Texas' Many Aquatic Ecosystems

Ecosystems are complex interdependent webs of relationships between living and nonliving things. Texas has six kinds of aquatic ecosystem supporting significant biodiversity.

Chapter 6

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Discuss their experiences in various Texas aquatic ecosystems.
2. Generate a list of all the Texas aquatic ecosystems.
3. Identify how all of the Texas aquatic ecosystems are related.
4. Define ecosystem and identify the factors that make up an ecosystem
5. Explain how the parts of an ecosystem interact with one another.
6. Identify Texas' aquatic ecosystems and explain how the characteristics of the land affect the nature of the water.
7. Compare and contrast Texas' aquatic ecosystem types.
8. Define biodiversity and assess its importance.
9. Predict the impact of a natural or human-caused environmental change on the organisms in an ecosystem.
10. Describe possible solutions to potentially harmful environmental changes within an ecosystem.
11. Read the student materials and answer the questions.
12. Make a picture and label the parts indicating the relationships among Texas aquatic ecosystems.
13. Identify good water quality as a requirement for a healthy aquatic ecosystem.
14. Identify environmental changes that impact water quality.
15. Generate ideas about how scientists can count populations of organisms.
16. Determine the species composition of plant life on school grounds using line transect sampling, one method used by wildlife biologists to estimate population size.
17. Determine how sampling size effects accuracy and standard error of estimates.

18. Practice the mark and recapture method to estimate the number of beans in a jar.
19. Use the mark and recapture method to estimate a population in a nearby creek or pond.
20. Review natural and manmade causes of environmental change
21. Generate ideas for conserving aquatic ecosystems.
22. 23 Generate a list of things that can be done to conserve aquatic ecosystems.
23. Choose one project from the list for the class to actively help conserve aquatic ecosystems.
24. Choose one thing that they will do individually to actively help conserve aquatic ecosystems.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E, F; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.8 A, B; 7.10 A, B; 7.11 A, B; 7.14 C; 8.1 A, B; 8.2 A, B, C, D, E; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, J, K; 3 E; 4 A, B; 5 A; 7 A; 9 A; 10 A; 11 B; 12 A, B, D

Environmental Science: 1 A, B; 2 E, F, G, H, J, K; 3 C, E; 4 A, B, D, E; 5 B, C, E, F; 8 A; 9 A, B, D, E, K

Materials Needed

Activity 6.1

Science Journals

Pencils or pens

Activity 6.2

Student Guide

Science journals

Pens or pencils

Colored pencils or markers

Activity 6.3

Science journals

Pencils/pens

1 copy of *Plant Sampling—Line Transect Survey Investigation Student Instruction Sheet* and Data Table for each student (optional-students can make their own data table in their journals)

<u>For each group</u>

Set of transect lines
Mallet or hammer for driving wooden transect stakes
Set of plant identification field guides

Activity 6.4

Each pair of students needs these materials:

1-600 ml. beaker, which represents the habitat to be sampled
1-small (50 ml.) beaker (sampling beaker)
White beans
A marker or black beans
Note: You can mark each bean with a marker or you can replace each white bean with a black bean to save on beans.

Activity 6.5

Science journals
Chart paper and markers
White board or chalk board

Safety Precautions

Identify and stay clear of poison ivy and other poisonous plants. Wear long pants and closed-toed shoes. Review field safety guidelines.

Vocabulary

- Abiotic
- Aquifer
- Assumptions
- Bay
- Biodiversity
- Biotic
- Conservation
- Damming
- Draining
- Ecosystem
- Emigration
- Erosion
- Estuary

- Gulf of Mexico
- Healthy ecosystem
- Human impact
- Immigration
- Lake
- Line transect
- Mark and recapture
- Ocean
- Pond
- Population studies
- River
- Sampling
- Spring
- Stream
- Water quality

Enrichments

Project WILD Aquatic

- Aquatic Roots
- Edge of Home
- Watered-Down History

Guest Speaker

- Fisheries biologist may talk about fisheries management and aquatic ecosystems.
- Botanist or wildlife biologist may talk about population studies

Lesson 6.1: It's All Part of a System
Texas Waters

Essential Concept

While Texas has many types of aquatic ecosystems, they are all part of a system of watersheds that feed into one large system: the Gulf of Mexico.

Objectives

1. Students will discuss their experiences in various Texas aquatic ecosystems.
2. Students will generate a list of all the Texas aquatic ecosystems.
3. Students will identify how all of the Texas aquatic ecosystems are related.
4. Students will identify the source of water for their home.
5. Students identify the different organisms that live in different aquatic ecosystems.
6. Students will describe organisms from at least two aquatic ecosystems.

TEKS

7.10 A, B; 8.11 A

Aquatic Science: 9 A

Environmental Science: 5 B

Estimated Time

30 minutes

Materials

Science Journals

Pencils or pens

Procedure

1. My Water Experiences

We've been talking about and investigating aquatic ecosystems.

- **What are some aquatic ecosystems that you have visited?**

Allow students time to share any aquatic ecosystems with which they have had experiences. They may name ponds, streams, or rivers that they have visited as a class or they may think of other places that they have been with their families, near their homes, or on vacation. Try to get students to name as many types of aquatic ecosystems as they can. (A pond at a park where they caught tadpoles, a creek near their house where they

went fishing, a lake where their families had a picnic, a vacation at the beach at the Gulf of Mexico, a river where they went tubing, fishing in a bay, etc.) When everyone has had a turn that would like to share, ask students to write down in their journals one memory from an experience in or around water.

2. Texas' Aquatic Ecosystems

Ask students to work in groups of four to think about all the water ecosystems that they might like to visit or that they have heard about. Ask students to think about how these aquatic ecosystems might be related.

Have each group write down three things that they know about aquatic ecosystems in Texas. (Various ideas may be suggested such as: Texas has many types of aquatic ecosystems; aquatic ecosystems are places we enjoy visiting; aquatic ecosystems are habitat for all kinds of wildlife; aquatic ecosystems help make Texas beautiful; much of the water in Texas' aquatic ecosystems eventually flows to the Gulf of Mexico, etc.)

3. Putting Our Ideas Together

Work as a class to answer the following questions. Record students' ideas on chart paper. Have students record the information in their journals at the end of the class discussion.

- **What are some of the aquatic ecosystem you have thought of that are found in Texas?** (Aquifers, springs, streams, rivers, lakes, ponds, wetlands, bays, estuaries and oceans).
- **How are all of these aquatic ecosystems related?** (They are all part of a system of watersheds that feed into one large system: the Gulf of Mexico.)
- **Which of the aquatic ecosystems is salt water or brackish, and which are freshwater ecosystems?** (Some wetlands are brackish water, a mixture of fresh and saltwater, such as estuaries. Bays, and oceans are also saltwater. Aquifers, springs, streams, rivers, lakes, ponds, and some wetlands are freshwater.)
- **How many have you visited? What aquatic ecosystems are close to our school?**

Students may think of swimming in a spring-fed pool such as Balmorhea State Park or Barton Springs pool in Austin. This would be a good time to bring up groundwater and its importance as a source of water in Texas. Talk about the importance of aquifers.

Ask students to write the answers to the following questions in their journals.

- **What is the source of water at your home?**
- **How are the different ecosystems different or similar in the aquatic organisms they support?**
- **Describe some typical organisms from at least 2 aquatic ecosystems, one saltwater ecosystem and one freshwater ecosystem.**

Vocabulary

- Aquifer

- Bay
- Estuary
- Gulf of Mexico
- Lake
- Ocean
- Pond
- River
- Spring
- Stream

Lesson 6.2: Reading and Research

Essential Concept

Texas has a wide variety of aquatic ecosystems that are constantly changing naturally and being changed by human activity.

Objectives

1. Students will read the student materials.
2. Students will answer the questions.
3. Students will make a picture and label the parts indicating how Texas' aquatic ecosystems are related.

TEKS

6.2 C; 7.2 C; 7.10 B; 8.2 C; 8.11 C

Aquatic Science: 2 J; 12 A

Environmental Science: 2 K; 9 E

Estimated Time

Varies, questions can be assigned as homework or done in class.

At least 30 minutes should be provided for class discussion and drawing the diagram.

Materials

Student Guide

Science journals

Pens or pencils

Colored pencils or markers

Procedure

1. Student Reading

Have students read *Chapter 6: Texas Aquatic Ecosystems*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is an ecosystem? What are some of the parts of an ecosystem?

An ecosystem is a complex web of relationships between living and non-living things. The biotic (living) parts of the ecosystem are the communities of plant and animal populations, including humans. The abiotic (non-living) parts include sunlight, air, water, temperatures, soil, and minerals.

2) How do the parts of an ecosystem interact with one another?

Each part of an ecosystem is connected to and depends on all the others. It takes all the parts interacting to make the system work. All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem. Conversely, a healthy, balanced ecosystem provides for all the needs of the communities that live in it.

3) What kinds of aquatic ecosystems do we have in Texas? How are they alike or different from one another?

Texas has six kinds of aquatic ecosystems: aquifers and springs, rivers and streams, lakes and ponds, wetlands, bays and estuaries, and the ocean/Gulf of Mexico.

These ecosystems are alike in that they are all aquatic homes for a variety of organisms. They are different in size, whether they are surface or groundwater, whether they are flowing or standing water, whether they are saltwater or freshwater, and whether they are inland or coastal. These characteristics help determine the organisms that can make each ecosystem its home.

4) What is biodiversity? Why is it important?

Biodiversity refers to the variety and number of different organisms and populations in a community, and the way they live together. The greater the biodiversity in an ecosystem, the healthier, more sustainable and better balanced it is. Biodiversity is very important to the stability of an ecosystem. If many different species are present, then the loss of one or two species will probably not have a great effect. But if species diversity is low, the loss of one or two species could have a major impact.

5) How do humans impact aquatic ecosystems?

A human activity such as straightening a stream speeds up erosion and cuts out curves that shelter fish and other aquatic life. Changes may destroy habitat for some species and create it for others. Some human activities that can reduce aquatic biodiversity are draining a swamp, damming a river or pumping out water. These activities destroy habitat, which is the main cause of species decline.

6) How can we help conserve aquatic ecosystems?

Protecting and restoring a wide variety of habitat helps keep species from becoming endangered or extinct helping to maintain biodiversity for healthy ecosystems.

3. Getting the Big Picture

Ask students to draw a picture in their journals showing all the types of aquatic ecosystems in Texas and how they are related. Students should label each aquatic ecosystem.

4. Challenge Question

Ask students to brainstorm answers to the following question. Write students' ideas on the board and have students add the list to their science journals.

- **How is the diversity of species in Texas' aquatic ecosystems connected to the economic well being of Texas' citizens?**

Vocabulary

- Abiotic
- Aquifer
- Bay
- Biodiversity
- Biotic
- Damming
- Draining
- Ecosystem
- Erosion
- Estuary
- Human impact
- Lake
- Ocean
- Pond
- River
- Spring
- Stream

Lesson 6.3: The Hunt for Biodiversity

Essential Concept

Biodiversity is important to the health of an ecosystem. Scientists use special methods to survey organisms to find the biodiversity of an ecosystem.

Objectives

1. Students will identify good water quality as a requirement for a healthy aquatic ecosystem.
2. Students will identify environmental changes that impact water quality.
3. Students will generate ideas about how scientists can count populations of organisms.
4. Students will determine the species composition of plant life on school grounds using line transect sampling.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 7.1 A, B; 2 A, C, D, E; 7.11 A, B; 8.1 A, B; 2.2 A, C, D, E; 8.11 C

Aquatic Science: 1 A, B; 2 E, F, J; 3 E; 12 B

Environmental Science: 1 A; 2 E, F, G; 3 E; 4 A, B; 9 E

Estimated Time

1 ½ class periods

Materials

Science journals

Pencils/pens

1 copy of *Plant Sampling—Line Transect Survey Investigation* instruction sheet and and data table for each student (optional-students can make their own data table in their journals)

<u>For each group</u>

Set of transect lines

Mallet or hammer for driving wooden transect stakes

Set of plant identification field guides

Special Instructions

<u>Make a set of transect lines—one for each group in class.</u>

- Tie heavy twine or nylon rope to a tent peg or small wooden stake.
- Measure out 10 meters of line and fasten the other end to another peg or stake.
- Set up transect lines by driving one peg or stake into the ground, stretching the line tight and driving the other into the ground. (Alternatively, class time may be used having students make and set their own transect lines.)

If possible, choose transect line placements that show changes of plant species along the line. For example, moving from a tree-covered area to an open field, from a mowed area to an unmowed area or down a slope.

Safety Precautions

Identify and stay clear of poison ivy and other poisonous plants. Wear long pants and closed-toed shoes for outdoor activities.

Procedure

1. Review of Water Quality Indicators

In lesson 1.9 and again in Lesson 4.4 we visited an aquatic site and looked at water quality. Ask students to work in small groups using their journals to review your data from the field trips checking water quality. (Students should include physical and chemical water testing, observation of watershed land uses and conditions, observations of populations, and community interactions.)

- **What is water quality? (**Water quality is really a check of the health of an aquatic ecosystem. It looks at water chemistry including the amount of oxygen in the water available for use by all the organisms that live there. It looks at other water chemistry [acidity, salinity, nitrates, phosphates, temperature, conductivity, color and odor], all of which impact the living things in the water, and it looks at the variety and number of living things present in the ecosystem. Few different types of organisms, and few numbers of organisms of each type indicate that the water is not providing a healthy ecosystem for the living things there.)
- **What kinds of things affect water quality? (**Runoff, erosion, land use, numbers of cattle, and other domestic animals, amount of rainfall, etc., all affect water quality.)

Have the small groups report back to the class their explanations of water quality and causes of problems with water quality. Each group should be able to give one test or observation that they have recorded in their journals that indicates the quality of water and health of an ecosystem. Each group should also provide one idea about what affects water quality.

2. Scientific Analysis of the Health of an Aquatic Ecosystem

Scientists also check the health of aquatic ecosystems by making observations of populations, and community interactions. Counting populations help us determine biodiversity in the ecosystem. A diverse ecosystem indicates a healthy ecosystem.

Class discussion. Ask students to imagine that they have just been given the task of finding out how many dandelions are on the school grounds.

- **How would you go about finding out how many dandelions are on the school grounds? (**The class may generate a number of ideas for finding this information including counting them all, or looking at various parts of the school grounds and generalizing to the whole area.)
- **Why would we need to know the number and types of land plants in an aquatic ecosystem? (**Few plants mean that more erosion will take place, less variety of plants limits the kinds of animals that can live in the environment.

Explain that counting specific plants such as dandelions is similar to the problems scientists face all the time counting populations.

- **What scientific careers might need to count plant populations?** (Ecologists, biologists, botanists, any of which might work for county or state conservation programs might want to assess plant populations. Before developing a site, builders need to know what kinds of plants and their relative abundance in order to comply with the law.)

Scientists might solve the problem by getting down on their hands and knees and counting every plant and every dandelion on the school grounds and figuring out the percentage of plants on the school grounds that are dandelions. This might take a very long time, but if done carefully it would give a precise answer.

It is often unrealistic for a scientist to count every organism in her/his research area. What scientists often do is to work with a sample, a small section or plot of their research area. From their sample the scientist can then estimate many things about their research area without having spent all the time to count each organism.

Scientists do not base their calculations on just one sample. Instead they use data from many samples.

- **Why do scientists use many samples?** (Scientists use many samples to get the most accurate analysis of the data collected. Multiple samples help take into account areas where there are many organisms and areas where there are fewer organisms.)

Explain that the precise technique or sampling method used depends on what kind of organism you are sampling.

3. Plant Sampling

Provide each student with a copy of *Plant Sampling—Line Transect Survey Investigation* data sheet and student instructions. Or have students make their own data sheet in their science journals.

Guide the class as needed through the procedure to count plants using a line transect. (See student instruction sheet at the end of this lesson.)Ask students to put their line transects in different areas such as mowed lawns, landscaped areas, fence lines, unmowed (natural) areas such as a vacant lot.

Ask students to count the plants that are touching the line or within 5 cm. on either side of the transect line.

Day Two

4. Sharing Our Data

Invite students to share drawings, rubbings, samples or descriptions of plants they could not identify. Have the class identify as many plants as possible using the class field guides.

Have the **recorder** for each group report their plant sampling findings.

Briefly summarize findings from the class's multiple samplings on the board.

Ask students what generalization or conclusions they would draw from their plant sampling findings.

5. Drawing Conclusions

- **What locations on the school grounds do you think might have more diverse plant life?** Natural areas like fence lines and areas with less foot traffic are more diverse than areas with more human control such as lawns or flowerbeds.
- **How diverse is the plant life on the school grounds?** Lawns will have little diversity; more natural areas will have more diversity. Finding a few species, even those with many individual plants of the same species, indicates little diversity. Finding a number of species with several individuals of each species indicates more diversity.

Compare the diversity in front of the school with the diversity in back of the school or along the fence lines.

- **What type of plant is most common in the mowed areas? The fence lines? The unmowed areas?**
- **What does this plant count tell us about the affect of humans on diversity? (**Human activity often causes less diversity either because of overuse, removal of plants, or planting of monocultures, etc.)
- **How might someone do this in an aquatic environment with either stationary (rooted) plants or even plankton? What about where the water is deep? How could you count other species like fish or coral?** (The aquatic environment poses many special difficulties. Transects are still often used. Nets are used to collect phytoplankton or fish along the transects. In the ocean the transects can be very long and the nets used at various depths. Scuba is often employed along short transects for closer counts of fish and coral on reefs for example.)

Vocabulary

- Biodiversity
- Diversity
- Estimate

- Healthy ecosystem
- Line transect
- Population
- Sampling
- Water quality

Student Page

PLANT SAMPLING— LINE TRANSECT INVESTIGATION

Directions

1. Work with your partners following your teacher's instructions to conduct a valid sampling.
2. One student should act as **recorder** for your group's observations. Other students should work together to count and identify plants.
3. Use plant identification guides to help you identify and list each species that touches the line. If you cannot identify a species, describe or draw it as well as you can. With your teacher's permission, you may make a leaf rubbing or take a sample to identify later. Even if you can't find a plant's name, keep track of it by your own name. "We counted 5 of the thin long leaf plants with white flowers, and 10 of the short leaf plants with no flowers." is sufficient if you can't identify the plant. Scientists may not know all the species they encounter, but they take detailed descriptions so they can find out later.
4. Make a tick mark under the "Individuals" column for each individual of a species that touches the line, but only count each individual once (This may be hard to determine for grasses and some other plants!).
5. Count live plants only—you want your data to reflect current conditions, not the past.
6. Imagine that the line is a plane that extends into the sky. If the vertical plane would touch a plant above the ground, count it. Examine each vertical layer of plants separately: upper (e.g., trees), middle (e.g., shrubs), lower (ground-level, e.g., forbes and grasses).
7. Add up the tick marks in each row and enter the result in the right-hand column under "Total" for that row.
8. Then add up the total number of species and enter that result at the bottom of the second column ("Total number of species").
9. Finally, add up all the numbers in the "Total" column and enter the result at the bottom of the column ("Total individuals").
10. Calculate species percent abundance. (Number of individuals of one species divided by total number of individual plants, x100.)
11. Have the **recorder** for your group report your information to the class.

Student Page

PLANT SAMPLING—LINE TRANSECT INVESTIGATION

Group: _____ (names)

Date: _____

Location:_____

Plant Species Occurrence and Percent Abundance

Layer (Upper, Middle, Ground)	Name or Description	Tally of Individuals	Total
	Total species	**Total Individuals**	
	Number of individuals of one species divided by Total number of individuals	**Percent Abundance**	

Lesson 6.4: Measuring Populations

Essential Concept

Estimating populations is important in finding the biodiversity of an ecosystem.

Objectives

1. Students will use the mark and recapture method of estimating population used by biologists.
2. Students will learn how sampling size effects accuracy and standard error of estimates.
3. Students will practice the mark and recapture method to estimate the number of beans in a jar.
4. Students will use the mark and recapture method to estimate a population in a nearby creek or pond.
5. Students will make graphs.
6. Students will draw conclusions based on their data.
7. Students will draw a diagram of a food chain.
8. Students will draw a diagram of levels of organization in an aquatic ecosystem.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E, F; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.11 A; 7.14 C; 8.1 A, B; 8.2 A, B, C, D, A; 8.4 A, B; 8.11 B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, I, J; 4 A, B; 5 A; 7 A; 10 A; 11 B; 12 A, D

Environmental Science: 1 A, B; 2 E, F, G, H, J, K; 3 C; 4 A, B, D, E; 9 A, B, E

Estimated Time

1 day in the classroom

1 day in the field

1 class period figuring formulas from fieldwork, answering questions, and making diagram

Materials

<u>For each pair of students:</u>

1-600 ml. beaker, which represents the habitat to be sampled

1-small (50 ml.) beaker (sampling beaker)

White beans

A marker or black beans

Note: You can mark each bean with a marker or you can replace the captured white bean

with black beans to save on beans.

For the class

Seines or nets

Containers

Silver, brown or tan fingernail polish

Water chemistry kits

Thermometers

Copies of data charts

Science journals

Special Instructions

The 600-ml. beakers should all contain the same number of beans, but the number should only be known by the teacher. This will help with checking math results when figuring total population, standard error and 95% certainty rate.

Safety Precautions

Review field safety measures.

Procedure

1. Population Studies and Biodiversity

Biodiversity of an area is an indicator of the health of an ecosystem. If there are many different kinds of species and a number of individuals of each species, the area is healthier than an area with only one or two species, even if there are many individuals in the area. Biodiversity is the variety of life forms in a given area. The major threats to biodiversity include: human population growth, habitat destruction, overexploitation, invasive species, and global climate change.

2. Estimating Populations

It is important to measure changes in populations in order to understand how different physical or biological factors influence the distribution or abundance of species. However, it usually is not possible to count every individual in a natural population of animals or plants. Instead, ecologists generally make an estimate of population. A variety of methods may be used depending on such factors as the type of organism, the habitat in which the population occurs, and the time and equipment available. These methods vary from counting individuals to quick methods that give crude/imprecise estimates of abundance.

For example some ways to make quick counts include:

- Counting all hummingbirds sighted that come to your hummingbird feeder
- Counting the number of salmon passing a point during migration
- Scanning aerial photographs of white-tailed deer on a ranch in South Texas.
- Counting animal tracks along a trail

Techniques for individually counting animals include:

- Compiling a catalog of photographs or drawings that show unique markings of individuals such as fin shape and markings on whales or spot patterns on African wild dogs or facial expressions in primates
- Tagging individuals with markers visible from a distance or in the hand (e.g., numbered metal leg bands on birds, or streamer tags on red drum

A variety of methods for estimating population size fall between these two extremes. The most popular way to measure the size of a population is called the *Mark and Recapture Technique*. This technique is commonly used by fish and wildlife managers to estimate population sizes before fishing or hunting seasons. These methods involve capturing a sample, marking the sample and releasing the marked individuals back into the population. Soon thereafter scientists sample the population again, recapturing some of the individuals previously marked. This forms the basis for estimating the size of the population at the time of marking and release. This procedure was first used by C. J. G. Petersen in studies of marine fishes and F. C. Lincoln in studies of waterfowl populations, and is often referred to as the Lincoln Index or the Petersen Index.

This concept may be difficult for the students to fully grasp, especially if it is presented only as a mathematical formula. Teachers should create many examples of how proportions are used to estimate the total of a larger sample. For example if I go see 10 classes and see that they all are 60% female, I might assume that the entire school is 60% female. This might not be true, but it will probably be a close estimate of the population of females in the school unless there is something special about the classes observed.

The mark and release method is based on the principle that if a proportion of the population was marked and returned to the original population and, the next time the population is sampled, the proportion of marked individuals in the second sample would be the same as the proportion marked initially to the total population.

Mathematically it looks like this

$$\frac{R}{T} = \frac{M}{N}$$

Where:

R = Marked recapture

M = Marked initially

T = Total in second capture

N = Total population size

For example, suppose you catch 200 bluegills out of a pond having an unknown number of bluegills. You notch the pectoral fins of the bluegills you caught (mark them) and then

return them to the pond. You then let them mix thoroughly with all the bluegills in the pond. Later you catch 250 bluegills from the pond and find 50 of them to have notches in their pectoral fins. Then *M = 200*, *T = 250*, *R = 50*, and the unknown total number of bluegills (N) could be estimated as:

$$\frac{R}{T} = \frac{M}{N} \qquad \frac{50}{250} = \frac{200}{N}$$

$$(M * T)/R = N$$

$$(200 * 250)/50 = 1{,}000\ Bluegills$$

Assumptions

The accuracy of this mark and recapture method rests on a number of assumptions being met.

Assumption 1.

During the interval between the preliminary marking period and the subsequent recapture period, nothing has happened to upset the proportions of marked to unmarked animals.

That is, no new individuals were born or immigrated into the population, and none died or emigrated.

Another way to state this assumption is that the population is assumed to be "closed".

You should also be aware that the length of the sampling period is very important. A shorter time interval between marking and recapturing individuals reduces the likelihood that this assumption will be violated. The longer the time interval, the greater the chance that some individuals will die, emigrate, immigrate or even be born, and in which case, it will become an "open" population. However, there must be enough time for the marked individuals to mix back into the population.

Assumption 2.

The chances for each individual in the population to be caught are equal and constant for both the initial marking period and the recapture period.

That is, marked individuals must not become either easier or more difficult to catch.

In addition, marking an individual does not make them more or less likely to be recaptured relative to unmarked individuals. Also, there cannot be something unique about those animals that were initially marked that makes them more conspicuous. For example, if the first time bluegills were sampled mostly females are caught because

males are busy watching the nest, then if the second sampling takes place after males are finished guarding nests, males will be more likely to be captured the second time fish are sampled than the first time.

Assumption 3.

Sufficient time must be allowed between the initial marking period and the recapture period for all marked individuals to become randomly dispersed throughout the population (so that assumption 2 above holds).

However, the time period must not be so long that Assumption 1 breaks down.

If marked animals fail to disperse from the sampling area, or if they tend to aggregate in groups, there is a higher probability that they will be recaptured relative to unmarked individuals (or not be captured at all, depending on where they aggregate).

Assumption 4.

Animals do not lose their marks. This is an important factor for animals that shed or molt as they grow.

3. Practicing Mark and Recapture Methods

In this activity your goal is to estimate a population size using the mark and recapture method. You will use an unknown amount of beans as your model population.

Each pair of students needs these materials:

- 1-600 ml beaker, which represents the habitat to be sampled
- 1-small beaker (sampling beaker)
- White beans
- Black beans or black marker

First Capture

1) Obtain a population of white beans, a large habitat beaker, and one small beaker. The white beans will represent the population to be sampled.
2) *Marking*: Using the small beaker as a "trap", push through the white bean population once, filling the trap with beans to the 10 ml line. Count the number of white beans caught, mark each, and record that number in your journal as: *Number marked = M.* (e.g., if you "trapped" 23 white beans with your sampling beaker you would mark and return those beans to the original population). **Note: You can mark each bean with a marker or you can replace the white bean with black beans to save on beans.**
3) Thoroughly mix the marked and unmarked bean population.
   - Which assumption does this fulfill?
4) *Recapturing*: Now sweep through the mixed bean population with the trap once, again filling the trap to the 10 ml line. If you recovered at least one marked or colored bean with this sweep, record the number of marked beans (*recaptures*) as *R*. Record

the total number of beans caught as *T*, (i.e. *marked* + *unmarked*).

5) Now calculate the bean population size using the formula $N = (M*T)/R$

Second Capture:

Repeat steps 2, 3, 4, and 5, but this time fill the trap to the 20 ml line at step 2 and step 4. You will be doubling your sample.

Third Capture:

Repeat steps 2, 3, 4, and 5, but this time fill the trap to the 30 ml line at step 2 and step 4. Again, you are increasing your sample size.

- **Based on the formula, what is the estimate of the total population?**
- **Find the mean of the class capture for each of the 3 sampling captures.**

4. Results

Make a graph of the entire class's mean estimates for population size for each of the three sampling captures.

- **Which sample came closest to the actual number of beans?** (The teacher should know the actual number of beans, and reveal it at this time.)
- **Assuming cost is an issue, which of the three sample sizes would be the most practical?**

In the sampling of actual wildlife, cost usually is an issue. It can be expensive and time-consuming and labor intensive to sample wild populations. Getting accurate results without consuming too many resources (time, money, possible harassment of animal populations) is an important goal.

5. Drawing Conclusions

Look at each assumption. Evaluate how well you were able to satisfy each of the assumptions of the mark and recapture technique. Write your evaluations in your science journals.

- **If migration occurred in a natural population being studied, how would this affect the reliability of your estimate of population size determined using the mark and recapture technique?**
- **Would your population estimate be too high or too low, or would you not be able to predict how your estimate would be biased?** (Remember: migration consists of both immigration and emigration.)

Discuss the kind of bias you would expect to be generated in the estimate of population size if each of the remaining assumptions (2, 3, and 4) were violated.

- **If Assumption 2 is not met, and it is easier to catch marked individuals would it cause the size of the population to be overestimated? Underestimated? Or**

have no effect?

- **If Assumption 3 is not met, and captured and marked individuals are not thoroughly mixed in the population, would it cause the size of the population to be overestimated? Underestimated? Or have no effect?**
- **If Assumption 4 is not met and the marker rubs off and you can't tell marked from unmarked individuals, would it cause the size of the population to be overestimated? Underestimated? Or have no effect?**

Note that it is possible that violating several different individual assumptions may have the same effects.

There are a number of other models (designs and equations) used to estimate population size. Each has its own set of assumptions.

For High School

This mark and recapture formula has been found to sometimes overestimate the true size of the population. By doing repeated estimates and using the following unbiased formula we get a more accurate estimate:

N = [(M-marked capture)(T-total second capture + 1)/(R-marked recaptures +1)] – 1

Which is: N = [(M)(T+1)/(R+1)]–1

As in all estimates, it is helpful to have some information about the uncertainty of the estimates (as measured by the standard error, and/or by 95% confidence intervals).

The standard error gives an idea of what the sample mean is likely to be if the experiment were conducted repeatedly. The standard error can be found by using the following formula:

SE-standard error = square root of {[M-first marked capture + 1)(T-total second capture + 1)(M-first marked capture – R-marked recapture)(T-total second capture – R-marked recapture)]/(R- marked recapture + 1)^2(R-marked recapture + 2)}

Which is: SE = square root of {[M+1)(T+1)(M–R)(T–R)]/(R+1)^2(R+2)}

From the standard error we can calculate the 95% confidence limits of the estimate (which defines the range of values within which the true population size is likely to lie with 95% certainty), using the following formula:

95% confidence interval = N + (1.96)(SE)

There are other formulas for estimating the 95% confidence interval and for estimating N, but these are the formulas we will use.

6. Using What We've Learned: Sampling Aquatic Insect Nymphs

Take a field trip to your nearby stream or pond. Using seines or nets capture aquatic insect nymphs (mayfly nymphs, dragonfly nymphs, stonefly nymphs, etc.) **Note: Be sure to record all invertebrates you captured to add to the records about this aquatic ecosystem.** In your journal, record all organisms that you catch and how many you caught of each. You will use the data later. Choose the most abundant species for a mark and recapture or assign a different nymph to each group to mark and recapture. You can

use a dot of silver, brown or tan fingernail polish to mark the thorax of each nymph. (You may want to use a different color of nail polish for each class period.) Return the nymphs to their original spot in the aquatic environment. Give the nymphs time to remix in the population.

Note: It's best to do this in a pond or backwater/quiet water area in a stream, because when you release them back into flowing water they are likely to be swept downstream.

However, these nymphs are a lot harder to capture in a pond.

Collecting Field Data

During the time when the nymphs are reentering the population, have students take weather readings and retest water samples for temperature, pH, dissolved oxygen, turbidity, conductivity, nitrates, speed of flow, or other tests you have been conducting.

In the afternoon, conduct another invertebrate capture and see if you recapture any insect nymphs that you have previously marked. Record your results and return your capture to the aquatic environment.

Note: If going to an aquatic setting is not possible, the class can simulate the same activity with grasshoppers, June bugs, and isopods on the school grounds.

7. Using Our Data

Give each student a *Using Field Data* student page. Have students use their field data to answer the following questions and draw the diagrams required.

- **What producers, consumers, predators, and prey did you capture?**

Draw a diagram of the food chain that you can document from your data.

Diagram the levels of organization within the ecosystem, including organism, population, community, and ecosystem based on your data.

When you return to school use the formula to estimate the population of your chosen insect nymph. (High school students can also find the standard error.)

- **What factors in the aquatic environment do you think may have affected the aquatic insect nymph population?**
- **What short or long-term environmental changes may have affected the individuals or populations in this aquatic environment?**
- **What land uses are present? Have any of these changed since your last visit?**
- **Does your data give you information about the water quality that can help you understand the aquatic insect nymph population?**
- **What are the biotic and abiotic parts of the ecosystem with which organisms interact? Could you see evidence of competition for any of these biotic or abiotic factors such as light, range of temperature, food source?**
- **Can you see any effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of an aquatic environment?**

- **Were any of the following human activities having any influence on the aquatic insect nymph population? (Fishing, transportation, dams, and recreation)**
- **How does the watershed influence the water quality? What is the source of the water?**
- **Has the amount of rainfall had an impact on the quality of the surface water?**
- **Can you identify any point source pollution in the area?**
- **Is there evidence of non-point source pollution in your data?**
- **Did you find any genetic abnormalities in the organisms you collected?**
- **Has there been any human intervention to improve the habitat?**
- **Do you see evidence of other human impact such as all terrain vehicles, or small personal watercraft? Evaluate the effect of human activities, including habitat restoration projects, species preservation efforts, nature conservation groups, hunting, fishing, and ecotourism, on the environment.**
- **Compare data from this visit with previous visits. How has the water quality changed since the last class field trip to the site?**
- **What is the overall quality of the aquatic environmental system based on your data?**
- **Do you think this is a biologically diverse aquatic ecosystem based on the numbers and types of organisms that you found in the environment?**

Vocabulary

- Assumptions
- Biodiversity
- Emigration
- Estimate
- Immigration
- Mark and recapture
- Population studies

Student Page

WATER CHEMISTRY INVESTIGATION

Objective

1. Record your group's observations about the color and odor of each water sample in the table below.

2. Following the directions for each meter, test kit or other equipment to test each water sample and record data in the table below.

Group: _____ (names)
Date: _____

Physical and Chemical Characteristics of Unknown Water Samples

Water sample	Temperature (^{o}C)	Color	Odor	Foam	pH	Conductivity _____ (units)	Dissolved oxygen _____ (units)	Nitrates And/or phosphates _____ (units)	Water sample source

Student Page

WEATHER OBSERVATIONS AND MEASUREMENTS

Objective

Obtain, record, and present weather data.

Directions

1. Find a reliable source of daily information about the weather in your area.

2. Record today's weather data for your area. Be sure you report the source of each piece of data, the date and location for which it was reported.

Name: _____

Date: _____

Location: _____

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Student Page

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A musky smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A *chlorine* smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

Student Page

Invertebrates and Vertebrates as Water Quality Indicators

Invertebrates

A stream with:

- A great variety of insects, with few of each kind, indicates clean water.
- Less variety of insects, with greater abundance of each kind, indicates that there is too much organic matter in the water.
- Finding only one or two kinds of insects in great abundance indicates severe organic pollution caused from excessive human or livestock waste or high algae populations.
- If no insects are found, but the stream appears clean there may be some type of toxic pollution, which includes chemical pollutants such as chlorine, acids, metals, pesticides, and oil.
- Excessive sediment may be caused by erosion or discharge from a pipe and may reduce the amount of water in the stream causing extreme temperatures, and causing a loss of oxygen, which may smother insects resulting in a reduction of the number of animals in the area.

Note about Invertebrates

The types of **invertebrates** found can help students know about the quality of the water. Print out the Texas Parks and Wildlife *Bug Picking Data Sheet* at **the end of this lesson** to help identify invertebrates found in creeks and indicate which invertebrates are associated with clean water and which predominate in polluted water.

Vertebrates

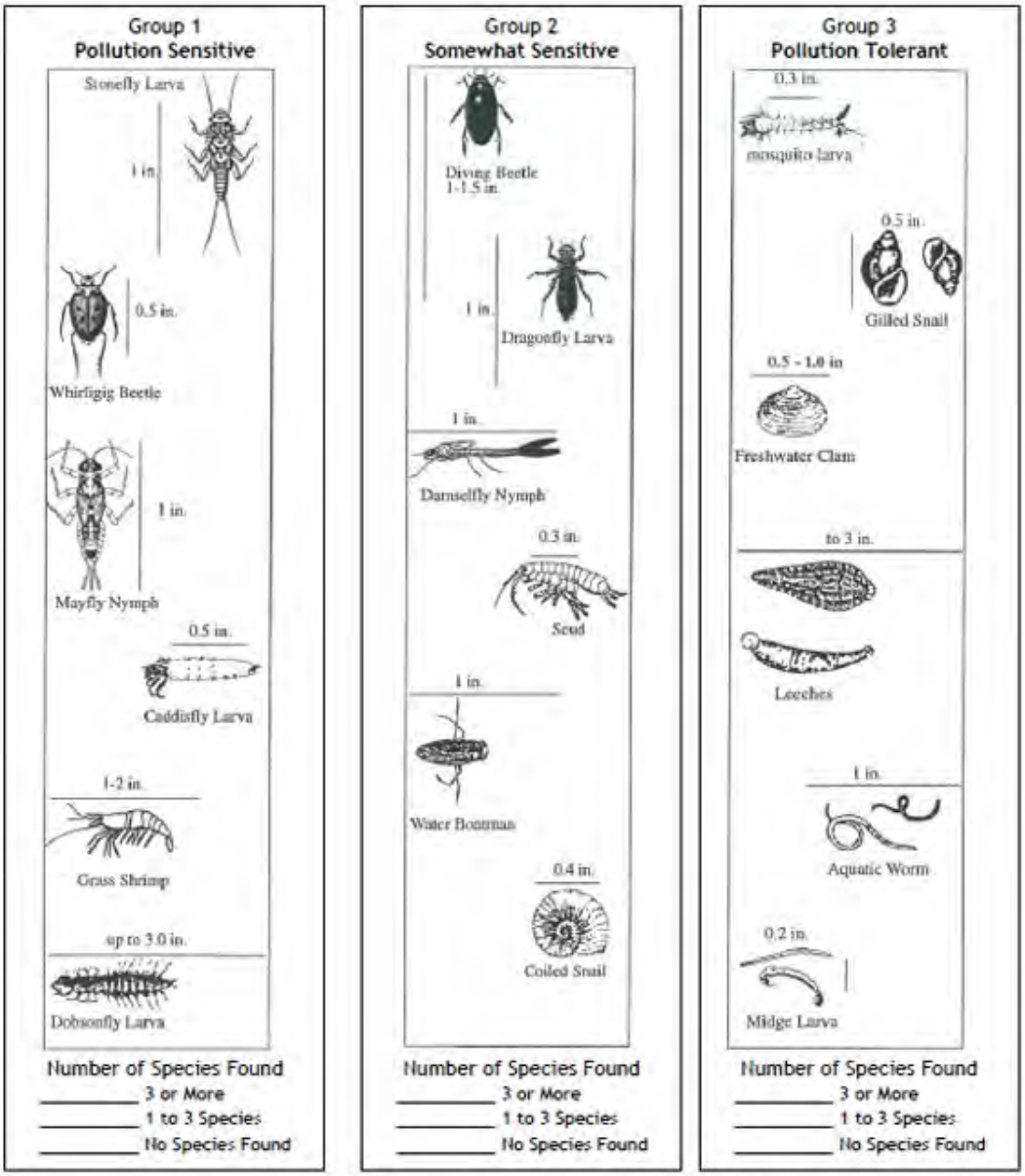
- If fish are exhibiting some odd behavior such as jumping out of the water or being non-responsive, it may indicate toxins in the creeks. A chemical analysis is needed to find the source of the toxin. Contact the TCEQ.
- If there are no fish or other vertebrates in the creek, it may indicate that the creek is stressed from urban runoff, sewage, or toxins entering the stream. Chemical analysis is needed to the find the source of the problem. Contact the TCEQ.

Student Page

Note: Bug Picking Data Sheet courtesy of Texas Parks and Wildlife Department

Use tally marks to keep count of each type of invertebrate.

Bug Picking Data Sheet



Conclusions: (Remember that the data you are taking will not give conclusive evidence of clean or polluted water, but might indicate the need for further investigation.)

1. What conclusion can you draw if you found species in Group3, but not in Groups 1 or 2?
2. What conclusion can you draw if you found several different species in each of the groups?
3. What could be happening upstream, on land around the water upstream, or in your present location to affect the water quality where you are sampling?

This water appears to be: Not Polluted OK Polluted

Student Page

Using Field Data

Use your data from the field trip to answer the following questions and make the diagrams required.

1. What producers, consumers, predators, and prey did you capture?
    - Draw a diagram of the food chain that you can document from your data.
    - Diagram the levels of organization within the ecosystem, including organism, population, community, and ecosystem based on your data.
    - When you return to school use the formula to find the estimate of the population of your insect nymph. (High school students can also find the standard error.)
2. What factors in the aquatic environment do you think may have affected the aquatic insect nymph population?
3. What short or long term environmental changes may have affected the individuals or populations in this aquatic environment?
4. What land uses are present? Have any of these changed since your last visit?
5. Does your data give you information about the water quality that can help you understand the aquatic insect nymph population?
6. What are the biotic and abiotic parts of the ecosystem with which organisms interact? Could you see evidence of competition for any of these biotic or abiotic factors such as light, range of temperature, food source?
7. Can you see any effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of an aquatic environment?
8. Were any of the following human activities having any influence on the aquatic insect nymph population? (Fishing, transportation, dams, and recreation)
9. How does the watershed influence the water quality? What is the source of the water?
10. Has the amount of rainfall had an impact on the quality of the surface water?
11. Can you identify any point source pollution in the area?
12. Is there evidence of non-point source pollution in your data?
13. Did you find any genetic abnormalities in the organisms you collected?
14. Has there been any human intervention to improve the habitat?
15. Do you see evidence of other human impact such as all terrain vehicles, or small personal watercraft? Evaluate the effect of human activities, including habitat restoration projects, species preservation efforts, nature conservation groups, hunting, fishing, or ecotourism on the environment.
16. Compare data from this visit with previous visits. How has the water quality changed since the last class field trip to the site?
17. What is the overall quality of the aquatic environmental system based on your data?
18. Do you think this is a biologically diverse aquatic ecosystem based on the numbers and types of organisms that you found in the environment?

Lesson 6.5: Conserving Aquatic Ecosystems

Essential Concept

Humans can damage aquatic ecosystems, but they can also improve and conserve aquatic ecosystems.

Objectives

1. Students will review natural and human causes of environmental change
2. Individual students will generate 3 ideas for conserving aquatic ecosystems.
3. Groups will build on individual ideas for conserving aquatic ecosystems.
4. The class will generate a list of things that can be done to conserve aquatic ecosystems.
5. The class will choose one project from the list to actively help conserve aquatic ecosystems.
6. Each student will choose one thing that they will do to actively help conserve aquatic ecosystems.

TEKS

6.12 E; 7.8 A, B; 8.11 C D, E

Aquatic Science: 12 A, B, C, D, E

Environmental Science: 5 B, C, E, F; 8 A; 9 A, D, E, K

Estimated Time

1 class period to generate the list of projects and choose one project in which the class can participate

Time needed to do the project will vary depending on the complexity of the project that the class chooses.

Materials

Science journals

Chart paper and markers

White board and markers

Procedure

1. Class Discussion

Have students review and discuss natural and manmade causes of environmental changes to aquatic ecosystems.

- **What have they seen that indicates a need for conservation of aquatic ecosystems?**

Have students identify the source, use, quality, management, and conservation of water in the watershed they have visited.

Have the class analyze and evaluate the economic significance and interdependence of resources within the environmental system.

Example: What is the economic significance of water in the area?

- **What is the economic significance of petroleum products in the area?**

How do these two resources interact? Water is recyclable, but water quality is often not good due to runoff from streets and roads putting oil residue into water sources. Petroleum products are not renewable, are expensive, and can pollute the water around us, but are significant to our economy.

- **How could we conserve oil and gasoline, reduce runoff, and save money while we protect water?**
- **How are humans dependent on ocean systems?**

Ask the class to evaluate the impact of waste management methods such as reduction, reuse, recycling, and composting on resource availability.

- **How does reduction, reuse, recycling, and composting impact water quality?**

Reducing packaging cuts down costs of manufacturing and reduces litter in streams and rivers, reusing glass bottles or recycling paper and aluminum helps keep litter out of water as well as cutting down manufacturing costs and use of resources. Composting increases soil fertility naturally and so helps keep chemical fertilizers from running off into streams, ponds and lakes.

2. Brainstorming

Use Round Robin Brainstorming to have students review natural and manmade causes of environmental change to aquatic ecosystems and brainstorm some ways humans can help conserve aquatic ecosystems.

Have individual students answer the questions above in their journals and generate three ideas for conserving aquatic ecosystems.

Individuals will share their ideas with their group. The group will take the ideas from individuals and embellish them or generate more ideas. The **recorder** should keep a record on chart paper of all ideas generated by the group.

The group **reporter** then shares the group's ideas with the class to generate a class list of ideas for conserving aquatic ecosystems.

The class will look at all the ideas and see what would be needed to carry out the conservation measures.

- **What problems do you find in aquatic ecosystems due to natural or human causes?**
- **What needs to be done to alleviate those problems?**

Extension

Ask each student group to research one of the following:

- The Clean Air Act
- The Soil and Water Resources Act
- The Endangered Species Act
- The National Park Service Act

Ask student to report their research to the class. Have all students take notes on the reports.

3. Making Conservation a Reality

Is there a way that the class can take on one of the problems discussed as a project?

Students may wish to raise money for a specific conservation organization, volunteer at a non-profit organization, work with a nature center, report on water quality as part of the Texas Stream Team, help the Natural Resource Conservation Service or other conservation group to set up a conservation program and help make it a reality. They might want to lobby the U. S. Congress on some conservation legislation by writing letters or sending e-mails to their congressman. They may want to set up a school recycling program. They may wish to set up and maintain an aquatic ecosystem such as a pond on the school grounds.

4. I Can Make a Difference

Have individual students write a science journal entry exploring something they would like to do themselves to help conserve Texas' aquatic ecosystems.

- **How could you make a difference?**

Ask students to set up a page in their science journals to document their efforts weekly. Have students document their use and conservation of both renewable and non-renewable resources that would affect an aquatic ecosystem.

- **How do they pertain to sustainability?** (Changes in water use, driving habits, recycling, reusing, and disposal of materials)

Vocabulary

- Conservation
- The Clean Water Act
- The Endangered Species Act
- The National Park Service Act
- The Soil and Water Resources Conservation Act

Chapter 6 Assessment

Multiple Choice Questions

Directions

Select the best answer for each of the following multiple-choice questions.

1. Why do scientists use sampling?

A To create new habitat

B Because each part of an ecosystem is connected to and depends on all the others

C Because ecosystems may change in response to natural or human-caused events

D To estimate populations without having to count each organism

2. What kinds of aquatic ecosystems do we have in Texas?

A Aquifers, springs, rivers, and streams

B Lakes, ponds, and wetlands

C Bays, estuaries, and oceans

D All of the above

3. What is biodiversity?

A A complex web of relationships between living and non-living things

B The variety and number of different organisms and populations, and the way they live together

C The kinds of aquatic ecosystems found in Texas

D None of the above

4. Some human activities that reduce aquatic biodiversity include:

A Draining a wetland

B Damming a river

C Pumping water out of an aquifer

D All of the above

5. A balanced ecosystem

A Is always changing

B Doesn’t change

C Changes in response to natural and human caused events

D A and C

Open-Ended Questions

Directions

Write your own answer for each of the following questions.

1. What are the biotic and abiotic factors that make up an ecosystem?

2. Describe a beneficial or harmful activity of humans, and explain how these activities affect organisms within an aquatic ecosystem in Texas. Use one of the following activities as the basis for your example: water pollution, restoration of natural environments, introduction of an invasive species, picking up trash.

3. Predict the impact (beneficial or harmful) on the organisms in an aquatic ecosystem in Texas that might be caused by each of the following natural environmental changes: a forest fire in the watershed, a flood, a drought.

4. Suggest a possible solution to one of the potentially harmful environmental changes within an ecosystem that you used as an example in question 2 or 3.

5. Draw a diagram showing Texas aquatic ecosystems from the headwaters to the ocean.