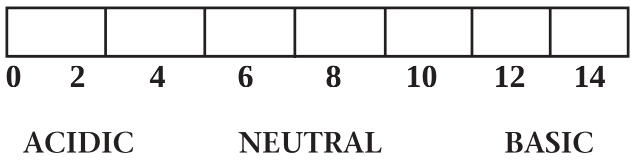
Procedure

1. Samples are easily contaminated. Clean equipment and hands are important.

2. Approximations of acidity can be easily obtained using pH paper.
   a. Tear off about 5 cm of pH paper.
   b. Place 3-4 drops of your sample onto the paper.
   c. Compare color to the standard chart.

3. A more accurate procedure uses a pH meter or test kit. One type of kit uses a pH indicator solution which changes the color of the sample. The color is then compared to the pure sample with a comparator wheel. Be sure to follow the directions supplied by the manufacturer of your test kit or meter.

4. **Important**: Measure the pH immediately after sampling, since temperature change can affect pH.



pH scale

Approximate pH's

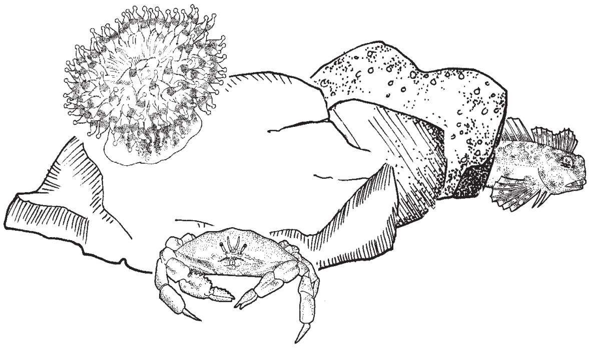
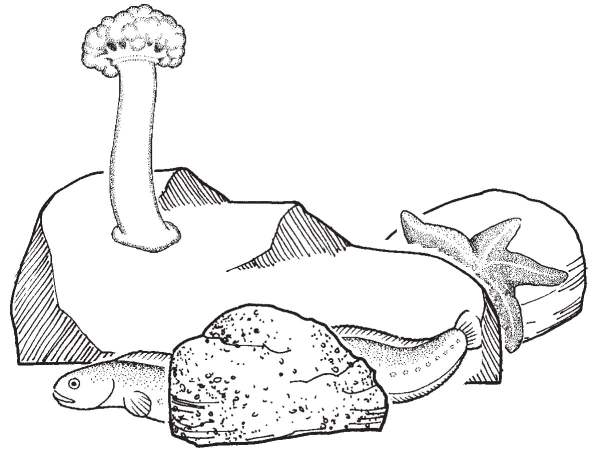
1.0 - stomach acid	6.3 - milk
2.0 - lemon juice	7.0 - distilled water
2.5 - vinegar	7.5 - human blood
<3.5-all fish die->9.5	11 - ammonia
4.0 - oranges	12 - bleach
5.6 - normal rain	13 - lye

Questions

1. On the pH scale, what readings indicate an acid?

2. A solution with a pH of 9 has how many times more OH^- than a solution with a pH of 7?

3. True or false? Organisms cannot live in areas where the pH changes? Explain your answer.

Keeping a Marine Aquarium - Activity 4

From kindergarten to graduate school, the marine aquarium arouses interest and enthusiasm. Traditionally, marine aquaria have been expensive and difficult to operate. Recent technological improvements have reduced the cost and labor involved in maintaining a marine aquarium. Teachers should give every consideration to the establishment of a marine aquarium in the classroom.

Before embarking on a marine aquarium project, some basic questions need to be resolved. The expenditure of time and money will vary greatly depending on your objectives. A simple set-up to keep hermit crabs can be had for a few dollars, and an elaborate temperature-controlled aquarium can cost several thousand dollars.

Regardless of the type of aquarium chosen, some facts pertain to all:

Aquarium tank: use only tanks made from all glass, plastic, epoxy-coated wood, or fiberglass. No metal edges. While a 10-gallon aquarium may be used in some cases, 20 gallon size is the preferred minimum.

Sub-gravel filter: a good sub-gravel filter should be employed to help control biological wastes.

Air pump: you can seldom have too much air. Get a pump with a capacity high enough to effectively run the sub-gravel filtration system.

Gravel filtrant: use dolomite, crushed coral rock, or crushed oyster shell. Builders' gravel has iron and similar materials that will harm or kill marine organisms.

Thermometer/Hydrometer: tools useful in determining the salinity and temperature of the water.

Seawater: synthetic sea salts may be used to make salt water solutions if you are too far from natural seawater.

Food: depends upon the type of organism. Use only high quality foods and remove uneaten food from aquarium.

If you buy a marine aquarium kit, instructions for set-up will be included. Otherwise, a few hints are given below:

1. Talk to people who have had marine aquaria (e.g., other teachers, pet shops). Their assistance can be invaluable.

2. Place the aquarium in desired location, away from direct sunlight, but near an electrical outlet.

3. Install sub-gravel filter.

4. Wash gravel in tap water. Spread evenly over the filter.

5. Fill tank with correct amount of water needed to make sea salt solution (follow directions of manufacturer), or fill to 1 or 2 inches from top with natural sea water if available.

6. Run filtration system for 24 hours to mix solution.

7. Shut off filter. Check specific gravity by floating hydrometer and reading it at the water-line: it should read between 1.021 and 1.023 when the water temperature is 68-77°F (20-25°C). If necessary, adjust by adding tap water to lower reading.

8. Run filter for 14 days. Some aquarists recommend placing one or two hardy specimens in the tank for this period. If available, hermit crabs or the like should be added to help condition the water.

9. Add speciments to tank. If you order the animals from a biological supply house, they will come with directions. Otherwise, open each plastic bag of specimens in subdued light and float it on top of the water in the aquarium for 15 to 30 minutes. In this period trickle water from the tank into the bags to slowly equalize temperature and salinity. This is the crucial step Now add animals to tank, one at a time. (If animals act nervous or contract, stop operation until they have adjusted.)

10. The specimens will live several months without being fed, but to keep them healthy, adopt a simple, regular feeding program. Feed carnivorous invertebrates (sea anemones, crabs, horseshoe crabs, starfish) once a week: they take small minnows, shrimp, earthworms, bits of lean beef. Filter-feeders (barnacles, hydroids, sea cucumbers, clams) eat *Daphnia*, brine shrimp, algae, protozoa, or dried fish foods. Herbivorous species (sea hares, sea urchins, turban snails) may be fed lettuce or spinach. Avoid water pollution -- remove all uneaten food.

Not all plants and animals are suitable for marine aquaria. Sea anemones, chitons, snails, crabs, shrimp, horseshoe crabs, hermit crabs, starfish, and brittle stars make good specimens. Avoid the burrowing forms. Sponges, jellyfish, corals, marine worms, and sand dollars should be avoided, since they may die unseen and foul the water. Cautious observation of fish and plants will determine which species will survive well in your situation. It is important to watch the organisms in your aquarium and remove any deceased members of the community immediately. Further information about suitable organisms can be found in the Resources section.

If you will be collecting your own specimens you need to be aware of state regulations. Species such as sport fishes and shellfish are "classified" with the Washington State Department of Fisheries. When collecting these you must abide by the regulations summarized in the "Salmon, Shellfish, Bottomfish, Sport Fishing Guide". This is available at most sporting goods stores. All other marine animals are regulated by the Washington State Department of Wildlife. To collect or harvest these "non-game species" you must obtain a Scientific Collection Permit. Call the Department of Wildlife at (206)753-2869 for more information.

Once the system is operating, care is easy. Each day, a person familiar with the aquarium should check filters and specimens.

Dead animals must be removed at once. Add **fresh water** as often as necessary to keep water at level marked. Do not add salt water, since this will increase the salinity. (Some tap water contains chlorine that is toxic to marine organisms. This water must be dechlorinated with a chemical additive or be allowed to stand for 24 hours, allowing the chlorine to evaporate.)

Though sea-salts don't disintegrate, specimens will stay healthier with partial water changes at regular intervals. Suggestion: once a month, add a few gallons of new seawater solution after siphoning off the same amount from the tank.

For algae control, scrape tank walls every two weeks.

The above suggestions apply to all marine aquaria. If you live in a northern latitude and want to keep local cold water species, you will need a refrigeration unit of some description. Instructions for homemade units can be found in reference books on marine aquaria. Ready-made refrigerated aquaria are available and expensive.

from: Marine Biology and Oceanography, Marine Science Project: For Sea, Marine Science Center, Poulsbo

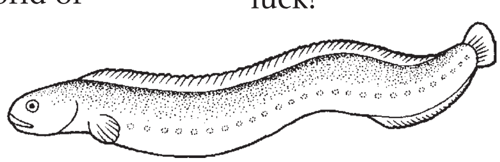
Creating a Mud Tank

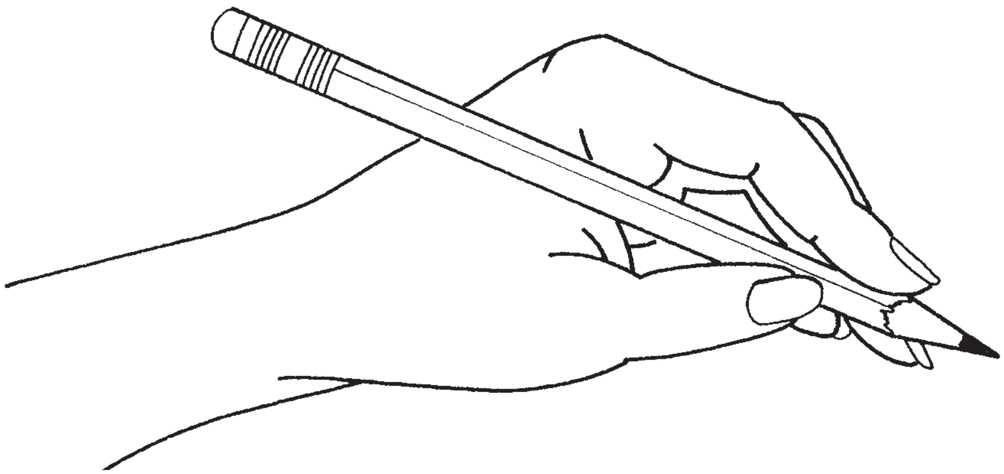
What do you get when you take one bucket of mud and an aerator and put them in a 10 gallon aquarium? Answer: your own mudflat.

This is an easy and inexpensive method to bring the estuary world into your classroom. You won't see a flashy tidepool or the famous aquarium characters like crabs and fish, but you will have a cut-a-way look inside the subtle world of worms, snails, and clams.

1. Start with 3-6 inches of estuary mud in the bottom of a 10 gallon tank.
2. Top with estuary water and install an aerator.
3. Add plankton as often as you can and change the water every few weeks.
4. After you see what's hiding in your mud you can add more. Lugworms, scale worms, snails, burrowing anemones, mud shrimp, and bubble shells (though slimy) are all well behaved visitors. We've had problems with clams (they may need more plankton food than we could provide) and nudibranchs (either they were very picky eaters, or they ate everyone else in the tank). You may want to try these as short-term visitors, releasing them after a week or two.
5. Once your tank is established, you'll notice the landscape changes daily as burrowers and microscopic detritivores poke around in the mud. Examining the mud surface or film on the aquarium sides with a microscope will give you a glimse of these tiny mud creatures.

If, after reading the above, you are discouraged, take heart. Hundreds of teachers are operating successful in-class marine aquaria. A simple aquarium for hermit crabs can be set up for a very few dollars. Solicit donations from students. Go to a pet shop and buy a hermit crab or two and get instructions on how to keep them alive. It can be fun! At the very least, set up a freshwater aquarium with goldfish or tropical fish so that you can use a living example when you talk about aquatic organisms. Here is a real opportunity to use all that creativity that got you into teaching in the first place. Good luck!





Writing With Estuaries - Activity 5

Before You Write

The following writing activities were chosen as a way for you to begin to individually explore and express thoughts about yourself and about the estuary. You can just as easily use the exercises to paint, sculpt, compose, or otherwise create your expression. These activities grew out of the following definition:

> "Self-expression is the source of all abasement (humility), just as . . . it is the basis for all true elevation. The first step is **introspection** - exclusive contemplation of the self. The second step must be genuine **observation** outward - spontaneous, sober observation of the external world."
>
> - Heinrich Novalis (1772-1801)
> German artist and writer

Expressing yourself through introspection and observation is the foundation for the following activities:

The first step of introspection can be tried in the **journaling activity**.

The second step of observation is the aim of the **object poem activity**.

These two steps are combined into a richer expression through the **I-search exercise**.

Warning: These activities may lead to personal satisfaction. Please perform only with teacher supervision.

Estuary by Journal

> "I come to this island every month of the year. I walk around it, stopping and staring, I straddle the sycamore log over the creek, curling my legs out of the water in winter, trying to read. Today I sit on the dry grass at the end of the island by the slower side of the creek. I'm drawn to this spot. I come to it as an oracle; I return to it as a man years later will seek out the battlefield where he lost a leg or an arm."
>
> \- Annie Dillard
> *Pilgrim at Tinker Creek*

Writing in a journal is an example of **introspection**. To write in a journal means to write in a purely personal dialogue. This is where many writers do more than record daily activities. They let their feelings as well as their thoughts interact on the paper without restricting their flow. Hopefully, you already have tried, or still keep a journal. Here is our simple suggestion for a journal exercise that focuses on the estuary.

1. Visit an estuary or read a poem or story relating to an estuary. (See Resources)

2. Find a place to write. A spot outside and away from other people is best, though a school desk can work just as well.

3. Write freely without worrying about punctuation or spelling on these two questions:
   -- How does the place or written piece make you feel? Start with a feeling, then expand on it. Maybe you feel relaxed from sitting in the sun by the water. At the sight of a fishing boat you may feel sorry for the fish or worried about the estuary's future. Maybe you feel disgusted by the images of death and decay. Different people will have different reactions to the same experience. Find your experience and write about it.

   -- Why does it make you feel that way? You can't always justify feelings, but you can explore them. If a boat makes you feel restless, maybe it's because you want to be on it, traveling to a different part of the world. If a small fish getting eaten by a heron makes you sad, maybe you can trace it to a pet that died. Usually it relates back to something going on in your life.

4. Keep writing until the writing takes over; it will come alive if given the time.

5. After you've searched your feelings, read back and find similarities between them and the images around you. (How is my feeling of optimism or pain like the waves? . . .)

Estuary by Object Poem

"When a man becomes proud to be not just the site where ideas and feelings are produced, but also the crossroad where they divide and mingle, he will be ready to be saved. Hope therefore lies in a poetry through which the world so invades the spirit of man that he becomes almost speechless, and later reinvents a language. . . . True poetry is what does not pretend to be poetry. It is in the dogged drafts of a few maniacs seeking the new encounter."

- Frances Ponge, French poet

The second step of self-expression is observation. The object poem, or as poetically labeled, the "thing" poem, is a great way to practice your observation skills at the estuary.

1. Pick an object (ideally an estuary object).
2. Observe it closely.
3. Write a poem about the object.

This appears easy enough, but the catch is to observe the object with such intensity that you actually see through the eyes of that object. If you observe a rock, "become" that rock. What does the rock do, think, feel? What is it like to be a million years old? How do you like being rolled by the waves?

"The boat rolled upon its tether, shifts its body from one foot to the other, restless and stubborn as a colt . . ."

- from "The Boat" by Francis Ponge

An object poem should not become overwhelmed by your thoughts and feelings. When you write a true object poem, you no longer exist and cannot write from your human perspective.

A Mount Vernon High School student sitting by Padilla Bay wrote this object poem about some footprints:

Footprints nestled in the mud;
softened by the tides.
Each one its own pool
after being tucked in by a wave.
The new footprint starts with a sole
that's pushed down any soul before it.
After the currents have carried it away
new creatures give it a newer,
naturalprint.
The millions of footprints have mulched up
the soft folds of life.

- Andrea Holloman

She wrote this in a 30 minute exercise, and already it's published. We observe things everyday, but we have so many stimuli pounding us that our senses become numb. Try reopening them.

Estuary by "I-Search" Paper

"The road I took back to my motel passes through a salt marsh - a fragrant, 3,000 acre blackness that winds towards the vaster blackness of the North Atlantic. A marsh smell is nothing you convince anyone about: it is either the stench of putrifying garbage or a tangy whiff of pure existence."

- Floyd C. Stuart
  "The Salt Marsh"

In an "I-Search" paper, the writer uses not only the traditional information sources such as libraries and schools, but also includes personal experiences, thoughts, and feelings to explore a theme.

1. Think of a way that you've experienced the estuary: eating oysters, visiting the beach, going fishing.

2. Research the estuary through the angle of your choice. Study the techniques of catching salmon, the proper preparation of an oyster, or the music of estuarine inhabitants. Photograph birds of the Pacific flyway. Collect the names of estuaries or types of boats. Talk to commercial fishermen, marsh artists -- whatever -- as long as it relates to the place where rivers meet the ocean.

2. Write about your topic using all of what you've discovered and experienced.

3. Tie the information together using your own thoughts, feelings, and memories.

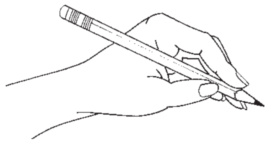
The Sound Of My Life by Carol Goncalves is an example of an estuary "I-search" paper about growing up on Long Island Sound. It begins:

" I remember as a child spending many summer days swimming in the salt water at Fairfield Beach. At night, as I lay in bed, I could hear the sounds of foghorns even though we lived three miles away...I sensed there was something special about the seacoast.

"I wondered what it was like to live on a New England beach year round. What was it like in the crisp air of autumn and the bleakness of winter, after the summer people headed for home? What were the pleasures as well as the dangers of living near the sea.

"I borrowed a few books from the Fairfield Public Library which I thought would provide me some answers . . ."

You can read more in Ken Macrorie's book, *The I-Search Paper*, listed in the Resources section.



Creative Exercises

Choose one of the following situations:

1. You are a Native American living near the Cascade Mountains 10,000 years ago. The great glacier has been gone for many generations, but oral tradition still tells of the colder times. Small glaciers still cover parts of the Cascades and send torrents of water down the many rivers. A remnant of the great glacier can still be seen blocking what is now the Strait of Juan de Fuca. You live on the shore of the huge, fresh water lake that the glacier created. Retell a story about the old times. (See Chapter 1, Estuary Formed.)

2. It is 1860. You are Samuel Calhoun, a lumber mill worker from Camano Island. One Sunday, you borrow a canoe and decide to go exploring in the vast Olympia Marsh. (Camano Island, Bay View Ridge, Fidalgo Island, Samish Island, and the hills around La Conner are all forested "islands" in the wild swamp created by the Skagit River's delta.) You soon realize that you should have hired a guide. Record your adventure in your diary. (See Chapter 2, Estuary Settled.)

3. Describe a walk along the dike between Padilla Bay and fertile farmland that was once a marsh. (Some possibilities: a stormy winter day with an unusually high tide, a hot summer day at low tide, a description of the weather, the view, or the animals you observe)

4. You are an animal in Padilla Bay, and the tide just went out. Write about your community and your role there. (See Chapter 3, Estuary Alive, or the Field Guide to Padilla Bay Organisms, Resources section.)

5. You are a 79-year-old woman living next to the bay in the farmhouse that you grew up in. The land is now worth hundreds of thousands of dollars as it could be subdivided and developed. Write down what is going through your mind as you both reminisce and look to the future.

6. Look through any of the text you have read in this curriculum and choose your own situation to write about. Choose something that is especially interesting to you. It could be from the past, present, or even future. You may want to discuss a problem from a particular point of view (human or non-human). You might look at a topic from many points of view. You might describe a personal experience.

Thinking Globally About Estuaries - Activity 6

Using an atlas or world map:

1. You live in a watershed that drains into an estuary. Locate and identify that estuary. Is there a city there?

2. Make a list of Washington rivers that have cities on their estuaries.

3. List several large rivers in North America. Find their estuaries. Which have a city at their mouth?

4. Find 10 large cities in the United States. Which are located on estuaries?

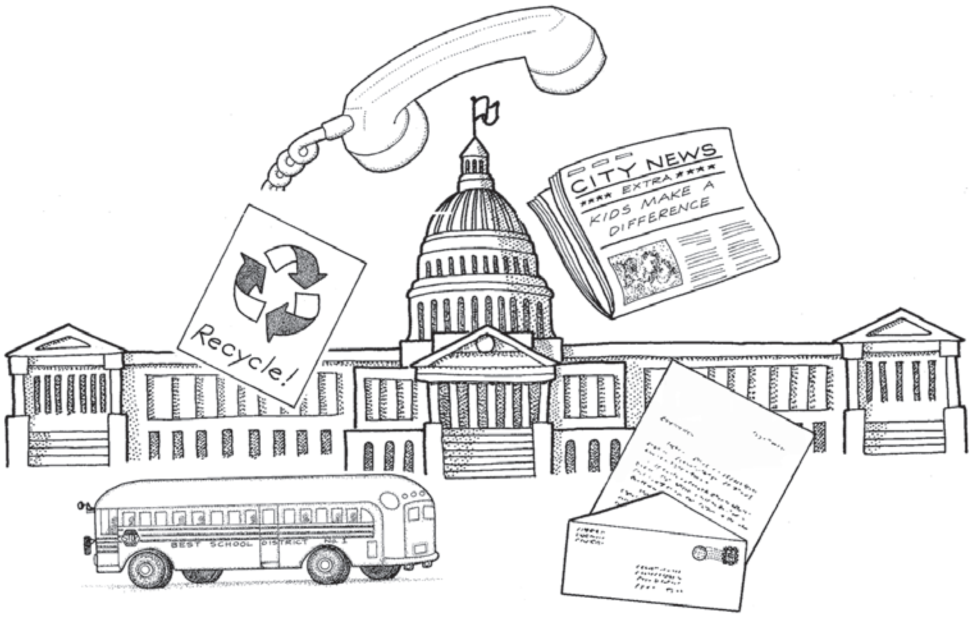
5. Find the world's largest cities. How many are on estuaries?

6. Find these famous rivers: Nile, Amazon, Congo, Mississippi, Columbia, Rio Grande, Hudson, Danube, Rhine, Volga, Euphrates, Tigris, Ganges, Yellow, Yangtze. Which have cities on their estuaries?

7. List some "upriver" activities that might affect water quality in an estuary.

8. Of the rivers listed in question 6, which have watersheds in more than one country? Describe some difficulties this might pose for regulation and management.

9. Many of Padilla Bay's waterfowl migrate. Research the migration route of one of the following: black brant, western sandpiper, peregrine falcon, bald eagle. Does that bird migrate to another estuary? If so, is it as "protected" as Padilla Bay?



What We Can Do for Estuaries - Activity 7

We are constantly making decisions which affect estuaries. Some of the decisions are big, like whether to allow destruction of critical habitat or deciding how much pollution from an industry is acceptable. Other decisions are smaller -- like whether to bike or drive somewhere or what to do with your old motor oil. These activities will 1) help you examine your personal actions that affect estuaries and 2) demonstrate ways that you can take part in the larger decisions being made around you.

In this section, you will find the following activities:

Surveying Your Behavior
Step 1: Drawing Your OwnWater
Step 2: Water Quantity Monitoring
Step 3: Perusing Through Poisons
Step 4: Cars and the Estuary

Know the Issues
Become the expert on estuary issues.

Working Together
Take a look at how other high school students have accomplished great things.

Write, Write, Write!
Letters from students make a big difference!

Speaking Your Mind
All about public hearings.

Step 1: Drawing Your Own Water

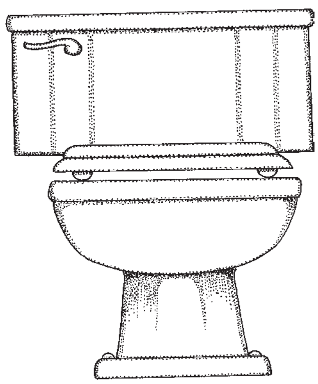
You remember the water cycle. Water evaporates from the ocean. Clouds form. Rain falls. . . . . But did you ever think of yourself as a part of that cycle?

Think about the water that goes through *your* house. Draw a picture of your water cycle (this will require some research). Use as many labels from this list as you can:

condensation
evaporation
stream (name?)
river (name?)
estuary
ocean (name?)
water tower
drain pipe
tree
evapotranspiration
water treatment plant
sewage treatment plant
wastewater outfall
septic tank
drain field
ground water
well
lake
sewer pipe
your home
wetland
cloud

1) What goes down the drain with the water at your house?
2) Are there things in your wastewater that the sewage treatment plant can't clean up?
3) What difference would it make if you used less water?
4) Is there a safe place to dump toxic products in your house or yard?

Step 2: Water Quantity Monitoring



"Mix one part excreta with one hundred parts clean water. Send the mixture through pipes to a central station where billions are spent in futile attempts to separate the two. Then dump the effluent, now poisoned with chemicals, but still rich in nutrients into the nearest body of water . . ."

from *The Toilet Papers*
by Sim Van Der Ryn

In a world where so many people have to walk miles for water, we are very lucky to have seemingly abundant water resources. So abundant that we can let gallons of clean, drinkable water trickle down the storm sewer while we polish the chrome on our car. Are we using this resource wisely? What effect does our extravagant water consumption have on the water system we are part of? In this activity, you will examine the amount of water you, personally, use in a week and then consider whether you can (or want to) use less.

Individually:

1. Estimate the amount of water your household uses in a week. Then divide that amount by the number of people in the household.

– Start by listing all the different uses you can think of (don't forget outdoor uses).

– For infrequent uses (like hosing down the driveway once a month), you'll need to "prorate." For example, you change your 4-gallon fish bowl every month. Write down 1 gallon/week.

As a class:

1. Find out how much water your school uses in a week. Divide by the number of people at your school.
2. What is the biggest water "user" in most homes? List ways you could conserve water in your home. List ways your school could conserve water.
3. Does water conservation affect the way a septic tank works? Does it make a difference in the sewage treatment process? (Call your sewage treatment plant to find out.) Would it make a difference to water quality in your estuary?
4. Why do you think some of us don't try to conserve water? (Think about "values" and what is important to people.) Why would someone voluntarily conserve water to help the environment? Would you (Be truthful)? Why or why not?

Step 3: Perusing the Poisons

Many useful products around our homes are hazardous to people, animals and the environment. If we pour these products down the drain, in a ditch, or in the back-yard, there is no doubt they will contact living organisms. Eventually they will drain into a wetland, the groundwater, or an estuary where they can wreak havoc.

This activity is an inventory. Hunt around your house, basement, and garage to find out which of these products you have. Ask your parents to assist you with this activity.

Caution: Please be very careful handling these products. While not all household products are hazardous, many could be harmful. Wash your hands carefully after you handle these containers.

Household products inventory

Do you have?	How much?	Where is it stored?	Warnings	Safer Alternative
PAINTS ___Enamel or oil based paints				
___Latex or water based paints				
___Rust paint				
___Thinners and turpentine				
___Furniture stripper				
___Stain or finish				

Household products inventory

Do you have?	How much?	Where is it stored?	Warnings	Safer Alternative
HOUSE ___Oven cleaner				
___Drain cleaner				
___ Toilet cleaner				
___Disinfectants				
___Upholstery or rug cleaners				
___Furniture or floor cleaners				
___Cleaners with bleach				
___Photographic chemicals				
___Silver polish				
___Pool chemicals				
___Cleaners with ammonia				
___Spot removers				
___Abrasive cleaners				

Adapted from *Away With Waste*, Washington State Department of Ecology Publication #90-12, 1990.

Household products inventory

Do you have?	How much?	Where is it stored?	Warnings	Safer Alternative
AUTO ___Antifreeze				
___Used oil				
___Brake fluid				
___Transmission fluid				
___Batteries				
___Gasoline				
PESTICIDES ___Herbicides				
___Mouse and rat killer				
___Roach and ant killer				
___Flea collars and sprays				
___Insecticides				
___Fungicides				
___Slug bait				
___Mothballs				
OTHER ___ ___				

Household products inventory

For this product	Try this safer substitute
Air freshener	Cinnamon & cloves (simmered)
Bathtub and tile cleaner	Baking soda & vinegar & water
Burn mark remover	Grated onion
Coffee cup stain cleaner	Salt (moist)
Decal remover	Vinegar (soak in white vinegar)
Drain cleaner	Plunger; baking soda or vinegar & hot water
Furniture polish	Olive oil; lemon juice & mineral oil
General household cleaner	Baking soda
Hand cleaner for paint/grease	Baby oil
Ink spot remover	Cream of tartar & lemon juice & cold water
Insects on plants	Soap & water
Moth repellent	Proper storage & laundering of clothing
Oil based paint	Water based paint
Oil stain remover	White chalk (rubbed in before laundering)
Paint brush softener	Vinegar (hot)
Refrigerator deoderizer	Baking soda
Roach repellent	Roach trap or "hotel"
Rug cleaner	Club soda
Rust remover	Lemon juice & salt & sunlight
Shoe polish	Banana peel
Slug repellent	Diatomaceous earth
Spot remover	Club soda; lemon juice; salt
Water mark remover	Toothpaste
Window cleaner	Vinegar (in warm water)
Wine stain remover	Salt

Adapted from *Away with Waste*, Washington State Department of Ecology Publication #90-12, 1990.

Step 4: Cars and the Estuary

Cars! What could be more important to us? They represent our status and freedom. They fuel the economy, give us independence, and take us to wild and exotic places (or to school and work). But at what cost?

You may have heard that automobiles are the largest source of air pollution in Washington, but have you ever thought of cars as water polluters, too? We won't even consider the environmental costs of manufacturing a car. Let's just consider using one.

What goes up usually comes down, so all that smog you've seen hovering around Puget Sound doesn't stay in the air, and it doesn't disappear. Invisibly, air pollution clings to water in the clouds and comes down as polluted rain. Nasty stuff if you are a plant, a lake, a granite statue, or (ironically) a car!

Even more damaging to our waters are the things cars leave behind on the roads. A car's tires wear on the road and leave cadmium and zinc to be picked up by the next rain. A parked car drips oil and grease. Chromium and zinc wear off the body. Copper and lead come from the engine. Once on the driveway or road, this ends up in ditches, storm sewers, and eventually the estuary.

As much as we might hate to admit it, driving less is good for an estuary (and good for lots of other parts of our environment, too). Driving less may seem impossible -- especially to high school students -- but if we want water that's clean, air that we can breathe, and some land that's not paved over, this society is going to have to change its ways.

Here are four short surveys which look at how we use cars. You may want to divide into four small groups and do one survey each.

1. The Student Parking Lot

- Count the number of cars in the student parking lot. What percentage of students drive a car to school?
- After school, stake out a spot near the exit and record the number of cars and occupants per vehicle. Calculate the average occupants per vehicle.
- Total the number of SOVs. (That's short for Single Occupancy Vehicle.)
- Interview 10 student drivers. Find out why they don't take the bus. Ask if they car pool. Find the average occupants per vehicle. Compare this to your observations above. Ask how many miles per day they drive to and from school. What is their gas mileage? How much gas is used on one trip to school? Calculate the amount of gas used per day per student driving to school.

2. The Faculty Parking Lot

Repeat the above survey for teachers.

- In your interview, find out if public transportation is available. If available, why don't the teachers take the bus? Ask if they ever car pool and why. Find out how many miles they commute daily. What is their gas mileage? How much gas is used per teacher per day driving to school?

3. The Buses

– Interview five bus drivers. Ask them the number of miles they drive each day for the high school run. Find out their gas mileage and the average number of students per trip.

– Calculate the amount of gas used per person per day.

4. The Pavement

– Estimate the percentage of your school property that is paved for vehicles.

– Go outside and find a storm drain or ditch that catches runoff from the parking lot. (This is easy if it's raining.) Make a note of any visible pollutants on the pavement or in the water. Where does the water go from there? If you need to ask your local public works department, designate one person to call.

Wrapping it up:

Sharing your results with the rest of the class, work together to answer these questions.

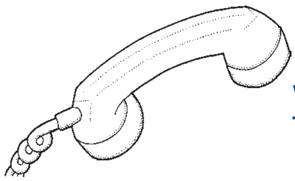
1. Why do some teachers and students choose not to use the bus? What difference would it make if they did?

2. How much space in your community is set aside for the care and use of cars? (Consider driveways, garages, streets, gas stations, freeways, malls. Look in the yellow pages in the automobile section for more ideas.) How does this compare to the amount of space set aside for people to live, play? . . .

3. Does the runoff from your school parking lot go directly to a body of water, or is it treated first? If it goes to a sewage treatment plant, are toxins removed from the water there?

4. List 10 advantages and 10 disadvantages for driving a car. Rank them. When do you choose **not** to use a car?

5. How do you think the use of cars differs for male and female high school students? For high school students and other adults?



So you've got your own house in order. You conserve water, electricity, gasoline, and paper products. You recycle, pick up litter, and buy only non-toxic products. You always fill in your holes after clam digging. Now what about those big decisions that are being made by our society? What can high school students do to take part in those big decisions? Try group action!

It is not often that students are advised to take action instead of waiting to be told to do something. But when they do take action, high school students have accomplished things that no one else could.

In Lynden, Washington, Lynden Christian High School students started a salmon enhancement project that raises and releases over 150,000 salmon each year. They've also worked with the Department of Fisheries to restore streams.

The biology students at Seaside High in Seaside Oregon worked for a year to get the city to designate part of the Necanicum estuary as a park. They then raised $7,000, designed the park with the help of an architect, made interpretive signs and brochures, then, to top it all off, constructed the park facilites.

These students took action instead of feeling powerless. They became involved.

Students at Madison High in Portland started their own environmental club. These are the steps they followed. You may want to do the same in your school.

1. **Care**
   After learning about local environmental problems, nine students decided to get involved.

2. **Contact other groups**
   They quickly joined community clean-ups, nature trips, Audubon bird rehabilitations, EPA streamwalks, tree plantings, drama projects, and YMCA Earth Service Corps. Other environmental groups generously donated time and materials. (See References section.)

3. **Find more information**
   They read newspapers and magazines from the library and checked with a local nature center to find out more about issues and events. They basically became experts.

4. **Get training**
   They paid their own way, or sought funding for a variety of conferences, camps, and leadership workshops.

5. **Broaden membership**
   They continually brought people aboard and within six months, expanded to 55 members.

6. **Start a project**
   They sponsored a local town Earth Summit meeting, began a cafeteria recycling project, and adopted their own wetland.

7. **Record involvement**
   They made slides, pictures, journals, and portfolios of their activities that they used in presentions for more funding. They also filmed and produced their own video.

Tips from "The Monday Group"

"The Monday Group," an environmental education class seminar in Florida is another example of a group of students working together to solve environmental problems in their community. This class meets for a full day, every other Monday. Each year the group selects a project to focus their efforts on. In past years they have facilitated the purchase and protection of a cypress swamp, helped solve a conflict between the EPA and the local power company over the effects of their canal discharge system on the local manatee population, and assisted the county in drawing up new development regulations protecting the southern bald eagle population.

This group has been effective, in part, because of some fundamental operating rules that maximize the power of their group:

- Be for something. Being against something is not allowable; only positive viewpoints are accepted. Extreme or radical views are also not acceptable.
- Know the issue. You can become the most knowledgeable person in your community on any topic, but remember to look at all the sides.
- Be persistent. Environmental problems are slow and painful to solve. Don't expect a complete victory; small victories are what count.
- Know your allies and enemies. Use positive energy from those who support you, and try to neutralize the energy of those who don't.
- Treat people as individuals. Stereotyping prevents solutions.
- If you fail, recycle. Re-use all the knowledge you gained, pinpoint why it didn't work, then re-do it (without blaming or scapegoating something else).

Know the Issues

Estuaries are affected by many human activities. Many of those activities are a result of ordinary people (not "bad guys") -- people trying to operate an industry, maintain highways, grow food, make a living. Below is a list of issues facing estuaries. Some are "hot" items. Some may only be "warm." All of them are showing up in newspapers around Puget Sound. Look over the list and discuss it in class. What does your class know about these issues as they relate to estuaries? Are any of the issues of concern in your community? Is there a problem in **your** estuary? Choose a topic that interests you. The issues can serve as topics for small group or individual research projects, or the whole class may investigate one topic together.

Salmon
Water Rights
Water Conservation
Property Rights
Oil Transportation
Forest Practices
Commercial Fishing
Non-native Species
Growth Management
Wetland Mitigation
Native American Rights
Shellfish Contamination
Household Hazardous Waste
Shoreline Development
Non-point Pollution
Agricultural Runoff

Before you tackle an issue or let decision makers know how you feel, you need to be well informed. Find out all you can about your issue first. Become an expert. The following steps will help you in your research.

1. Find out why estuaries are important to people and wildlife. Start by reading this book if you haven't already done so.

2. Go to the library and look through newspapers and magazines. Try to find the history of the issue. What is the problem? Does it involve a conflict between different interests?

3. Find out what the existing regulations are concerning your issue (not an easy task!). There is no single law that governs estuaries, nor any single agency that regulates all estuary matters. Rather, there are a number of laws which pertain, at least in part, to estuary issues. These laws are administered by several different agencies, each with specific responsibilities and jurisdiction. To make things even more complicated, these agencies represent all three levels of government -- federal, state, and local. The following overview of major regulations pertaining to wetlands may send you in the right direction (see page 118). Remember, wetlands regulations are changing frequently these days.

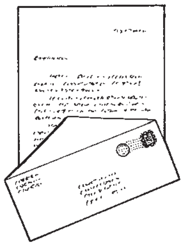
4. What government agencies are involved? Call an agency and ask. (See the "Resources" section or the blue pages of your phone book for a listing of agencies.) When you call or write, be specific about the information you need. "I'm a high school student researching ______. Is your agency involved in ______? Can you direct me to any regulations concerning _______? Who else might have information?"

5. Utilities, industries, and private interests like developers may have important information. Even if they seem to be on the "other side" of the issue, be open to their point of view.

6. Call environmental organizations such as the National Audubon Society or People for Puget Sound who might be following your issue. They are usually up-to-date on current legislation affecting estuaries. (See Resources section.)

7. Organize your information and give a class presentation. Remember to present all the different views. You've now done your homework and are ready to make some changes.

Regulation	Description	Agency
Federal Clean Water Act Section 404	Requires a permit for placement of all dredge and fill materials, and covers all the waters of the United States, including most wetlands.	U.S. Army Corps of Engineers/EPA
Federal Clean Water Act Section 401	Requires certification from the state that any materials discharged into a wetland under a federal permit meet state water quality standards.	Department of Ecology
Federal River and Harbor Act Section 10	Requires a permit for all construction activities in navigable waters, including wetlands within those waters.	U.S. Army Corps of Engineers
State Shoreline Management Act	Requires a permit to ensure that proposed activity complies with local shoreline master plan; includes all land within 200 feet of ordinary high water mark of a state shoreline, and may be extended to include an entire associated watershed.	Local jurisdiction/ Department of Ecology
State Hydraulic Code	Requires a permit for all work that occurs below the ordinary high water mark of state waters, including portions of wetlands.	State Depts. of of Fisheries and Wildlife
State Environmental Policy Act (SEPA)	Requires full disclosure of the potential adverse environmental effects of any proposed actions; applies to all federal, state, and local actions and all wetlands.	Usually a local agency
National Environmental permit Policy Act (NEPA)	Requires full disclosure of the potential effects of proposed federal action; applies to all wetlands	Usually federal agency issuing
Federal Coastal Zone Management Act	Requires a notice of consistency with the state coastal zone management plan as a condition of federal support of local activities; covers Washington's 15 coastal counties and the wetlands within them.	Department of Ecology
Floodplain Management Program	Regulates construction and other activities that might increase flood flow; covers wetlands incidentally.	Local jurisdictions and Department of Ecology
Local Regulations	May require permits for various activities. May identify specific wetlands or performance standards. May vary widely from jurisdiction to jurisdiction.	Local jurisdiction



Write, Write, Write!

Now that you've researched your issue, you can begin making things happen. People who make changes happen need to hear from YOU! Your parents, teachers, or a librarian can help you to identify your representative in Congress or the state legislature. Depending on your issue, you may also want to write to someone on your county council, the mayor of your city or town, your state's governor or other government officials. Keep up with the news about legislation. If a bill has been proposed that deals with your issue, write and let your legislator know about it before the bill comes up for a vote.

No matter what the issue or who you write to, you'll be more successful if you follow these simple rules:

1. Do your homework. Be certain that you understand the issue and can discuss it clearly.

2. Make a list of what you want to say before you start to write.

3. Use language that shows that you are courteous and respectful of the person to whom you are writing. Thank him or her for taking the time to read your letter.

4. Explain the problem and your feelings about it, but keep the letter short (one page). Be specific. For example: "I am concerned that the shopping mall planned in my community will destroy valuable wetlands nearby." Or, "I am writing to show my support for bill no. _______ which states . . ." and then say why you support it.

5. If you have a reasonable solution in mind, state it. Ask what the person feels can be done about the problem, and ask for a response. Be sure that your address appears on the letter, in case the envelope is lost.

6. Ask someone to check your grammar and spelling. Type or write the final letter on clean paper without errors.

7. If you do not get a response in a few weeks, write a second letter, briefly re-stating what your first letter said. If this doesn't work, don't give up! Try another representative.

Adapted with permission from WOW!: The Wonders of Wetlands, Britt Eckhardt Slattery, Environmental Concern, Inc., 1991.

If you have carefully researched a problem and feel that something should be done about it, there are many ways to make sure your voice is heard. You can bring up an issue before a government body such as your city council, county board, or even state legislature. Another very effective place to "speak your mind" is a public hearing.

A public hearing is a meeting scheduled by an agency or organization in order to gather information from the public as well as to provide information to the public. Meetings have different formats, but the most common structure is to schedule part of the meeting for public input. At that time, speakers will be asked to come forward and present their views. This could be you! Decision makers are often required to consider public input when dealing with an issue. One good presentation (especially from a young person) can have a great deal of influence. In fact, one well prepared and informed high school student will attract attention that the decision makers can't ignore.

Before you go to a meeting

1. Know why the meeting was called. Is it a regularly scheduled meeting dealing with more than one topic? Was it called to give information and answer questions? Is it a panel presentation with time for questions and answers? Is it being held to solicit public input (your input)? Not all meetings include a time for you to share your views. If this is the case, the meeting may still be a good place for you to gather information and see other people's perspectives. Who and how many are expected to attend?

2. Know exactly what the topic is and be sure to address that topic.

3. Research the issue. (See p. 116-118.)

4. Prepare your presentation. Outline the points you want to make before you speak. A section on "Power Speeches" in *The Kid's Guide to Social Action* by Barbara A. Lewis has some great tips for preparing an effective presentation. You don't need to limit yourself to "talk." Handouts, visual aids like slides or posters, and petitions can make your presentation more effective.

5. Know your time limit: Lots of people come with too much to say, and run out of time before they get to the main point. Remember the Gettysburg Address? That three-minute speech changed the course of American history. *Short* can be better. Make clear, succinct points and back them up with stories or instances. You may also want to allow time for questions.

6. If you think it would help your cause to have media coverage, you can inform local newspapers, radio and TV stations that you will be presenting.

At the Meeting

1. Arrive on time and get your name on the list of speakers.

2. Be polite. Pay close attention to what others say, especially if their views differ from yours. You may want to take notes. Use this time to gather more information.

3. When it is your turn to speak, identify yourself clearly so that you can be reached in the future. (Include your name and address on any handouts.) Speak up. Your views are important and should be heard.

4. Stay until the end of the meeting. This will demonstrate your desire to listen as well as to be heard.

5. Keep your cool. Things may get hot when emotions misconstrue issues into polarized sides. The resulting outbursts are usually counter-productive. If you look at the issue as a problem to be solved together rather than a fight to be won, you will make a greater contribution to the decision making process.