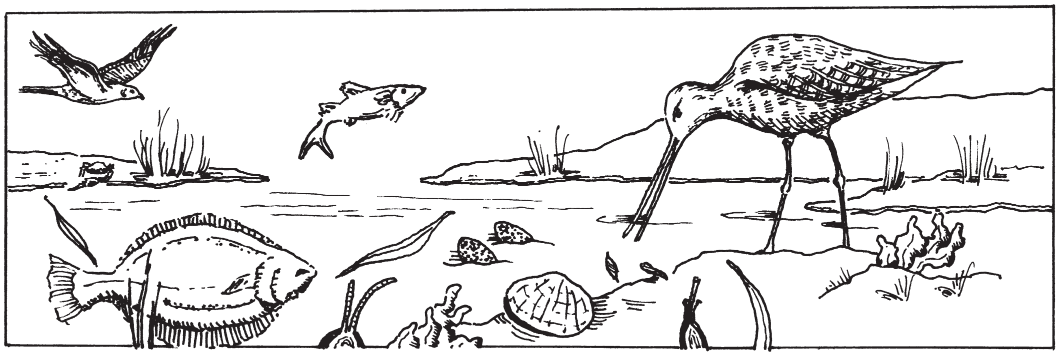


Activity #2: Measuring Water Quality

Adapted from "Water Quality Monitoring," The Estuary Guide, Padilla Bay National Estuarine Research Reserve.

California Content Standards
Earth Sciences 9c
Investigation and Experimentation 1a

Objectives:

To familiarize students with the tests that are necessary to monitor the pH, dissolved oxygen, nitrates, phosphates, add salinity of a sample of water. These parameters are an indication of water quality.

Time:

One day for lab preparation, one day to complete pH, nitrate, phosphate, and salinity tests, one day for dissolved oxygen tests, and one day for discussion and final report. The final report can also be assigned for homework. Note: Students with very low reading skills may require more than one day for the lab preparation.

Background:

Water monitoring is a systematic measurement of parameters that indicate water quality. The activities in this section are designed to be completed in the classroom to familiarize students with the procedures for completing five tests that give information about the health of a body of water: pH, dissolved oxygen, nitrates, phosphates, and salinity. If you decide to bring your students on a field trip to the estuary, the students can complete these same tests either at one site, to get a small picture of the conditions in the estuary at that site, or, if possible, at various sites throughout the estuary to give a more complete picture of the health of the estuary as a whole. This will give a larger picture and demonstrate the great variability within the system. See the Estuary Field Trip Guide for more information.

Materials:

You will need to provide a sample of water from the estuary, or from any natural body of salt-water. Each group of 4 students will need 500 ml the first day and 100 ml the second day. If possible, you might want to get samples from several different locations so students can compare results and speculate as to the reasons for the different results.

Water quality test kits are available free to teachers from the San Diego County Water Authority, after the teacher has completed a one day in-service workshop in the use of the kit. The Water Authority will pay for a substitute so you can attend this workshop. Contact Ivan Golakoff at (858) 522-6719 or igolakoff@sdcwa.org, or go to their website at http://www.sdcwa.org/education/secondary.phtml#allaboutwater. Scroll down to "Water Quality Testing Program" 6th-12th. If you have access to one of these kits, complete materials and instructions are included for the water tests. You can modify the instructions for each test in the Student Packet. If you don't have access to one of these kits, you will need the following:

pH tests: pH paper, color charts, and droppers.

Nitrates: Perform the nitrate test using the Aquarium Pharmaceuticals Freshwater/Saltwater Nitrate Test Kit available from PetsMart. Follow the instructions provided with the kit. You can find the kit at http://www.petsmart.com/fish/shopping/water_test_kits/products/product_13116.shtml. You can also use Aquarium Test strips that measure nitrates, nitrites, and pH.

Phosphates: Test for phosphates by using the phosphate test kit provided by LaMotte (or other supplier). Follow the instructions provided with the kit. It is important that the vials or test tubes used in the test be extremely clean. Preferably they should be soaked in diluted HCl and rinsed with distilled or demineralized water prior to the test.

Salinity: Each group of students needs a hydrometer, available at aquarium stores, a thermometer, and a 500 ml graduated cylinder.

Dissolved O2: Use the method known as the Winkler titration technique. Water sample for dissolved oxygen (DO) analysis must be carefully collected for the Winkler titration technique, so that the DO in the sample is representative of the water from which it was taken. Changes in DO are likely to occur if the sample is agitated or exposed to air. Rinse the sample bottle twice with water from the sample location. When collecting samples by hand, hold the bottle upside down until it is submerged, then turn it at an angle to fill completely. Cap the bottle under water. You will need to provide each group of students with MnSO4 (manganous sulfate), alkaline iodide azide, HISO4, 0.025N Na2S2O3 (Sodium thiosulfate), starch indicator, volumetric pipettes, a 250 ml Erlenmyer flask, automatic buret, and a 300 ml BOD bottle. The reagents can be purchased from a chemical supply company. Instructions for preparing the reagents are also included on the last page of this teacher guide.

Procedure:

1. On the day before the testing, divide the students into groups of four and provide each student with a Student Packet. The students should read the packet, highlight (or underline) any word or phrase they are not sure of, and discuss those words or phrases with their group. Allow approximately 15 - 20 minutes for the discussion, then ask the students to tell you the words or phrases they have highlighted. Write these words or phrases on an overhead or whiteboard, and discuss their meanings with the students. The students should write these words or phrases in their notebooks or journals, along with their meanings.

2. On the day of testing, provide each group with a sample of water from the estuary. Each group will complete the 5 water quality tests. At the end of the testing, the groups will compare their results and discuss any anomalies they might find.

3. Set up a materials cart with all the materials the students need to complete the 5 water quality tests. Each group of students should designate one student as the "Materials Manager," who is responsible for providing the group with all the materials they need to complete the tests, and returning those materials to the materials cart when each test is completed. The Materials Manager is the only student who should be moving around the room. This will keep traffic in the room to a minimum.

4. Make a transparency of the Water Monitoring Data Sheet. After all water tests are completed, fill in the results of the tests from all groups. Discuss the results of each of the five tests, and what those results might mean to the organisms living in the estuary.

5. Each student completes a lab report including the reasons for the tests, the test results, and the implication of the results for organisms in the estuary.

Reagent Preparation

a. Manganous sulfate: Dissolve 400g MnSO4 -H2O in 1L of distilled water.

b. Alkaline iodide azide: Dissolve 400g NaOH in 500ml boiled and cooled distilled water in a 1L volumetric flask, cool slightly, and then dissolve 900g NaI in this solution. Dissolve 10g NaN3 in 40ml distilled water and add the above solution. Add distilled water to the mark to make I liter.

c. Concentrated H2SO4 (no preparation necessary).

d. Starch indicator: Make a cold-water suspension of 5g arrowroot (or soluble starch) and add to about 800ml boiling water, stirring. Dilute to 1 liter and let settle 8 to 12 hours. Use the clear supernatant. Preserve with 1.25g salicylic acid per liter or by adding a few drops of toluene.

e. Standardized sodium thiosulfate:
  i). 0.1N stock solution: Dissolve 12.41g Na2S2O3-5H2O in boiled and cooled distilled water, dilute to 500ml. Preserve by adding 2g borax or 0.5g NaOH.
  ii). 0.0125N: -Measure 125 ml of 0.1N stock solution into a 1-L volumetric flask. Dilute to the mark with distilled water.

Answers to student questions:

1. List four reasons researchers monitor water quality.

   Answers will vary, but students should understand that water quality is essential to the health of the estuary and the plants and animals living in the estuary. Identifying, and correcting when possible, problems with the quality of the water in the estuary is of prime importance in managing the estuary.

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

   A pH below 7 indicates an acid, and a pH above 7 indicates a base. pH 7 is neutral.

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

   The pH scale is logarithmic, so an increase of 2 pH points would indicate an actual increase times 100 (10 times 10)

4. How can high levels of nitrates be harmful to aquatic systems?

   Nitrates are nutrients. High levels of nitrates cause large plant blooms, which can sometimes cover the entire surface of a body of water. These large mats of plants block light from getting into the water, and when they die, the bacterial decomposition can deplete the water of oxygen, leading to anoxic (without oxygen) conditions.

5. How can fertilizing lawns, washing clothes, and raising livestock often cause an excess of nitrates and phosphates entering the watershed"?

   Agricultural fertilizers, soaps, and livestock wastes can get washed into the rivers and streams by runoff during rains.

6. Why does fresh water float on salt water?

   Fresh water is less dense than salt water.

7. Convert 35 parts per thousand (0/00) to percent (%).

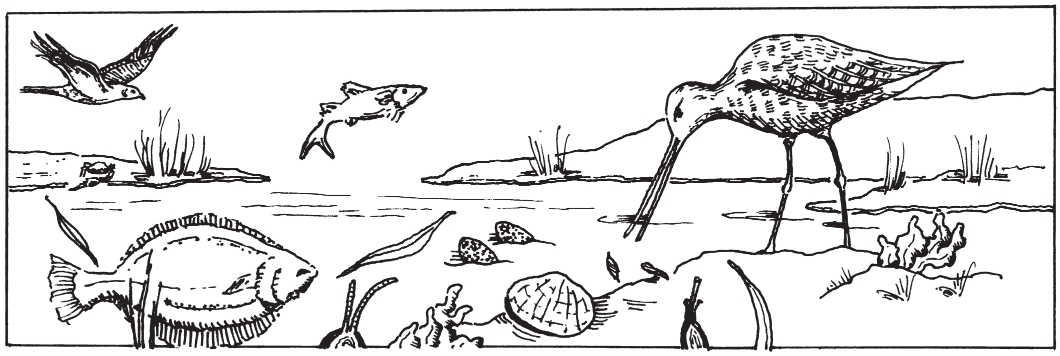
   35 parts per thousand equals 3.5 percent

8. What human activities can alter the salinity of coastal waters?

   Students should list ways that fresh water runoff is increased, such a irrigation of farm land, and ways that fresh water runoff is decreased, such as dams.

9. When scientists measure DO in the field, they are required to either complete the measurement immediately or fix the oxygen before storage and transportation. What might make the DO levels change if they didn't take these precautions?

   DO can change due to microscopic plants (phytoplankton) in the water that add oxygen to the water during photosynthesis, due to microscopic animals (zooplankton) that remove oxygen from the water, or to changes in the water temperature.



Activity #2: Measuring Water Quality

PURPOSE:

You will be performing five tests on a sample of water: pH, nitrates, phosphates, salinity, and dissolved oxygen. After following these activities, you should understand the purpose of these tests, know how to run accurate water quality tests, and see how these parameters relate to the quality of the water in the estuary.

INTRODUCTION:

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 damage done by an accident such as a toxic spill; to determine which topics need to be investigated further; to design a study to determine the effects of the results on the organisms living in or using the estuary, including humans.

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.

Keep in mind the limitations of water monitoring. The individual activities give a small piece of information about the sample of estuary water you will be testing. 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 testing activities include a short description of the parameter, how that factor is important in an estuarine system, and a description of the testing procedure.

MATERIALS:

For each student:

goggles, student packet, notebook or journal
Materials needed for each test are listed in the test sections of this packet.

PROCEDURE:

1. Read this entire packet of instructions, highlighting or underlining any words or phrases that are unfamiliar to you. With your partner, discuss the words/phrases you have each highlighted and try to find a meaning for each one. Be prepared to discuss your answers with the class.

2. On the day of testing, select one member of your group to act as the Materials Manager. The Materials Manager will provide the group with the materials you need to perform each test, one test at a time, and return the materials to the designated area when each test is completed. The Materials Manager should be the only person from your group who is walking around the room. All other group members should remain at your lab station.

3. Your group will perform the dissolved oxygen tests the first day, and the pH, nitrates, phosphates, and salinity tests, in any order, the second day.

Testing Day 1:

1. All group members must wear their safety goggles at all times.

2. Obtain a 500 ml sample of water from your teacher. When collecting your sample, try to prevent extra oxygen from entering the sample through bubbles. Siphon the water from one container to another rather than pouring, and allow your bottle to over flow to eliminate any atmospheric oxygen. Place a stopper or lid on the sample bottle carefully so that no air bubbles remain in the bottle.

DISSOLVED OXYGEN TEST:

For estuary organisms, oxygen (O2) 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 it is supplied by the photosynthesis of plants.

Many things affect the amount of O2 dissolved in water:

Temperature - Cold holds more O2 than warm water.
Aeration - Water stirred by currents and winds picks up extra O2.
Photosynthesis
Plankton growth - Plankton blooms caused by excess nutrients deplete the O2 when the microorganisms die and decay.
Organic Matter - Uses O2 when it decomposes

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.

TEST MATERIALS:

MnSO4	starch indicator	250 ml Erlenmyer flask
Alkaline iodide azide	Na2S2O3	300 ml BOD bottle
HISO4	Buret	Pipettes

Safety goggles must be worn at all times.

PROCEDURE:

This test uses the Winkler Titration method. First, you will "fix" the oxygen in your water sample by adding a floc of manganous hydroxide to the sample. This causes oxidation of the manganous hydroxide. When oxidation occurs, the sample has been "fixed" because the oxygen is "trapped" by its reaction with the floc. Potassium iodide is then added to the sample. When the sample is acidified, the floc is dissolved and iodine is liberated from the potassium iodide. The quantity of iodine liberated is equivalent to the quantity of oxygen in the sample. The iodine is then titrated with sodium thiosulfate and a starch indicator to determine the amount of dissolved oxygen in the sample.

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

b. With a pipette, add 2 ml MnSO4 (manganous hydroxide) reagent to your sample.

c. Add 2 ml alkaline iodide azide reagent in the same way.

d. Carefully stopper the bottle without introducing any air bubbles and mix by inverting the bottle ten to twenty times. When mixing, avoid splattering the liquid on the top of the bottle on your clothes or skin.

e. Allow to settle until at least 1/3 of the bottle is clear and then mix again.

f. When the floc has settled to the bottom 1/3 of the bottle, add 2 ml of concentrated HISO4 below the surface with a pipette. Carefully restopper and mix until the floc has dissolved.

g. Measure out 100 ml of the sample with a volumetric pipette and transfer to a 250-ml Erlenmyer flask. Touch the pipette tip to the side of the flask to remove the last drop.

h. Fill an automatic buret with 0.0125 N standardized sodium thiosulfate (Na2S2O3). Add titrate to the sample until a very pale yellow color appears. Mix the solution while titrating by swirling or with a magnetic stirrer.

i. Add two drops (1 ml) of starch indicator, mixing to get a uniform blue color.

j. Titrate carefully until the first disappearance of color. Do not overshoot the endpoint. The blue color should return on standing in 10 to 15 seconds. If it does not, too much titrate was added. Record the number of milliliters of titrate used.

k. Since 1 ml of 0.0125 N Na2S2O3 is equivalent to 0.1 mg DO, each milliliter of titrate used is equivalent to 1 mg DO per liter when a volume of 100 ml is titrated.

Testing Day 2:

1. All group members must wear their safety goggles at all times.

2. Obtain a 500 ml sample of water from your teacher. You will perform all four of today's tests on this sample. You will need about 450 ml for the last test.

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pH test:

The pH scale is a measure of the amount of hydrogen ions in a solution. 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 "p" in pH stands 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. PH is one way to measure the health of a system.

TEST MATERIALS:

pH paper, dropper

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. DO NOT put the pH paper into your water sample.
    c. Compare the color of the treated pH paper to the standard chart.
    d. Write the pH of your sample on the Student Data Sheet in this packet.

NITRATES TEST:

Nitrogen is an element needed by all living plants and animals to build protein. In aquatic ecosystems, nitrogen is present in many forms. It can combine with oxygen to form a compound called nitrate. Though nitrates are necessary for a productive system, too much can be a problem. High levels of nitrates can cause eutrophication of the body of water. Eutrophication refers to the aging of the body of water. Bodies of water with high levels of nitrates usually have low dissolved oxygen levels. Human activities such as fertilizing lawns, washing clothes, and raising livestock often cause an excess of nitrates and phosphates entering the watershed.

TEST MATERIALS:

Nitrate test kit.

PROCEDURE:

1. Be sure to carefully follow the instructions which accompany your nitrate-nitrogen test kit.

2. Record nitrate-nitrogen levels in pph on the Student Data Sheet. Nitrate-nitrogen levels can be converted to nitrate by multiplying by 4.4, but for this test, nitrate-nitrogen levels will be recorded.

3. A nitrate-nitrogen reading of less than 1.0 ppm is considered to be excellent. A reading between 1.1 - 3 ppm is considered to be good. A reading between 3.1 - 5 ppm is fair, and a reading greater than 5 ppm is considered to be poor.

PHOSPHATES TEST:

Phosphorous is usually present in natural waters as phosphate and is an essential element of life. Phosphates can come from fertilizers, human or animal wastes, soaps or detergents, or industrial waste. When too much phosphorous is present in the water, plants grow rapidly. Phosphates that enter a stream may cause algae to multiply and grow quickly. This may result in an algae bloom. Algae blooms are thick layers of green slime that cover the surface of ponds or slow moving streams.

Algae blooms are harmful to most aquatic organisms. They cause a decrease in the dissolved oxygen of the water. They prevent waves and the surface of the water from coming into contact with the air which provides the main source of oxygen for the water. Their dark color absorbs more heat energy from sunlight causing the water temperature to rise. Warm water holds less oxygen than cold and it causes the metabolic rate of aquatic organisms to increase. In addition, the algae which grow rapidly near the surface block sunlight to plants that live on the bottom causing them to die. Plants which grow fast die fast and sink to the bottom. Dead plant material is decomposed by bacteria increasing the biological oxygen demand. All of these factors combine to cause oxygen levels in the water to decrease rapidly. This can result in a fish kill and the death of many organisms.

TEST MATERIALS:

Phosphate test kit.

PROCEDURE:

1. Follow the instructions provided with the kit. It is important that the vials or test tubes used in the test by extremely clean. Preferably they should be soaked in dilute HCl (hydrochloric acid) and then rinsed in distilled or demineralized water. Your teacher may have already done this for you.

2. Record your results for the phosphate test in ppm on the Student Data Sheet. A reading of 1.0 ppm or less is considered excellent. A reading between 1.1 - 4 ppm is good. A reading between 4.1 - 9.9 ppm is fair, and a level greater than 10 ppm is poor.

SALINITY TEST:

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 living 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 are: Chlorine - 54%; Sodium - 31%; Sulfate - 8%; Magnesium - 4%; Calcium - 1%; Potassium - 1%; Others - 1%.

Organisms living in salt water get these elements directly from the water, and 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.

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

TEST MATERIALS:

Hydrometer, thermometer, 500 ml graduated cylinder.

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 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 150C, you need to determine what the water density would be at this temperature.

PROCEDURE:

1. Pour about 450 ml of your sample into a container such as a 500 ml graduated cylinder.

2. Measure and record temperature (centigrade).

3. Measure density with the hydrometer. (Look at the point where the water line

crosses the scale)

4. Correct the density using Chart 1, the Density-Water Temperature Chart. For exam ple, if your sample was 50C with a density of 1.0100, find the 50 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.

5. Use this new, corrected density to determine salinity on Chart 2, Salinity/Corrected Density Chart. Record the salinity of your sample on the Student Data Sheet.

QUESTIONS:

1. List four reasons researchers monitor water quality.

pH Test:

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

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

4. Compare the pH of each of the group water samples. Are they relatively uniform, or is there one or some that are higher or lower than the rest? Why do you think the water samples have these pH values?

5. The average pH of seawater is about 8. How does your sample compare to the average pH of seawater?

6. Describe the effect a large change in pH of the water would have on organisms living in the estuary.

Nitrates and Phosphates Tests:
7. How can high levels of nitrates be harmful to aquatic systems?

8. Compare the class data for nitrates and phosphates and discuss the reasons for any anomalies (higher or lower results).

9. How can "fertilizing lawns, washing clothes, and raising livestock often cause an excess of nitrates and phosphates entering the watershed?"

Salinities Tests:
10. Why does fresh water float on salt water?

11. The average salinity of seawater is 350/00. How does your sample compare? List some reasons for the difference between the salinity of your sample and the average salinity of sea-water.

12. What human activities can alter the salinity of coastal waters?

Dissolved Oxygen (DO) Tests:
13. When scientists measure DO in the field, they are required to either complete the measurement immediately or fix the oxygen before storage and transportation. What might make the DO levels change if they didn't take these precautions?

14. Plants emit oxygen as a waste product of photosynthesis, yet a large bloom of photosynthetic algae will cause a calm body of water to become anoxic (low to zero dissolved oxygen). Explain how this can happen. (Hint: It starts to happen after the algae bloom begins to die)

15. What would you suggest as a remedy if a part of the Tijuana Estuary became anoxic?

STUDENT DATA SHEET
WATER MONITORING

SCHOOL: **DATE:**

RESEARCHERS: **PERIOD:**

TEST	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
pH								
Nitrates								
Phosphates								
Salinity								
Dissolved Oxygen								