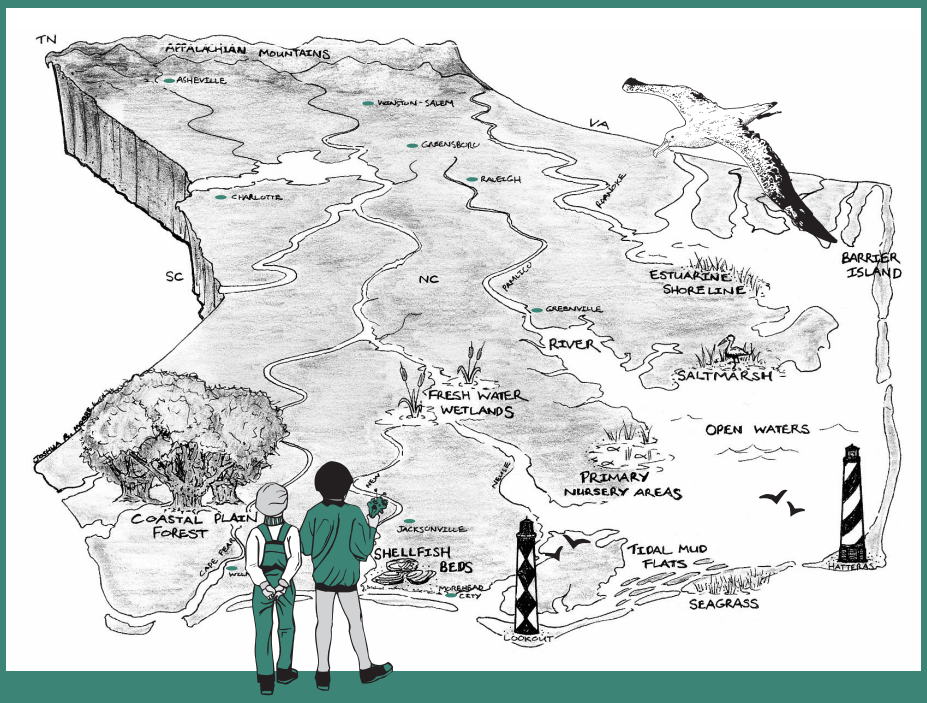
Coastal Connections

A SUPPLEMENTAL CLASSROOM CURRICULUM



North Carolina Coastal Federation

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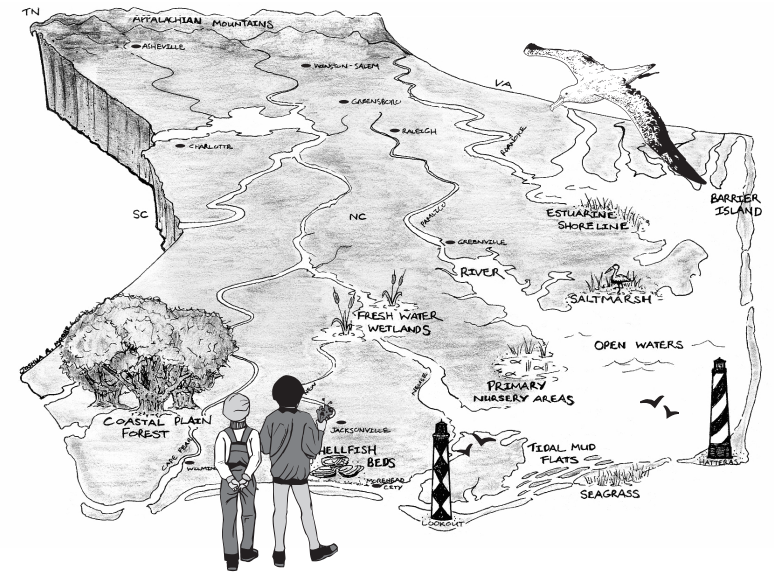


Coastal Connections

A SUPPLEMENTAL CLASSROOM CURRICULUM

INTRODUCTION TO THE NORTH CAROLINA COASTAL FEDERATION AND CLEAN-NC

The North Carolina Coastal Federation (NCCF) is a private, non-profit conservation organization working with citizens for a healthy coastal environment. Founded in 1982, NCCF seeks to protect our coastal environment, culture, and economy through habitat protection and restoration; environmental law and order; and environmental education.

NCCF's Education Program reaches over 5,000 people each year and is a major focus of the organization. In 1996 NCCF began the Children Linking with the Environment Across the Nation – North Carolina (CLEAN-NC) program with the help of a grant from the Chesapeake Bay Foundation (CBF) and Toyota Motor Corporation. CLEAN-NC provides the students and teachers of North Carolina with canoeing field trips, teacher workshops, a student newsletter, action projects and now a supplemental classroom curriculum.

The mission of NCCF's education program is to provide educational experiences and resources that will produce an understanding and appreciation of North Carolina's coastal areas, motivating participants to make informed decisions and become active stewards. This mission is based on the NCCF's education program's commitment to offer educational experiences and resources that are accurate, non-biased, and non-advocacy orientated. Our goal is to create informed decision-makers instilled with a sense of responsibility, ownership, and stewardship toward North Carolina's estuaries, their tributaries, and all of their inhabitants.

If you have any questions or comments please contact NCCF at:

3609 Hwy 24 (Ocean)
Newport, NC 28570
Tel: 252-393-8185 or 800-232-6210
Fax: 252-393-7508
Email: nccf@nccoast.org
Website: www.nccoast.org

INTRODUCTION TO THE CURRICULUM

From the streams of North Carolina's Piedmont to the coastal communities lining our estuaries, people in coastal watersheds are linked to the land and water through their livelihoods, recreational hobbies, and well being. From cities like Greensboro to Morehead City the land and our activities on it affect the water as it flows from the land into ditches and creeks, to fast flowing then wide tidal rivers, into the sounds and out to the ocean. NCCF's curriculum, *Coastal Connections*, allows students to explore how these links connect them to the water quality and health of their local environment and the coast through local and regional environmental issues.

Activities in this supplemental curriculum guide students as they discover their local environment, investigate the characteristics and connections of the different aspects of their environment, discuss case studies of habitat, water quality and fishery issues, and become involved with exciting restoration efforts through meaningful action projects. By developing a sense of ownership of – and subsequent responsibility for – their local land and waterways, students take a big step in helping to improve the quality of the entire coastal watershed.

Coastal Connections curriculum materials are best used as a preparation or follow-up to a field-based experience, but also work quite well alone. It is written especially for North Carolina middle school students, but it is easily adaptable for younger and older students. The activities are flexible enough to be used with existing courses of study, or in conjunction with other environmental curricula.

Coastal Connections consists of teacher training, curriculum materials, and action and restoration projects. Through one or two day workshops, teachers receive hands-on training in the concept, activities and projects contained in the module. Teachers leave the training with curriculum materials, resources, and an individualized plan for how to implement the curriculum at their school.

ORGANIZATION OF THE MATERIALS

PATHWAYS

The curriculum is divided into four sections: *Streams to Sounds; The Estuary and You; Watershed Worries;* and *Rising to the Challenge.* The module is designed ideally for students and teachers to choose a learning pathway of activities that will guide them through each section and conclude with an action or restoration project from *Rising to the Challenge*. This pathway strives to have students: ➠ make connections ➠ gain awareness ➠ weigh choices ➠ and develop solutions. By carefully choosing the activities and placing them in a series, supplemented with outdoor experiences or another curriculum, the teacher can create a powerful pathway of learning.

Coastal Connections is designed to allow the teacher to pick and choose how many and which activities from each section will best be suited to complement their course of study. Refer to the sample pathways, following this section to begin creating a pathway for your students.

ACTIVITIES

Each activity in the curriculum contains the following structural similarities:

■ TEACHER'S PAGES

This first section of each activity contains everything that you as the teacher may need to know about the activity preparation and procedure before doing it in the classroom. These pages include:

- **Overview:** Briefly summarizes the focus and goals of the activity.
- **Estimated Time:** Time necessary to complete the activity. Please note that these times are based on one teacher completing one whole activity with a single group of students. Most activities are in several parts and often one or more parts can be omitted to reduce time commitments. It is also possible in many cases for one activity to be divided among a team of teachers, each of whom take responsibility for covering relevant

parts of the activity in his or her class.

- **Objectives:** The academic objectives that the activity is designed to accomplish. The objectives sections describe the skills and knowledge that students can be expected to have after completing the activity.
- **Materials:** This list includes the required and optional materials needed to implement the activity successfully. Many of these materials are distributed through training and most others – such as milk cartons or plastic containers – are easily accessible.
- **Vocabulary:** Words found in each activity that may be unfamiliar to your students. You may decide to add more vocabulary terms to these suggested lists.
- **Background:** This section will familiarize you with the subject matter to be addressed in the activity.
- **Procedure:** In addition to the steps involved in preparing and conducting the activity, this part of the Teacher's Pages includes any special instructions or hints for success that you might find helpful during implementation.
- **Journal Entry:** Suggests writing exercises to be used as a regular part of your classroom routine, an occasional creative writing prompt, or as a way to integrate social studies, math, or science concepts into the language arts.
- **Extension Ideas:** These ideas are designed to encourage students to share what they learn in the classroom with family members and other students, and to apply the concepts presented in *Coastal Connections* to their own neighborhoods, homes, and backyards. These can also be questions or assignments for the student who wants to find out more.

■ STUDENT PAGES

These pages are designed to be reproduced and used independently by individual or groups of students. Readings, graphic organizers, and answer spaces are included. Simply make copies of these sheets and hand them out. Teachers may reproduce any part of the student pages for use in their classroom without seeking permission. Activities that contain numerous parts are broken up so that you can choose to pass out and/or collect separate sections without reformatting the pages. All Student Pages include:

- **Introduction:** Background information that students need to complete the activity, and a brief description of the activity's content. The student Introduction should be read by all students before beginning an activity.
- **Materials:** A list of necessary materials.
- **Procedure:** The procedure includes complete answer sheets with all necessary instructions.
- **Attachments:** Often, student pages will include graphic organizers, readings, charts, graphs, or diagrams that students need to complete the activity.

COMMON QUESTIONS ABOUT IMPLEMENTATION

Who should use this curriculum?

Although individual teachers have implemented this curriculum successfully, it is best suited for an interdisciplinary team of teachers. The integrated activities benefit from the diversity of knowledge and collective expertise represented by an interdisciplinary team. Because each activity contains elements of several disciplines, a teacher administering this curriculum alone will need to teach outside of his or her discipline at some point in the curriculum.

What is my role as a teacher?

The problems of the estuaries and their tributaries cannot be solved through knowledge alone. Instead, these problems demand a sense of ownership, creative problem-solving skills, critical thinking, and action strategies. These skills are acquired as students choose, decide, discuss, and interact. As a teacher, this will often require you to facilitate cooperative groups and discussions.

What is the best way to structure each day?

The concepts in each module follow a somewhat linear pathway. Students should, for example, have an introduction to the connections between the coast and estuaries and their own waterways before they undergo a more in-depth investigation of the sources of and solutions to potential problems facing these waterways. To guide you in sequencing the activities within your school's structure, several hours of our teacher training program are devoted to planning.

How do I evaluate student performance?

The intent of this curriculum is to provide students with the skills to synthesize, extract, and apply knowledge to solve real world problems. To assess these skills, consider the following suggestions:

1. Assign roles to each student within a cooperative learning group. Observe the students as they work and evaluate them individually on how successfully they complete tasks and take responsibility for their roles. You may also wish to collect both group and individual work to assess the quality of the work (i.e. the level of skill and comprehension demonstrated both by the group and by individuals).
2. Adapt one of the activities in the module to serve as a test. This test may be used to evaluate the level to which students understand the presented material, their ability to complete the activity in cooperative groups, their ability to express the main ideas of the activity in written or verbal form, and their ability to apply their skills and knowledge to new tasks and topics.
3. Assign students to keep a portfolio of their work. Portfolios are not only good assessment tools, they allow students to track their progress and to maintain a record of what they have accomplished. The journal activities included in this module may serve as the basis for your student portfolios.
4. As the action project is designed to stimulate the synthesis and application of knowledge acquired, the project itself can serve as an assessment tool. Again, you may want to assess the students on their performance individually, and in cooperative learning roles.

THE CURRICULUM'S MAIN COMPONENTS

CRITICAL THINKING

Critics of environmental education claim that it is an attempt to overwhelm today's youth with inaccurate and biased information about the future of our planet. The goal of this curriculum, however, is to provide students and teachers with the tools necessary to investigate their local environment, and come to their own conclusions, based on what they find. Students need to be prepared to work both individually and in groups to synthesize, interpret and apply real data and information, identify problems, and implement solutions. Instruction leading to these higher-order thinking skills is necessary to create a citizenry that is prepared to meet the world's changing needs. The ambiguity in our future job market demands instruction that equips students with the skills to adapt and apply their learning. By instilling in our youth the ability to approach any subject critically and thoughtfully, we will better prepare them to be productive members of our communities, to weigh choices and make educated decisions based on careful consideration of the facts at hand.

ACTION PROJECTS

Traditionally, most environmental education efforts have focused on enhancing student awareness and knowledge of environmental problems. Many students, however, report

feeling depressed and anxious about the future of the earth and its supply of natural resources. They are overwhelmed by the enormity of the environmental degradation facing their future and feel powerless in their ability to affect change. Research recognizes the importance of students' awareness of environmental problems, but suggests that it is equally important to teach students the strategies and skills for solving these problems (Hungerford & Volk, 1991). This supports a growing movement in environmental education that provides students with a more balanced view of the environment by focusing on environmental solutions in addition to problems.

By teaching our youth the skills for identifying and solving environmental problems, the North Carolina Coastal Federation hopes to provide a framework for enhancing environmental education in the classroom. Involvement in community-based action projects has been demonstrated to increase student problem solving ability, factual knowledge, and reading and mathematics scores, in addition to self-efficacy and self-esteem (Conrad & Hedin, 1991). When infused into the curriculum, such projects give students the opportunity to evaluate problems, plan, set goals, and make decisions in a real-life and meaningful context. These are strategies and skills that many professionals feel should receive greater emphasis in our instructional practices because they enhance both student motivation and subsequent achievement (Blumenfeld, 1992).

SUBJECT INTEGRATION

Although most environmental instruction occurs in science classes, the richness, diversity and complexity of the Coastal region cannot be conveyed through a single discipline. North Carolina's sounds and their tributaries are central to the state's history and culture, its economy, its development, and its ecology. A study of North Carolina's waterways and coast from a purely scientific perspective cannot possibly reflect the complex interaction among factors that influence the health and resources of the Coastal region.

It is for this reason that *Coastal Connections* employs an integrated approach in teaching students about environmental issues. Research suggests that the brain searches for interconnections that create understanding (Caine & Caine, 1991) and that learning is more meaningful to students if they understand how concepts are related to one another (Bransford, 1989). This curriculum integrates several subject areas within each activity as a method of demonstrating complex themes. By transcending the boundaries of traditional disciplines, *Coastal Connections* allows students to grapple with real-life interconnections that necessitate higher-order thinking skills (Drake, 1993).

TEACHING STRATEGIES

This curriculum employs instructional techniques such as cooperative learning and problem solving, as well as authentic resources. Other skills and tools called for include: Think-pair-share; think-write-pair-compare; student led discussions; paraphrasing; critical thinking; reading instruction; large and small group brainstorming; round table, and round robin discussion.

T A B L E O F C O N T E N T S

Coastal Curriculum

Coastal Connections

TEACHER EVALUATION

Please complete this evaluation form and return it to:

Education Director
North Carolina Coastal Federation
3609 Hwy 24 (Ocean)
Newport, NC 28570

If you need additional space, please attach separate sheets of paper. Your comments are extremely valuable for future revisions of this module. To thank you for your time and input we will highlight your class in the "Making a Difference" section of our student newsletter, *ShoreLines.*

BACKGROUND

Please provide the following background information about your class and the activities you have used:

What grade level did you use these activities with? _____

What subject or class did you use the activities for? _____

Please check the activities you used with your students.

____ Wishes of Fishes	____ Testing the Waters
____ Going with the Flow	____ Oysters in a Clear Sound
____ When Rain Hits the Land	____ Schoolyard Report Card
____ Net Results	____ Sediment: Clouding Our Rivers …

Did you receive sufficient training prior to using these activities? If not, what additional training would you recommend?

_____

_____

_____

_____

_____

_____

CONTENT

Please provide your overall opinion of the activities in terms of the following categories. If you have comments about a specific activity, please use the space following the category.

1 = Above average, 2 = Average, 3 = Below average, NA = Not applicable

FAIRNESS AND ACCURACY

The activities should be fair and accurate in describing environmental problems, issues, and conditions, and in reflecting the diversity of perspectives on them.

1. Factual accuracy	1	2	3	NA
2. Balanced presentation of differing viewpoints and theories	1	2	3	NA
3. Activities promotes inquiry	1	2	3	NA

Additional comments:

DEVELOPMENT

Developing CLEAN-NC/NCCF's model of education and pathway to action: Activities should follow the model of education and the pathway to action summarized in the introduction.

4. Activities build awareness	1	2	3	NA
5. Activities build sensitivity	1	2	3	NA
6. Focus on concepts	1	2	3	NA
7. Build a connection with the learner's everyday life	1	2	3	NA
8. Develop action skills	1	2	3	NA
9. Lead the learner to a sense of ownership and responsibility	1	2	3	NA

Additional comments:

INSTRUCTIONAL SOUNDNESS

The activities should rely on instructional techniques that create an effective learning environment.

10. Learner-centered instruction	1	2	3	NA
11. Appeal to different learning styles/ multiple intelligences	1	2	3	NA
12. Activities are hands-on	1	2	3	NA
13. Activities are interdisciplinary	1	2	3	NA
14. Age appropriate	1	2	3	NA
15. Develops critical and creative thinking skills	1	2	3	NA

Additional comments:

USABILITY

The activities should be well-designed and easy to use.

16. Clear purpose and goals	1	2	3	NA
17. Clear language and follow a logical order	1	2	3	NA
18. Sufficient background information	1	2	3	NA
19. Adaptable for various age and skill levels	1	2	3	NA
20. Fits with state standards	1	2	3	NA

Additional comments:

Did your students enjoy the activities? ____ Yes ____ No. What activity did they enjoy the most?

Were you able to obtain all of the resources and materials necessary to conduct the activities? If not, which should be supplied with curriculum training?

Were you able to incorporate other teachers in your team while using the curriculum?
____ Yes ____ No. If yes, what other disciplines?

Will you use the activities again? ____ Yes ____ No

Did your class complete a service learning project in conjunction with *Coastal Connections* activities? If so, please describe your project.

Please attach any additional comments.

If you would make any specific changes to the activities, then please attach your suggestions.

Master Vocabulary List

The vocabulary in *Coastal Connections* may be difficult to find in a standard dictionary because the words are applied to specific ecological contexts. A list of vocabulary words specific to each activity can be found in the vocabulary section of the activity's Teacher's Pages.

abundance: An extremely plentiful quantity or supply.

adaptation: Any form or structure in an organism that helps it survive in its environment.

adverse: A bad or negative effect.

algae: A group of primitive, non-flowering plants which include certain seaweed and microscopic phytoplankton.

anadromous: A fish that is born in fresh water, spends its life in salt water, and migrates back to fresh water to spawn.

angler: A recreational fisherperson who fishes with a fishing rod or a hand line.

aquaculture: Raising fish or shellfish in hatcheries or other artificial environments in order to supplement or restore the natural stocks.

bait: Anything that attracts fish, crabs, eels, or other aquatic organisms to a hook, net, or trap where they are caught by people. Bait can be natural (worms, insects, soft shelled crabs, other organisms) or artificial (plastic lures, horsehair flies).

barrier islands: Sandy islands that run parallel to the coast and serve to protect the mainland from the full force of ocean waves and winds.

bio-diversity: The variety of life, both plant and animal, complex and simple, that is found in a healthy system.

blockage: Any structure or material in a waterway that prevents fish from traveling from one part of the waterway to another.

brackish water: Water having a salt content in the range between freshwater and sea water.

buffer: Something that shields or protects something else.

buffer zone: Vegetation that separates and protects a waterway from human activities and helps to filter out pollutants before they reach the waterway.

catadromous fish: Fish such as the American eel, that migrate from their primary habitat (ie. freshwater) to the ocean to spawn.

commercial fisherperson: Someone who fishes, crabs, oysters, or clams and sells their catch to make a living.

community: A group of animals and plants living together and interdependently in a common environment.

culvert: A drain or channel – usually made of concrete – that drains rain water from roads, parking lots, or other impervious surfaces and carries it to a waterway.

dam: A barrier built across a stream or river to obstruct the flow of water. Dams are used to provide hydroelectric power and to create ponds and resevoirs.

decomposer: Organisms (chiefly bacteria and fungi) that break down dead organic matter.

deplete: To decrease seriously or exhaust the supply of something.

depletion: The significant reduction or loss of a resource.

detritus: Decomposed or partly decomposed plant and animal matter.

dissipate: To decrease or disappear

dissolved oxygen: The amount of oxygen in the water, measured in parts per million, or ppm. Although most fish can survive low dissolved oxygen for short periods of time, most fish need at least 5 ppm to be healthy and grow.

diversion block: Concrete block placed below a rain gutter downspout to divert rainwater away from a building's foundation.

downspout: A pipe that drains water from a gutter down the side of a building (usually a corner) and onto the ground.

drainage ditch: A channel that is cut into the ground (not made of concrete) that water flows through as it drains off the land. Drainage ditches often deposit large volumes of runoff into streams and rivers.

ecosystem: A community of animals and plants, and the physical environment in which they interact.

erosion: The process by which land surfaces are worn away by the movement of water, wind or waves.

estuary: A body of water in which salt water from the ocean and fresh water from rivers and land drainage meet and mix, producing intermediate salinities.

eutrophication: Over-enrichment of a body of water as a result of excessive nutrient loading, often resulting in depletion of dissolved oxygen.

experimental control: Something used as a standard of comparison in judging experimental effects of a new procedure, idea, or activity.

experimental trial: A scientific test run more than once under different conditions.

faucet aerator: A device that fills water from your tap with air so that you use less water.

fecundity: The capacity of a female animal to produce great numbers of young.

filter: (*v*) To strain particles out of water; (*n*) A device or organism that strains particles out of water.

fisheries: The commercial and recreational fishing industries.

fisheries populations: The fish and shellfish that are harvested for commercial or recreational purposes.

gear: The tools that are used to harvest a particular species.

groundwater: Water within the earth that supplies wells and springs.

habitat: The place where a plant or animal lives, including its surrounding environment.

harvesting: The gathering of crops or other food for human consumption.

harvesting gear: Tools used to gather or catch food; in this case, the tools used to harvest a particular sort of aquatic species.

hydroelectric power: Electricity generated from the energy of falling water.

impervious surface: Any surface that water cannot soak into, including sidewalks, roads, parking lots, packed soil, and the roofs of buildings.

inorganic matter: Compounds composed of matter other than plant or animal, which cannot be broken down.

juvenile: A young fish.

land form: A natural feature of a land surface.

land use: Land and whatever is on it, man-made or natural. Broad categories for land use include: urban, suburban, rural. More

specific categories include: wetlands, agriculture, forests, industrial development, vegetation, parking lots, lawns, etc.

larvae: The immature form of some animals that undergo radical transformation to attain their adult form.

life cycle: The series of stages (physical changes) an organism goes through before reaching its adult form.

low flow showerheads: A device that fills water coming from your showerhead with air so you use less water.

lunar tide: The periodic variation in the surface level of the oceans and of bays, gulfs, inlets, and tidal regions of rivers, caused by the gravitational action of the sun and moon.

macroinvertebrates: Small bottom-dwelling insect larvae, snails, clams, and leaches that provide food for many fish. Macroinvertebrates are a good indication of water quality, since some species are extremely sensitive to pollution while others are fairly tolerant of it.

migration: When fish (or other animals) instinctively travel from one place to another, often over great distances, to spawn or reach feeding grounds.

moratorium: A complete ban on all harvesting.

natural mortality: Death caused by disease, age, predation, or any natural phenomena such as hurricanes or heat waves.

non-point source pollution: Pollutants entering waterways from a general area, such as runoff from farmland or suburban communities.

nursery: An area of habitat that provides food and protection to newly hatched fish and some crabs.

nutrient loading: When nutrient levels in the water increase to unhealthy amounts due to human activities on land. Nutrient loading can lead to eutrophication.

organic matter: Chemical compounds made with carbon, made in live processes by plants and animals.

oyster dredge: A harvesting tool that can be dragged along an oyster reef or bar by a power boat. An oyster dredge is made up of a triangular steel frame supporting a chain net bag; it scrapes oysters off the bottom with a metal-toothed edge and collects them in the bag.

oyster tongs: Long, tweezers like tool, usually between 14 and 30 feet long, used by watermen to pluck oysters off of reefs or bars.

oyster reef: Tall piles of living oysters and shell that provide habitat for oysters and many other bottom dwelling organisms. Most reefs in the sounds have been flattened into bars through extensive dredging.

oyster bar: A slight rise on the estuary floor where oysters are clustered; former oyster reefs.

percolation: To allow water to ooze or trickle through a permeable substance.

permeable: Having pores or openings that permit liquids or gasses to pass through.

pH: The acidity or alkalinity of the water. pH is measured on a scale of 0-14; less than 7 is acidic; over 7 is basic; and 7 is neutral.

phytoplankton: The plant form of plankton, most are microscopic; they are important as primary producers in an estuarine ecosystem.

photosynthesis: The process by which plants convert sunlight into living tissue using carbon dioxide, water and nutrients; primary production.

plankton: Passively drifting or weakly swimming organisms living suspended in the water column, often microscopic but sometimes visible to the naked eye.

point source pollution: Pollution from a definable source, such as an outfall pipe.

pollutant: A substance added to the water in greater than natural concentrations as a result of human activity producing a net, detrimental effect on the environment.

pool: Deeper portion of a stream where water flows more slowly than in neighboring shallow sections, often found at a bend or behind a large rock, snag, or root mass. Pools

provide good habitat for fish and other aquatic organisms.

primary producers: Organisms using the sun's energy and inorganic nutrients to synthesize organic compounds which in turn may provide energy to other organisms.

recreational fisherperson: Someone who fishes, crabs, oysters, or clams for sport or fun – not to make a living.

regulation: A rule or law that is set by authority.

replenishment: The ability of a species to reproduce and repopulate itself.

riffle: A place in a stream where shallow water runs quickly over rocks or gravel. Riffles provide excellent habitat for macroinvertebrates because the well-oxygenated water creates nooks where the macroinvertebrates can hide.

river basin: The land area that drains into a river, river system, or body of water.

root mat: Also called root mass or root wad; a tangle of tree roots in a stream or river that can serve as habitat for aquatic species.

runoff: Rain water that flows off the land into streams, rivers and the sounds, rather than soaking into the ground.

rural: Of or relating to the country (*i.e. a small town or a farm*).

salinity: The saltiness of the water, measured in parts per thousand, or ppt. For example, water in the sounds ranges from freshwater (0 ppt) to almost complete salt water (30 ppt).

scarcity: An insufficient amount or supply of something.

sediment: Dirt, silt, or sand that settles to the bottom of a waterway or is suspended in the water.

sedimentation: Deposition of sediment, such as sand, clay, or silt.

seine: A large net with sinkers on one edge and floats on the other that hangs vertically in the water and is used to enclose fish when its ends are pulled together or are drawn ashore.

sewage treatment: primary – screening or settling large solids out of sewage (only removes visible material); ***secondary*** – removal of organic material in sewage by aeration and by bacterial action; ***tertiary*** – removal of nutrients and traces of toxic organic material from sewage by additional treatment processes.

smother: To cause death by cutting of oxygen supply.

snag: A tree, or part of a tree, that sticks up from the bottom of a river or stream, or into the river or stream from the bank. Snags can provide habitat for aquatic organisms.

sound: A long passage of water connecting two larger bodies of water (a river and an ocean) and separating a mainland from an island.

spawn: To deposit eggs and/or sperm directly into the water.

spat: Baby oysters that have recently set on (attached to) a hard surface.

stormwater retention pond: A manmade pond, designed to reduce sediment pollution, that catches water flowing from culverts and drainage ditches, allows the sediment to settle out of the water, and releases the water, slowly, into streams or rivers.

submerge: To cover or overflow with water.

Submerged Aquatic Vegetation (SAV): Underwater grasses (usually rooted) in the sounds and rivers.

suburban: A residential area outside of a city.

toilet dam: Device that you place in the toilet tank to displace or restrict unnecessary water, so that each flush uses only the amount of water necessary.

tributaries: Streams and rivers that supply a larger body of water.

undercut banks: When the water in a stream or river has cut into the banks, forming an overhang. Undercut banks provide habitat for fish and other aquatic species and are not evidence of erosion. An abundance of roots holds the overhang in place, preventing

erosion of the bank. If the bank is eroded, you will see bare and exposed soil; if the bank is undercut, you will not.

urban: Of or relating to a city.

vegetated: An area of land adjacent to a body of water that has lots of plant life, which act as buffers.

waterman: Someone who fishes, crabs, oysters, or clams and sells their catch to make a living.

water quality: The health of the water, made up of interactions between certain physical, chemical, and biological components.

waterway: A way or channel for water.

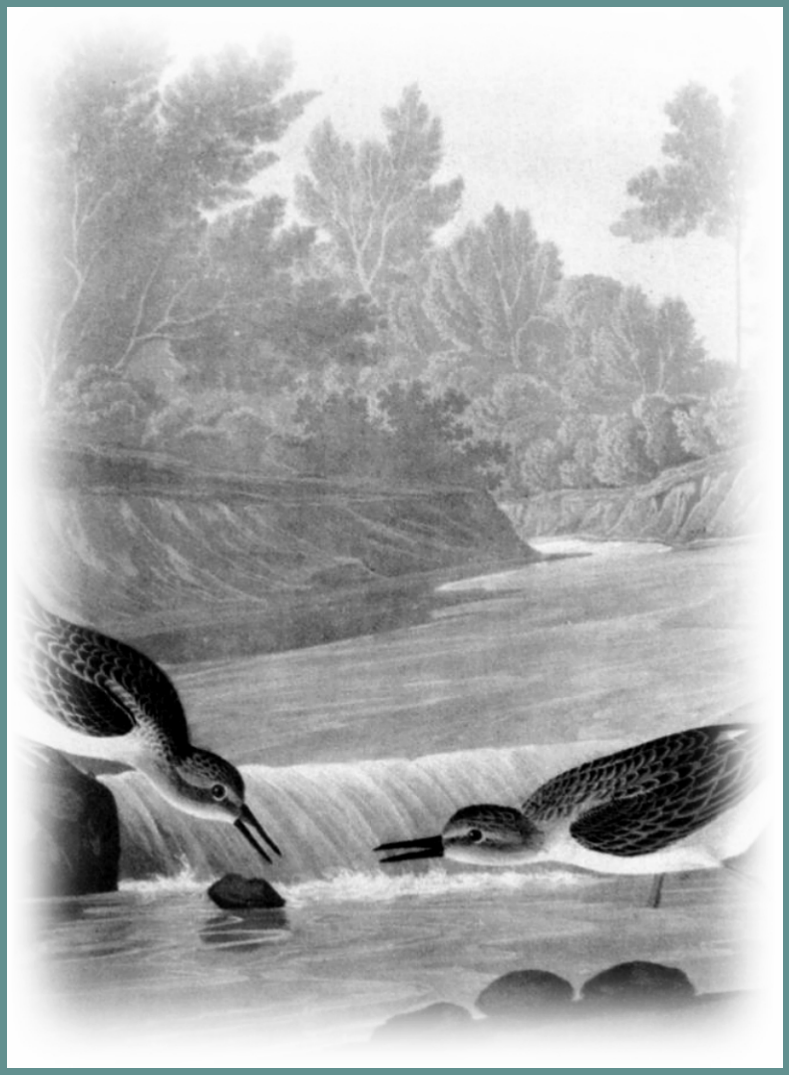
watershed: The land area that drains into a river, river system, or body of water.

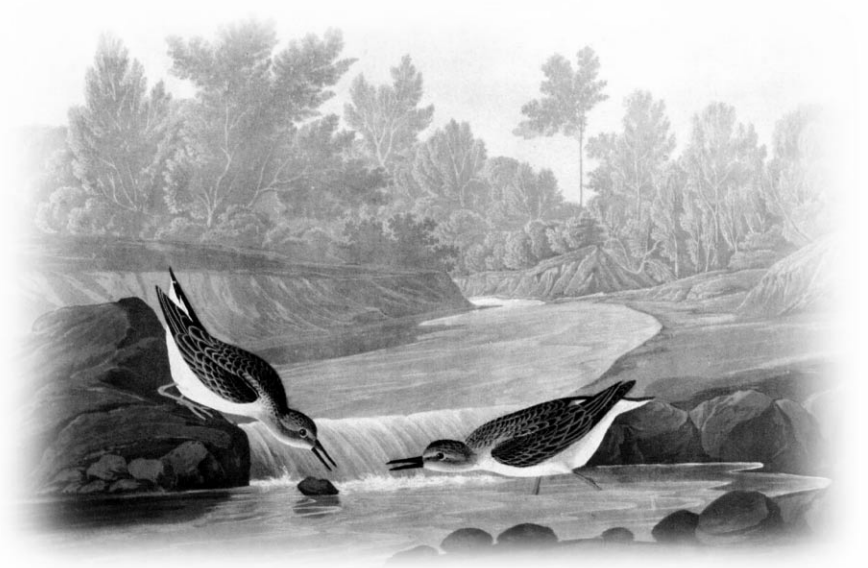
wind tide: A rise or drop in the surface level of estuarine waters caused by the movement of water by winds.

young of the year: The number of baby fish produced in a given year. Scientists calculate the young of the year by counting the number of newly hatched fish that are caught in each haul of the seine net. They use these numbers to estimate the total population of newly hatched fish.

INTRODUCTION

Water Quality 101





WATER QUALITY 101

Part I:

What is water quality?

Water quality is defined as the "health of the water," which is made up of interactions between certain physical, chemical, and biological components. This subject can be very complex and involve a tremendous amount of research. We have chosen several key factors in determining water quality to focus our activities on and to provide you with an introduction. There are many excellent sources for further discussion, research, and testing methods available to you. Listed at the end of this chapter and in the resource section of the curriculum are a few of these sources. What follows is meant to be a brief introduction to some of these factors that will enable you and your students to complete the activities and begin your journey into the complex world of water quality.

We measure water quality factors repetitively to detect changes and trends in water conditions that occur due to natural events or pollution. Water quality testing can be done on any body of water: a lake, stream, river, estuary, ocean, or even the water coming out of your faucet. Here, we will discuss some of the key factors to test for when evaluating rivers, sounds, and estuaries, and why they are so important.

Many things can affect the health of the water. There are physical variables, such as the tide, the temperature of the water, and the turbidity. Also, many chemical variables play a part in overall water quality: dissolved oxygen, pH, nutrients, and salinity, to name a few. Biological factors include aquatic plant and algae growth, and the presence of organisms including filter feeders, disease causing and other organisms. Both natural and man-made forces are constantly changing these variables. In conclusion, water quality is a complicated equation of these three natural characteristics; no standards for good water quality can be applied to all bodies of water. Rather, each type of water body has its own combination of characteristics that ultimately determine water's health. Long term, repetitive water quality monitoring can help us to form a "big picture" of the health of a particular body of water.

Part II:

What are We Testing For and Why?

PHYSICAL VARIABLES

1. **Temperature**

   Temperature is a critical factor when determining water quality. Many biological, physical and chemical principals as well as feeding and reproduction of aquatic life are temperature dependant. Temperature is defined as the degree of hotness or coldness measured on a definite scale. Some bodies of water have a temperature that remains fairly constant, but this is not the case for rivers, sounds and estuaries. Because they have a variety of depth and are affected by currents, the temperature varies greatly depending on a number of factors, especially the season of the year.

   In the spring and summer, the sun warms the surface waters and the deeper waters stay a bit cooler. The surface waters cool down in the fall, becoming denser than the bottom waters. The density causes the surface water to sink to the bottom, pushing the bottom waters closer to the surface. This process is known as "turn over." Turn over is very important because it stirs up all of the nutrients resting on the estuary floor and releases them into higher water levels. These nutrients are essential to the growth of all organisms.

   The temperature of the water is also critical in determining where marine organisms live and how well they thrive there. Oysters, for example, spawn only when the water temperature reaches 68 degrees Fahrenheit or above.

   Temperature is usually recorded in degrees Celsius. Here is a formula used for converting Celsius to Fahrenheit and Fahrenheit to Celsius :

$$C = \frac{(F-32.0)}{1.80}$$

$$F = (C \times 1.80) + 32.0)$$

2. **Tides**

   Tides are the periodic movement (raising and lowering) of a body of water by the gravitational attraction of the moon and sun with the rotation of the earth. Tides can fluctuate depending on the changing position of the moon and sun; wind direction and strength, and storms. A flood tide occurs as the tide is rising, and an ebb tide occurs as the tide is falling. Between these two occurrences the water slows and doesn't move, this is called slack water. Tides make our estuaries and sounds and some of the rivers very unique, in that water is coming in and going out twice a day. They create a "flushing" affect that constantly changes the chemistry of the water. Tides can also cause changes in turbidity, temperature, pH, dissolved oxygen, salinity, the amount of nutrients found in the water, and the movement of aquatic life.

3. **Turbidity**

   Turbidity is the amount of suspended particles (not necessarily water color) that prevent the penetration of light through water. Turbidity, or reduced water clarity, is often caused by phytoplankton (single-celled algae), or sediment in the water column. Submerged Aquatic Vegetation (SAV) needs light for photosynthesis, and fish need SAV for food, shelter, and oxygen. If suspended particles "block out" light, then these underwater plants cannot thrive. Turbidity can prevent fish from finding food and from operating effectively within their environment. It can also clog the gills of fish and shellfish, killing them directly.

   The shallowness of sounds and estuaries make them extra vulnerable to turbidity. Natural forces like high winds, hurricanes, and rain storms stir up sediments on the bottom, increasing the cloudiness of the water. Man made disturbances can include boat propellers, sediment from construction sites too close to the water, and dredging.

4. **Weather**

   Weather influences every factor of water quality, and because it changes everyday, it is extremely important to note the weather when you are conducting water quality tests. This will enable you to factor this in on the day you test as well as over a long period of time. The sun on a bright day can affect the turbidity and increase the temperature of the water, which can decrease the amount of dissolved oxygen. Rain can decrease the salinity by adding more fresh water, and it carries runoff from the land into rivers, sounds, and estuaries possibly increasing the amount of nutrients and pollution in the water. Many shellfish beds are automatically closed to harvesting after a rain storm. The aeration of the wind on a windy day can increase dissolved oxygen levels as well as turbidity.

CHEMICAL VARIABLES

1. **Dissolved Oxygen**

   Dissolved oxygen (DO) is the amount of oxygen dissolved in water, measured in parts per million (ppm) or milligrams per liter (mg/l). DO is a critical factor for most aquatic organisms and is one of the most important indicators of environmental health. When oxygen levels in water fall below 4 ppm, fish and other aquatic organisms become severely stressed; below 2ppm, many cannot survive. Oxygen is added to the water from the air through the churning action of the wind. Underwater plants (SAV) also supply oxygen to water during photosynthesis. Salinity can also affect dissolved oxygen. As salinity increases, DO potential in the water decreases.

   Dissolved oxygen levels in an estuary vary seasonally, with the lowest levels usually occurring during the summer months. Cold water can hold more oxygen that warm water, so levels naturally increase during the fall and winter.

   Bacteria, fungi, and other organisms affect DO levels in an estuary because they consume oxygen while breaking down organic matter (dead plants and animals). When runoff, poorly treated wastewater containing large amounts of sewage, or excess nutrients from fertilizers enter the estuary, they can cause phytoplankton (algal) blooms. When these organisms die, their bodies fall to the bottom of the estuary and begin to decompose. Bacteria and fungi increase in numbers to eat the decomposing matter and in turn, deplete the oxygen supply in the water. This process is known as "eutrophication."

2. **pH**

   The pH of water is a measure of how acidic or basic (alkaline) a solution is. The pH scale ranges from 0 to 14. Pure water has a pH of 7.0 (neutral). When the pH is less than 7.0, the water is said to be acidic. When the pH is greater than 7.0, the water is said to be basic or alkaline. Because the scale is logarithmic, when the pH increases or decreases by a whole number, the acidity changes by a factor of 10.

   As water receives mineral substances, aerosols, dust from the air, man-made wastes, and photosynthetic organisms, its pH can change. These pH changes affect the ability of organisms to reproduce and survive. In general, wetlands and other forested waters will have lower pH's. River water may normally vary from 6-7 and coastal waters from 7-8. The ability of aquatic organisms to complete a life cycle greatly diminishes as pH becomes greater than 9.0 or less than 5.0.

3. **Nutrients**

   Nutrients promote growth in plants and humans. In water, algae and aquatic plants use nutrients for healthy growth. These plants provide cover and food for aquatic organisms. In excess, nutrients cause aquatic plants and algae to grow in the extreme, otherwise known as eutrophication. Impacts include algal

blooms on the surface of the water that block out light critical to fish habitat; increased nuisance plants that reduce recreational and navigational activities; and increased plant growth that die and decay, robbing critical oxygen from aquatic life. Two types of nutrients are Nitrate and Phosphate.

Nitrate sources include agricultural fertilizers, sewage, industrial and packing house wastes, drainage from livestock areas and manure. Generally, unpolluted waters have nitrate levels below 1ppm.

Phosphates result primarily from chemical fertilizers. Total phosphate levels above 0.003 ppm can contribute to increased plant growth or eutrophication.

4. **Salinity**

Salinity is the concentration of dissolved salts in water, usually expressed in parts of salts per 1000 part of water, also known as parts per thousand (ppt). Freshwater contains few salts (0 to .5ppt) while seawater averages 35ppt. Estuaries are defined as a place where the rivers meet the sea. They contain brackish water which is a dynamic mixture of fresh and saltwater (.5 to 30ppt). Therefore, salinity is a key factor affecting the physical make-up of an estuary. Perhaps the most important aspect of salinity is its effect on the variety and well being of the various aquatic organisms living in the estuary. Some species of fish spawn in fresh water and live part of their lives at sea; others do the opposite. Bottom dwelling species such as oysters and crabs are tolerant of salinity variations but will decline when salinity conditions change dramatically.

Increased freshwater flow created by heavy rains, wetland drainage and land clearing impact salinity levels by introducing fresh water into areas that were historically brackish. Likewise, droughts and increased dredging of ocean inlets introduces salt water in higher volumes causing impacts to areas where salinity has been historically lower. These constant changes in the natural environment obviously produce unstable conditions. As a result, species that are unable to maintain normal biological activities are lost.

5. **Fecal Coliform**

Fecal coliform bacteria are a group of bacteria that normally reside in the intestinal tract of warm-blooded animals, including humans. Therefore, they are present in the feces of all humans and animals. They can enter a body of water in three ways: 1) direct discharge from mammals and birds, 2) runoff of waters carrying animal wastes, and 3) sewage discharged into the water.

The coliform bacteria by themselves are not pathogenic. Pathogenic organisms include bacteria, viruses, and parasites that cause disease and illness. Because it is very time consuming and difficult to detect the pathogenic organisms, fecal coliform bacteria are tested instead. If fecal coliform counts are high (over 200 colonies / 100 ml water sample), the chance that pathogenic organisms are present and the probability of contracting a disease through exposure (swimming, etc.) increases. A person swimming in such water could receive disease causing organisms through numerous ways such as cuts in the skin and through the nose, mouth, or ears. Diseases and illness such as typhoid fever, hepatitis, gastroenteritis, dysentery, and ear infections can be contracted in waters with high fecal coliform counts.

EXTENSION IDEAS

- Although a one-shot assessment of your waterway can be instructive, it is only with long-term monitoring that a true pattern of water and habitat quality or degradation becomes evident. If you enjoyed monitoring your stream, consider monitoring on a regular basis by adopting your stream. Register and receive more information from Izaak Walton League's ***Save Our Streams.*** Rachel Carson National Estuarine Research Reserve's ***Estuary Net***, or ***StreamWatch***.

- If you discover threats to the health of your stream and would like to do something about them, here are a few possibilities:

    - Organize a clean-up. A clean-up will not solve most water quality problems, but it will make the stream look better and will mobilize the community to become involved and invested in the stream. It is also a fantastic organizing experience for your students. NC Big Sweep is an annual statewide waterway cleanup held the third Saturday in September that you and your students could join.

      NC Big Sweep
      PO Box 908
      Raleigh, NC 27602-0908
      919-828-6686 or 1-800-27-SWEEP

    - Contact your local health department to notify them if the waterway is unhealthy for human contact. After your initial contact, follow up with them to see what is being done to fix the problem, and if there is anything you can do to help.

    - Work with your community members, leaders, and businesses on an education campaign to prevent dumping and runoff into your local waterway.

EDUCATIONAL RESOURCES

Izaak Walton
League of America
Save Our Streams Program
707 Conservation Lane
Gaithersburg, MD
20878-2983
800-BUG-IWLA

Rachel Carson
National Estuarine Research
Reserve Estuary Program
PO Box 1040
Beaufort, NC 28516
252-728-2170

Stream Watch
Division of Water Resources
PO Box 27611
Raleigh, NC 27611
919-733-4064

Adopt-A-Stream Foundation
600-128th Street SE
Everett, WA 98208-6353
425-316-8592
email: aasf@streamkeeper.org

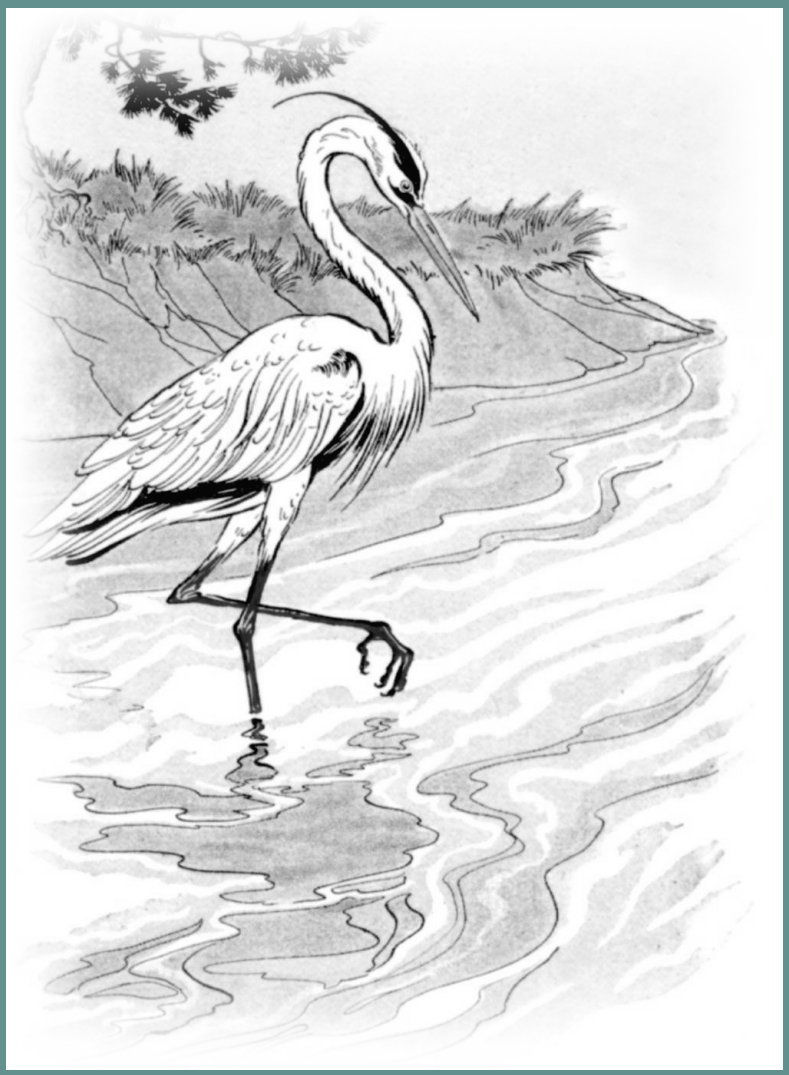
GREEN:
Global Rivers
Environmental Education
Earth Force Network
1908 Mount Vernon Ave.
2nd Floor
Alexandria, VA 22301
703-519-6877
www.earthforce.org
email: green@earthforce.org

NC Geological Survey
PO Box 27687
Raleigh, NC 27611-7687
919-733-2423
Fax: 919-733-0900

Albermarle-Pamlico Estuarine
Study (APES)
Albermarle-Pamlico Citizen Water
Quality Monitoring Program
Institute for Coastal and Marine
Resources
East Carolina University
Mamie Jenkins Building
Greenville, NC 27858-4353

SECTION ONE

Streams to Sounds



The Wishes of Fishes

T E A C H E R P A G E S

OVERVIEW

Students investigate the adaptations of an aquatic species, looking at the way its characteristics, life cycle, and behavior allow it to survive in an ever-changing habitat. Students apply this knowledge in a local waterway assessment where they collect and analyze data to determine if the species they have studied could be, or is, living in that area.

ESTIMATED TIME

3 hours in class; 1-3 hours outside

LEARNING OBJECTIVES

- **Science:** *Nature of Science; Science as Inquiry; Science & Technology*
- **Social Studies:** *Information Acquisition Skills; Problem solving, decision-making, and planning; Group Participation Skills*
- **English Language Arts:** *Acquisition, interpretation, and application of information*
- **Mathematics:** *Measurement; Data*

VOCABULARY

adaptations, dissolved oxygen, fisheries, habitat, juvenile, larvae, life cycle, macroinvertebrates, migration, pH, spawn, salinity, water quality

MATERIALS

Part I:
For each group of 4 students

- 1 species-specific packet of information (provided at training)
- 4 photocopies of the "Critter Questions Worksheet" (in student pages)
- Art supplies (including: large paper, markers, glue, construction paper, scissors)
- 1 blank, four-season calendar
- Scrap paper

Part II: *For the class*

- 1 of each of the following test kits: pH, dissolved oxygen
- 1 thermometer
- 1 meter stick
- 4 fine metal mesh kitchen strainers
- 8 ice cube trays
- Tweezers (optional)
- Knee or hip boots (optional)
- Shallow pan (for muddy bottom streams)
- Magnifying glasses
- Maps: state highway, watershed, ADC street map for the area
- *The Monitor's Handbook* by Steve Wildberger, LaMotte Company
- "Water Quality Glyph Worksheet" (in student pages)
- "Data Collection Chart" (in student pages)
- "Macroinvertebrate Sampling Instructions" (in student pages)
- "Stream Insects & Crustaceans" by The Izaak Walton League of America (in student pages)
- "Macroinvertebrate Chart" (in student pages)

BACKGROUND

In North Carolina, comparing the environmental conditions and water quality in one river to that of another river or comparing the conditions in a river to coastal waters is like comparing an apple to a Volkswagen. Aquatic habitats may vary in terms of salinity, temperature, pollution concentrations, or bottom conditions – just to begin with. Amazingly, organisms that look very different (a clam and a dolphin, for example) can share the same habitat. Still even more impressive is the fact that the creatures are able to travel from one habitat to another like the American Eel, which travels from shallow streams to the Sargasso Sea. These organisms have adapted their behavior and physiology to survive in variable and sometimes harsh conditions of life underwater.

The varied habitats of North Carolina's coasts and rivers shape the behavior and life cycles of its inhabitants, sometimes resulting in extraordinary adaptations. This activity is designed to allow students to explore these adaptations and how a single species may use many strategies for survival over the course of its lifetime.

TEACHER PROCEDURE

Part I

1. Each student explores the concept of habitat through an evaluation of their own living conditions and a comparison of their habitat with that of an aquatic species. Have students complete Questions 1, 2, and 3 individually.
2. Divide students into cooperative groups of four and use a *Round Robin* to facilitate the sharing of ideas. A discussion of your students' responses will help to cement their understanding of basic human needs.
3. For the rest of the section, students investigate an aquatic species and organize their information in a calendar. We suggest that your students research species that are indigenous to your region, or the species that they will be doing a service-project to help. (See the list of suggested species at the end of this activity. NCCF can supply background materials for these species.)
4. In Question 5, students create a calendar. To create these calendars, determine the distinct life cycle stages for each species and instruct the students to use one page for each stage. Students will also create a cover page for their calendars, so provide the group with one page for each stage and a page for the cover sheet. Connect the calendar pages with a paper clip so that students can take them apart to work on them.
5. Distribute art supplies when students are ready to design their calendars in Question 7. This is an excellent

opportunity to involve the art teacher!

The calendars can be time-consuming for students to research and put together, so if you have limited time, you should set very strict time limits for your students.

Part II*

6. The second section of this activity is a chemical and biological waterway assessment designed to help students decide whether their species inhabits local waterways. Locate an accessible waterway (a stream, creek, pond, ditch, river, or estuary close to your school). Choose and mark a 75 meter site along the waterway before bringing your students outside. Check with state and county agencies to make sure that you are not disturbing an existing survey area and contact local land owners to make sure that you are not trespassing without permission. DENR's StreamWatch program often keeps track of ongoing monitoring projects, so contact them to find out about monitoring on your waterway. Keep an eye out for flags or marking tape that could mark a study area. ***If it is not possible for students to test the water quality, focus the activity on the unique features or adaptations of each species or on geographic range.***
7. Refer to Testing the Waters and the Water Quality Testing section of this curriculum for specific water quality testing instructions. Organizations such as Save Our Streams, Isaac Walton League, DENR's StreamWatch and Rachel Carson National Estuarine Research Reserve can provide assistance in assessing your waterway.

   To obtain topographic maps for your waterway contact the NC Geological Survey. (Their address can be found at the end of this section.)

   If you are studying a river or portion of the coast, you will not have a macroinvertebrate biology section that corresponds to your assessment. However, if you have access to a large seine net, you can get a good sense of the richness (number of fish) and diversity (variety of species) of your segment of river by doing two or three seine hauls and identifying the species you find. This will also allow you to know if the fish in your assessment area have abnormal growths or mutations, which can be caused by abnormal conditions, including toxins, in the water. Fish identification books and guides can be obtained from libraries and bookstores.
8. In the excitement of being outdoors and using complicated test kits, your students may have difficulty understanding the significance of the data they are collecting. It will help if you go over the meaning and significance of each factor that you will be testing before your students set foot in the water. If possible, have your students practice their tests on aquarium or tap water before going outside, or have them practice once on site before recording any data. In Question 3, complete the first column of the Water Quality Ideal versus Real Chart, make sure this step is complete before students conduct water quality tests.
9. When your students reach Question 4 and are ready to go outside, assign each group one or several tests to complete. At least two groups should do macroinvertebrate sampling. In this curriculum, we advocate the use of strainers, rather than kick seines, for the macroinvertebrate survey because strainers minimize the damage to the bottom of your waterway. Whether you decide to use kick seines or strainers to collect macroinvertebrate samples, emphasize to your students the importance of treating the stream with respect and care.
10. When you come back into class, help students to compile their data into a class set, on an overhead or poster.

JOURNAL ENTRY

- Ask your students to consider the conditions fish endure in different North Carolina habitats. Choose a habitat type (estuary, sound, river, ocean). Discuss with your students how that habitat changes over the course of a year, in terms of temperature, salinity, water flow rates, and water quality. Write examples of challenges fish might face throughout the year on the board. Give students the option of writing a short creative story about an aquatic organism facing one of these real life challenges.
- Ask your class to write a short paragraph describing what you would have to do and what features you would need in order to live in conditions listed on the board. Remind them they will be in an underwater habitat where the environment is constantly changing.

EXTENSION IDEAS

- If your students enjoy measuring and calculating dissolved oxygen, salinity, and temperature, you can extend the activity by making connections between these factors. Salinity, temperature, and atmospheric pressure have a direct influence on the potential dissolved oxygen that can be present in a waterway. For an in-depth discussion of these connections, see *The Monitor's Handbook,* written and printed by LaMotte Company, PO Box 329, Chestertown, MD 21620, 800-344-3100.
- To study the influence of seasonal water quality or environmental change, have students create a calendar focused on what their species does each month or season.
- Although a one-shot assessment of your waterway can be instructive, it is only with long-term monitoring that a true pattern of water and habitat quality or degradation becomes evident. If you enjoyed monitoring your stream, consider monitoring on a regular basis by adopting your stream. Register and receive more information from Izaak Walton League's *Save Our Streams*, Rachel Carson National Estuarine Research Reserve's *Estuary Net*, or *StreamWatch*.

EDUCATIONAL RESOURCES

Izaak Walton League of America
Save Our Streams Program
707 Conservation Lane
Gaithersburg, MD
20878-2983
800-BUG-IWLA

Rachel Carson National Estuarine Research Reserve Estuary Program
PO Box 1040
Beaufort, NC 28516
252-728-2170

Stream Watch
Division of Water Resources
PO Box 27611
Raleigh, NC 27611
919-733-4064

Adopt-A-Stream Foundation
600-128th Street SE
Everett, WA 98208-6353
425-316-8592
email:
aasf@streamkeeper.org

GREEN:
Global Rivers Environmental Education Earth Force Network
1908 Mount Vernon Ave.
2nd Floor
Alexandria, VA 22301
703-519-6877
www.earthforce.org
email: green@earthforce.org

NC Geological Survey
PO Box 27687
Raleigh, NC 27611-7687
919-733-2423
Fax: 919-733-0900

The Wishes of Fishes

S T U D E N T P A G E S

INTRODUCTION

Why do striped bass travel hundreds of miles every year between the ocean and the rivers of the North Carolina? Why do oysters spend the early part of their life riding the water currents and the rest of their life stuck on a hard surface? In this activity your group will study how a fish or shellfish survives in constantly changing conditions. You will design a calendar showing what one species does during different stages of its life to survive. Just like a human's life is divided into childhood, adolescence, and adulthood, the life cycles of aquatic organisms are also divided up. Most commonly, we divide the life cycle of an aquatic species into larval, juvenile, and adult stages. Sometimes special names are given to these stages, for example, after the oyster's larval stage it becomes a spat, and then an adult. Your teacher will help you figure out the important stages of your species life. You will use the information from your calendar and the water quality test results from a waterway near your school to find out if the creature you studied could be living near you!

MATERIALS

Part I:
Your group will need

- 1 resource packet of information (collect from your teacher)
- 4 copies of the "Critter Questions Worksheet" (attached)
- "Water Quality Ideal versus Real Chart" (attached)
- Art supplies
- Blank paper for your calendar

Part II:
The class will need:

- Kits to test pH, dissolved oxygen, salinity
- Strainers and ice-cube trays to sample macroinvertebrates
- 1 thermometer
- 1 meter stick (to test depth of the water)
- 1 of each: state highway and watershed maps
- "Macroinvertebrate Sampling Instructions" (attached)
- "Stream Insects & Crustaceans" (attached)
- "Macroinvertebrate Chart" (attached)
- "Data Collection Chart" (attached)

PROCEDURE

Part I: ***What do species need to survive? In this section you will create calendars that display the basic needs of aquatic species.***

1. Think about all the things that you need to be healthy and happy. On your own, list 15 of the most important things you can think of in the space below.

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____

2. Go back through your list and circle the elements that you absolutely must have to survive. If you think of any other items you need, add them to the list.

3. The list you have created describes your personal "habitat." The circled items, the items you need to survive, represent your "basic needs." Examine the following definition and example of habitat from *A Chesapeake Bay Primer:*

> *An animal's habitat is the place where it lives, finds food, defends itself from predators, finds a mate and reproduces. Most animals confine their activities to a particular kind of habitat where they are most successful at fulfilling their needs. For example … oysters populate areas where there is a suitable flow of oxygen-filled water, an abundant supply of plankton to serve as a food source, and a hard surface to settle on.* — ***A Chesapeake Bay Primer,*** 1989

Circle the things an oyster needs to survive.

Compare your list of basic needs with the needs of an oyster. How are your needs different from the oyster's? How are they similar?

SIMILARITIES	DIFFERENCES

4. Your teacher will give your group a resource packet that contains information about one aquatic species. When you get your packet, write the name of the species your group has been assigned on the top of the "Critter Questions Worksheet."

5. Your group will be using your resource packet to investigate the habitat requirements of your species during each stage of its life. You'll be organizing your information in a calendar that is divided into at least three stages. Determine the three most important stages in the life of your species. After checking with your teacher, assign each group member at least one stage to research. Write the stage you are responsible for on your "Critter Questions Worksheet."

6. The questions on the "Critter Questions Worksheet" will help you find the information you will need to design your calendar. Answer as many of the questions on the worksheet as you can, using information from the resource packet. Since some information might be the same during the entire life cycle, group members will probably share information.

7. Organize and display the most important pieces of information on your group's blank calendar. Use art supplies to create a cover for your calendar and design a creative way to display your information in the spaces for each stage. If you are stumped about what to include on your calendar, each page should have:
   - Ideal water quality levels (What ranges can it survive in during this stage?)
   - Geographic range (Where does it live? Try drawing a map!)
   - Specific needs (What does it need for food or habitat?)
   - Primary activity or behavior (What is it doing?)
   - Picture or drawing (What does it look like? Do males and females look different?)
   - Fun Facts

Part II: ***In this section, your class will go out to a waterway in your region to determine whether or not the species you studied could be found there – today or any day!***

8. When you go to your waterway, you may not have the time or equipment to catch your species. Instead, you will have to find clues from the habitat to determine if the waterway has everything your species needs at this time of the year. Use the information in your calendar to predict whether or not your species could be found in your region (now or in another season). Write your prediction (and the information or knowledge that helped you make it) below:

9. Turn to the "Data Collection Chart" in the back of your activity. Add any categories to this chart that would make it more useful to you.

10. Before you go outside, complete the Ideal column on the "Water Quality Ideal versus Real Chart." Use the information your group members collected to create the calendar.

11. When you go outside, you will not collect every piece of data your group will need. Instead, your teacher will assign your group one or several pieces of data to collect. You will get the rest of the information from other groups later and record it on your data chart. Find out from your teacher what test your group is assigned and write it here:

12. Conduct your waterway assessment. Your teacher will help you divide into groups to test different aspects of the waterway!

13. Your teacher will help your class share the data you collected and put it all together in a class chart. Use the class data to complete your individual ""Data Collection Chart." Fill in the Real column on the "Water Quality Ideal versus Real Chart" with the information collected by your class.

14. Compare your "ideal conditions" data and your "real conditions" data – you should be able to tell at a glance whether or not conditions are right for your species to exist in your waterway! Write a short persuasive paragraph arguing whether or not your species could be in your waterway right now or at any other time of the year. Support your argument with examples from your investigation.

15. Even though this activity is finished, your investigation is not over. Chances are, there are still a lot of unanswered questions on your mind. If your species is absent from your waterway, you may want to know if it ever lived there and what is causing it to be absent. If your species is present in your waterway, you might want to know how it is doing and what you can do to help it out. List three questions that you still have about your species or your waterway in general.

16. Some people in your community might know whether your species has ever lived in the waterway you studied? Who could you ask or where could you look to find answers for your questions?

CRITTER QUESTIONS WORKSHEET

Species Name: _____

Life cycle stage: _____

1. What does your species look like? Draw or find pictures of your species during this stage (you may find more than one form during this stage). Use the back of this page or a piece of scrap paper.

2. What does your species need and do during this stage? Make sure to research the following basic needs:

   Food [What does it eat? Where does it find its food? How much does it eat?]

   _____

   _____

   Protection [How does it protect itself? Who or what does it need protection from?]

   _____

   _____

   Migration [Does it travel? Why?]

   _____

   _____

   Does your species spawn during this stage? _____

   Does your species need anything else during this stage? _____

   _____

3. What are your species' water quality requirements?

   pH: _____ Dissolved Oxygen: _____

   Temperature: _____ Depth: _____

   Salinity: _____ Bottom Conditions: _____

4. What is unique and interesting about your species? List the "fun facts" about your species on the back of this page.

DATA COLLECTION CHART

	TEST SITE 1	TEST SITE 1
pH Level		
Dissolved Oxygen Level		
Salinity		
Water Temperature		
Water Depth		
Bottom Conditions		
Water Flow Rate [rate = distance/time]		
Macroinvertebrate Score [Water Quality Rating]		

Water Quality Ideal versus Real Chart

Species Name: _____

Life cycle stage: _____

Before going outside to test the water, complete the **IDEAL RANGE** column. For each category, the range of values in brackets are possible results for that test.

	IDEAL RANGE	**REAL DATA**
pH Level [0 - 14]		
Dissolved Oxygen Level [0 - 14.6 parts per million]		
Salinity [0 - 35 parts per thousand]		
Water Temperature [0 - 100 degrees Celsius]		
Water Depth [0 - 120 feet]		
Bottom Conditions [concrete bottom hard bottom – rocks or shells soft bottom – mud or silt sandy bottom]		
Water Flow Rate [rate = distance/time]		
Macroinvertebrate Score [good, fair, or poor water quality rating]		

Macroinvertebrate Sampling Instructions

Rocky Bottom Streams:

1. Fill your ice cube tray with clear stream water. Select a riffle (shallow, fast-moving area with fist-size stones) and place your strainer or kick seine at the downstream edge of the riffle.
2. While one person holds the strainer, the other person should move upstream and dislodge macroinvertebrates by rubbing rocks and stirring up the bottom sediments and leaves. You can also dip the strainer into the bottom sediments to catch macroinvertebrates. If you remove rocks, be sure to return them to the stream immediately.
3. Pick up the strainer and bring it to the side of the stream. Use your magnifying glass, hands and tweezers to find and pick up (carefully) anything that moves. Place all samples in your ice cube trays, grouping macroinvertebrates that look the same in the same cube.
4. Repeat steps 1-3 two more times at the same location. If you have time, repeat the whole process at another site.
5. Identify the organisms that you have collected using the "Stream Insects and Crustaceans" card. Check off each macroinvertebrate species on your "Macroinvertebrate Chart" before releasing them into the stream.

Muddy or Sandy Bottom Streams:

1. Look for the following types of muddy bottom habitat:
    - Steep banks/vegetated margins: *overhanging vegetation, plants along the bank*
    - Silty (soft mud) bottom: *found where water moves slowly*
    - Woody debris with organic matter: *dead or living trees, roots, leaves, etc.*
    - Sand, rock, or gravel bottom
2. Fill a shallow pan with a thin layer of clear stream water before the stream gets muddy.
3. You should sample each of the existing types of habitat by scooping your strainer along one square foot of the habitat. When you scoop, use a jabbing motion to loosen organisms from the bank or the bottom of the waterway. Always move your strainer from the bottom to the surface of the water or upstream, so that your samples do not escape. Take ten scoops from steep banks/vegetated margins, three scoops from silty bottom, four scoops from woody debris with organic matter, and three scoops from sand, rock, or gravel bottom.
4. After every three scoops, dump the contents of your strainer into the shallow pan and separate the macroinvertebrates from the rest of the silt and debris. Put the organisms that you find into your ice cube trays.
5. When you have completed your sampling, identify your macroinvertebrates using the "Stream Insects and Crustaceans" card. Check off each macroinvertebrate species on your "Macroinvertebrate Chart" before releasing the organisms back into the water.

MACROINVERTEBRATE CHART

A healthy stream has many different kinds of macroinvertebrates. Therefore, you will be scoring according to how many varieties of macroinvertebrates you find, not how many of each you find. This means that three caddisfly larvae score the same as 17 caddisfly larvae. Still, it is a good idea to count the number of each type of macroinvertebrate you find.

Sensitive to Pollution	**Somewhat Sensitive to Pollution**	**Tolerant of Pollution**
_____ caddisfly larvae	_____ beetle larvae	_____ aquatic worms
_____ hellgrammite	_____ clams	_____ blackfly larvae
_____ mayfly	_____ crane fly larvae	_____ leeches
_____ right-opening snail	_____ crayfish	_____ midge larvae
_____ water penny	_____ damselfly	_____ left-pening snail
_____ riffle beetle	_____ dragonfly	_____ flat-coiled snail
_____ stonefly	_____ scuds	
	_____ sowbugs	
	_____ fishfly larvae	
	_____ alderfly larvae	
	_____ atherix	
Total varieties found _____	Total varieties found _____	Total varieties found _____
x 3 = _____	x 2 = _____	x 1 = _____

Total index value (add the final value for each column) = _____

Water Quality Rating:

>22: Excellent	11-16: Fair
17-22: Good	<11: Poor

Testing the Waters

T E A C H E R P A G E S

OVERVIEW

Through a comprehensive examination of a local waterway, students investigate the general habitat requirements and problems that affect aquatic organisms North Carolina's rivers and sounds. At the same time, students discover the water quality and habitat concerns specific to their local waterway and determine how these problems can be mitigated through local service-learning projects.

ESTIMATED TIME

3-4 hours

LEARNING OBJECTIVES

- **Science:** *Nature of Science; Science as Inquiry; Science and Technology*
- **Mathematics:** *Measurement; Data Collection and Analysis*
- **Social Studies:** *Information acquisition skills; Problem- solving, decision-making, and planning*
- **English Language Arts:** *Acquisition, interpretation, and application of information; Critical analysis and Evaluation*

VOCABULARY

The vocabulary for this activity is likely to be unfamiliar to students. We suggest that you go over the following words before beginning the activity:

buffer zone

culvert

drainage ditch

erosion

impervious surface

habitat

pool

riffle

root mat

runoff

rural

sediment

seine net

snag

stormwater retention pond

suburban

undercut banks

urban

MATERIALS

Land Use Investigation Group:

- Maps of the watershed showing land use (USGS 7.5 topographical maps), county street maps, other topographical maps, and/or landsat maps
- Stormwater maps (optional – call the Public Works Department in your town or city)
- Long tape measure
- Wooden dowel (half an inch thick, one foot long, marked at one inch intervals)

Water Quality Investigation Group:

- Dissolved oxygen, nitrate, phosphate, and pH testing kits
- Thermometer
- Salinity test kit (river survey only)
- Bottom grab or bucket to take bottom samples (river survey only)
- Paper and pens for sketching (SAV) distribution (river survey only)
- Rubber gloves

Habitat Investigation Group:

- Meter stick (or Secchi disk for the river survey)
- An orange, small rubber ball, and/or ping pong ball for measuring rate of flow (stream survey only)
- Stopwatch or watch with a second hand

Biology Investigation Group:

- 4 fine metal mesh kitchen strainers
- 8 ice cube trays
- Magnifying glasses
- Shallow pan (for muddy bottom streams)
- Tweezers (optional)
- Knee or hip boots (optional)
- Macroinvertebrate Guide

BACKGROUND

It is impossible to learn about the species that live in the coastal waters of North Carolina and their tributaries without, at some point, considering the ways in which human activity and development have affected their habitat. As we strive to live our lives as productively and comfortably as possible, our needs sometimes interfere with the productivity of local waterways and the comfort and survival of aquatic species. Many of these species indicate the health of their environment, and thus can tell us a lot about our surroundings.

This activity draws an explicit connection between the health of your waterway (and, subsequently, the health of local species) and the use of the land surrounding it by helping students trace concerns about a local waterway's water quality or habitat back to human activities. Your students will conduct a waterway assessment that will help them understand the condition of their waterway and the potential sources of the problems they discover.

Whether you live in an urban, suburban, or rural area, the most important function of "Testing the Waters" is to encourage you and your students to look for viable solutions to some of the problems you may encounter. Actions as simple as planting trees to stabilize a streambank or reporting leaking pipes are important steps toward creating healthier aquatic environments. The more we know about our waterways and the more invested we are in their health, the easier it will be to turn human impacts into positive actions to help restore North Carolina coastal waters and your local environment.

AGRICULTURAL AND URBAN AREAS

Because "Testing the Waters" focuses on the health of a small waterway and not on more comprehensive development patterns, predominantly urban or agricultural areas require a little extra explanation. Assessing the impacts of these areas is more complicated than the scores of this assessment suggest. Because urban areas are composed primarily of paved surfaces, they score low in any assessment (such as this one) that concentrates on land's impact on a particular small waterway. While it is true that the large areas of pavement found in cities pose a threat to water quality, in the bigger picture, urban areas concentrate more people on a smaller area of land and offer conservation opportunities not found in suburban or rural areas such as the following: cluster development, vertical development rather than sprawl, public transportation, fewer miles of highway, and effective wastewater treatment. Urban development, in this way, is more environmentally responsible than suburban development, which actually requires more paved areas spread out over more space. Unfortunately, in an assessment of a small waterway's health, the ecological advantages to living in a city are often obscured by our attention to the immediate threat that impervious surfaces pose to stream health.

Similarly, agricultural areas receive a mixed message about their impact. Because there is tremendous variability in agricultural practices, farmland can be considered both the best and worst land use. When Best Management Practices such as no-till planting, contour farming, vegetative buffers, and manure storage are practiced, farming's porous land surfaces and vegetation make it the best type of developed land. However, farmland that is used without efforts to reduce its impact can contribute large amounts of sediment (from plowed fields), nutrients (from fertilizers and manure), and toxins (from pesticides) to waterways. Unfortunately, the scores in this assessment represent only the average impact of current agricultural practices, and do not necessarily reflect the many farmers who are working hard to reduce their impact.

TEACHER PROCEDURE

1. **Locate an accessible waterway *(a stream, creek, pond, ditch, river, or estuary close to your school):*** Choose and mark a 75 meter site along the waterway before bringing your students outside. Check with state and county agencies to make sure that you are not disturbing an existing survey area and contact local land owners to make sure that you are not trespassing without permission. DENR's StreamWatch program often keeps track of ongoing monitoring projects, so contact them to find out about monitoring on your waterway. Keep an eye out for flags or marking tape that could mark a study area.

   If there are any dead fish with sores, do not touch the fish. If you see a large number of fish floating in the water (a fish kill) when you are marking the stream or when surveying with your students, do not sample the area or touch the water. Leave the area and promptly notify your local health department.

   Make it clear to your students that all assessment questions will be answered according to what can be observed or measured within the marked area. However, you should also explain to your students that they will need to think about development and activities in the watershed – outside of the site's boundaries – to explain some of what they will find.

2. **Classify your waterway:** If your waterway is a portion of a sound or a river, classifying your waterway is quite straightforward. However, if your waterway is a stream, you will need to determine whether it is a rocky bottom or muddy/sandy bottom stream. Both types are perfectly natural: some aquatic organisms are adapted to live in rocky bottom streams while others inhabit only muddy bottom streams. You may have to determine your stream type simply by observation.

   When appropriate, we have provided questions specific to each stream type to help you and your students assess the quality of your stream accurately. For rocky bottom streams, have students complete questions designated by "R" (for example, question 2R). For muddy bottom streams, have students answer questions designated by an "M" (for example, 2M).

3. **Divide your students into investigation groups:** Because this assessment is a comprehensive survey of your waterway's habitat, it would take an individual hours to complete. The assessment is divided into four sections:

   - ***Land Use***
   - ***Water Quality***
   - ***Habitat***
   - ***Biology***

   Divide the class into pairs and assign two or three pairs of students to each section of the assessment.

   If you are studying a river, you will not have a macroinvertebrate biology section that corresponds to your assessment. However, if you have access to a large seine net, you can get a good sense of the richness (number of fish) and diversity (variety of species) of your segment of river by doing two or three seine hauls and identifying the species you find. This will also allow you to tell whether the fish in your river have abnormal growths or mutations, which can be caused by abnormal conditions, including toxins, in the water. Fish identification books and guides can be obtained from libraries and bookstores.

4. **Prepare your students for the waterway assessment:** This activity has been developed to mirror the waterway assessments that are done by professional ecologists. While this does increase its accuracy and relevance, it also increases its level of difficulty. Troubleshoot by dividing the students into their investigation groups and distributing the assessment questions at

least one day before going out to the waterway. Have each group go through their section of the assessment, asking about things they do not understand and looking up words that are unfamiliar.

5. **After the assessment:** To help your students understand what their assessment means, go over their results as soon as possible! Group together all of the pairs that conducted the same section of the survey and allow them to talk to each other about their results and come up with a final assessment for their section. If you want students to share information in cooperative groups, rather than a full class discussion, facilitate a *jigsaw*, grouping two students from each section together to form groups of eight.

   Have your students score their sections and add up the total score for their section using the scoring guides at the end of each investigation. Have the class consider what their test results mean by using the scoring matrix.

6. **Understanding the matrix:** In most cases, your macroinvertebrate (biology) scores should correspond with your habitat, water quality, and land use scores. If you did not do a macroinvertebrate survey, your habitat and water quality scores should correspond with your land use score. There may be times, however, when these scores don't match and you and your students will need to determine the cause of the inconsistency! For example, if your stream had good water quality and habitat but a poor macroinvertebrate count, you might suspect periodic, occasional, or seasonal water quality or habitat problems (such as periodic drying up of the stream, or seasonal hot water flashes in the summer) that are not present at the moment you are looking at the stream. A high land use score coupled with a low water quality score might indicate a hidden source of pollution, such as chlorinated pool water draining into the waterway or a broken pipe somewhere upstream. *Remind your students that, within a section, a single bad score can mean tremendous problems for a stream or river, even if other aspects seem to be fine.* See "Analyzing Your Results" at the end of the Teacher's Pages for a more detailed explanation about the possible interpretations of different scores.

   - Student groups will determine a score for your waterway and then be asked to analyze it (decide if it is high or low or if the river scored well or poor). You should have your students decide how they will judge the scores before going outside. We have included a sample rating system, which was decided arbitrarily – any grounds

STREAM SURVEY

For the Stream Survey each Land Use, Water Quality and Habitat Investigation groups can have a total of 35 points. Use the table below as a guideline for judging your group's score.

GROUP SCORE	RATING
25 TO 35	High / well
Less than 25	Low / poor

The ratings and scores are provided for the Biology Investigation Group.

RIVER SURVEY

The scores are variable for each of the investigation groups. Before testing the river determine, as a class, what scores will be rated excellent, good, fair, or poor. For the Land Use and Water Quality Surveys (total points possible 21), a score of 17 or higher could be considered high and anything below 17 a low score. For the Habitat Survey (total points possible 18), a score of 15 or higher could be considered high and anything else a low score.

In most river or coastal areas, there will not be a significant macroinvertebrate

population. Therefore, your group should try to use a seine net to assess the richness and diversity of the fish and invertebrate population. Again, determine what will be considered a high score for richness and diversity.

JOURNAL ENTRY

- **Pose the following questions for your students:** When people see a polluted body of water, their first thought is often "YUCK! How did we let it get like this?" How do streams, rivers and other bodies of water become polluted? Ask them to free write (write without worrying about form, audience, grammar or punctuation) to explain how human beings, who love water, endanger it with their actions.
- **Discuss trash with your students.** Point out that: "When people think of pollution, they often think of trash. Yet, as you discovered in this activity, trash is usually a minor problem compared to other forms of pollution in the water." Ask them to write a paragraph explaining the other types of pollution that can affect a waterway and ask what can we do to clean up our waterways?

EXTENSION IDEAS

- Although a one-shot assessment of your waterway can be instructive, it is only with long-term monitoring that a true pattern of water and habitat quality or degradation becomes evident. If you enjoyed monitoring your stream, consider monitoring on a regular basis by adopting your stream. Register and receive more information from Izaak Walton League's "Save Our Streams," Rachel Carson National Estuarine Research Reserve's "Estuary Net," or StreamWatch.
- If you would like to focus more on water chemistry, then also conduct a fecal coliform test on your waterway. You can include nitrate and phosphate tests on the river survey as well and use the results as an additional indicator of water quality.
- If you discover threats to the health of your stream and would like to do something about them, organize a clean-up! A clean-up will not solve most water quality problems, but it will make the stream look better and will mobilize the community to become involved and invested in the stream. NC Big Sweep is an annual statewide waterway cleanup held the third Saturday in September that you and your students could join.

  NC Big Sweep
  PO Box 908
  Raleigh, NC 27602-0908
  919-828-6686 or 1-800-27-SWEEP

EDUCATIONAL RESOURCES

Izaak Walton League of America
Save Our Streams Program
707 Conservation Lane
Gaithersburg, MD
20878-2983
800-BUG-IWLA

Rachel Carson National Estuarine Research Reserve Estuary Program
PO Box 1040
Beaufort, NC 28516
252-728-2170

Stream Watch
Division of Water Resources
PO Box 27611
Raleigh, NC 27611
919-733-4064

Adopt-A-Stream Foundation
600-128th Street SE
Everett, WA 98208-6353
425-316-8592
email:
aasf@streamkeeper.org

GREEN:
Global Rivers Environmental Education Earth Force Network
1908 Mount Vernon Ave.
2nd Floor
Alexandria, VA 22301
703-519-6877
www.earthforce.org
email: green@earthforce.org

NC Geological Survey
PO Box 27687
Raleigh, NC 27611-7687
919-733-2423
Fax: 919-733-0900

ANALYZING YOUR RESULTS: STREAM SURVEY

Possible Meanings of Your Results Are Given

BIOLOGY/HABITAT

High Biology Score High Habitat Score	Ideal Conditions.
High Biology Score Low Habitat Score	Habitat problem that hasn't had time to affect the aquatic life.
Low Biology Score High Habitat Score	Biology is affected by something other than immediate habitat (maybe water quality or periodic habitat problems).
Low Biology Score Low Habitat Score	Long-term habitat problems are probably affecting biology.

BIOLOGY/WATER QUALITY (WQ)

High Biology Score High WQ Score	Ideal Conditions.
High Biology Score Low WQ Score	Recent or periodic problem that has not yet affected biology.
Low Biology Score High WQ Score	Problem is unrelated to water quality, or periodic or short term WQ problems exist, but not seen on this day.
Low Biology Score Low WQ Score	WQ problem is affecting biology.

BIOLOGY/LAND USE

High Biology Score High Land Use Score	Ideal Conditions.
High Biology Score Low Land Use Score	Land use is not affecting biology at this time, possibly because there has been no rain to cause runoff.
Low Biology Score High Land Use Score	Biology problem is not caused by immediate land use.
Low Biology Score Low Land Use Score	Land use is affecting biology.

ANALYZING YOUR RESULTS: RIVER SURVEY

Possible Meanings of Your Results Are Given

WATER QUALITY (WQ)/LAND USE

High WQ Score High Land Use Score	Ideal Conditions.
High WQ Score Low Land Use Score	Land use problems are not affecting stream habitat at this time. Problems might be periodic or seasonal.
Low WQ Score High Land Use Score	WQ problems are not caused by immediate land use, but could be caused by land use upstream.
Low WQ Score Low Land Use Score	Land use is affecting the water.

HABITAT/LAND USE

High Habitat Score High Land Use Score	Ideal Conditions.
High Habitat Score Low Land Use Score	Land use problems are not affecting stream habitat at this time. Problems might be periodic or seasonal.
Low Habitat Score High Land Use Score	Habitat problems are not caused by nearby land use, but might be caused by a land use upstream or some other factor.
Low Habitat Score Low Land Use Score	Land use is affecting the habitat.

Testing the Waters

STUDENT PAGES

INTRODUCTION

As you know, the health of a waterway can affect the health and survival of all the species that live in it. Whether a habitat is healthy, polluted, or somewhere in between often depends on the human activities that occur in the watershed that surrounds the stream. To figure out the best ways to help the species that live in your waterway, you must first find the sources of the problems that threaten them.

In this activity, you will conduct a thorough waterway assessment to determine both the health of your waterway and the sources of whatever problems you find.

PROCEDURE

Your teacher will help you form investigation groups for the land use, water quality, biology and habitat of your waterway. Parts of the investigation may be challenging! Read each question carefully and ask for help if you do not understand something.

STREAM SURVEY
Land Use Investigation Group

INTRODUCTION

When a factory in a town far away pollutes the air, it might affect you even though it is not near where you live. In the same way, aquatic organisms can be hurt by activities outside of their immediate habitat. The way that people use the land around a waterway can change the quality of the water, the habitat, and the health of the aquatic species. Unfortunately, aquatic organisms can't do anything about these threats to their habitat – but we can! This group is responsible for investigating the way land is used around your waterway.

MATERIALS

Your group will need:

- USGS topographical maps, county maps, and/or satellite maps of the watershed showing land use
- Stormwater maps (useful for urban or suburban setting)
- Tape measure
- Wooden dowel (half an inch thick, one foot long, marked at one inch intervals)

Read through the instructions, record your measurements, and assign the appropriate point values to your results.

1. Vegetation that separates a stream from human activities helps to filter out pollutants that might be carried by rain into the water. This area of vegetation is known as a "Buffer Zone." (Any type of vegetation is considered a buffer zone.) Use a tape measure to measure how wide your stream's buffer zone is at three different places. If you see a drainage ditch or a culvert coming into your stream, you must do one of your measurements there. Take the average of the three measurements, and then determine your score for the question.

   Measurement 1: _____

   Measurement 2: _____

   Measurement 3: _____

   Average: _____

   a) At least 18 m (~54 ft) wide — 5 points
   b) Between 12-18 m (36-54 ft) wide — 3 points
   c) Between 6-12 m (18-36 ft) wide — 2 points
   d) Less than 6 meters (18 ft) wide — 0 points

2. It has been estimated that at least 18 meters (54 feet) of vegetation are necessary to protect a stream. What ground surfaces make up most of the 18 meters surrounding your stream?

   a) Mainly trees or wetlands — 5 points
   b) Mainly shrubs, unmowed grass, or pasture land — 3 points
   c) Mainly mowed lawns or agricultural crops — 2 points
   d) Mainly pavement — 0 points

3. One way to figure out whether dirt and pollution are a problem for your stream is to test the compaction, or hardness of the soil. If the ground in your stream's immediate watershed is very hard, the water will rush off the land into the stream, erode the banks, and carry dirt and pollution into your stream. However, if the ground is somewhat soft, the water will sink right in and travel to the stream slowly, from underground. You will use the wooden dowel to test the compaction of your soil.

   Beginning at the edge of the stream and traveling away from the stream, stop every ten feet and try to push the dowel into the ground as far as you can. Record the depth the dowel goes into the ground on the chart below:

	DOWEL DEPTH (inches)
10 feet from the stream	
20 feet from the stream	
30 feet from the stream	
40 feet from the stream	
50 feet from the stream	
Average	

   Average the depth you pushed the dowel into the ground to determine your score for this question:

   a) The dowel went in an average of five inches or more — 5 points
   b) The dowel went in an average of three to five inches — 3 points
   c) The dowel went in an average of one to three inches — 2 points
   d) The dowel went in an average of less than one inch — 0 points

4. Another good way to tell if the land use around the stream is affecting the stream is to look at the stream itself. Heavy erosion on the banks of the stream usually means that significant development directly around your stream or in upstream areas is channeling lots of water directly into your stream every time it rains.

   a) Little to no erosion: boulders, shrubs, trees, and vegetation present — 5 points
   b) Small areas of erosion: 10-30% of the bank shows signs of erosion — 3 points
   c) Streambanks are quite steep and 30-60% show bare, eroded soil — 2 points
   d) 61-100% of the banks have bare, eroded soil; banks look "raw" and have no vegetation. Banks are very steep. — 0 points

5. If there are pipes, culverts, or drainage ditches entering the stream, trace their path to where they begin by following them or by looking at stormwater maps. Water traveling through these pathways is not filtered after it has entered them, so it carries whatever trash, sediment, or pollutants it picks up into your stream. Where do your pipes, culverts, or drainage ditches begin? *If several pipes begin in different places, use the lowest score.*

   a) Man-made wetlands or a natural area — 5 points
   b) Stormwater retention pond; unmowed grass — 3 points
   c) Farmland and mowed grass — 2 points
   d) Pavement, buildings, bare soil — 0 points

6. Streams need to have ways to maintain stable water temperatures as the temperature of the air changes from day to day. Trees and shrubs covering the stream provide shade, which helps to keep the stream cool in the summer. Within your study site, how much of the stream is shaded?

   a) Greater than 80% — 5 points
   b) Between 50 and 80% — 3 points
   c) Between 30 and 49% — 2 points
   d) Less than 30%; most of the stream is in direct sunlight — 0 points

7. If you've ever walked barefoot on a hot summer day, then you know that pavement can absorb a tremendous amount of heat. During hot weather, when rain falls on pavement and runs into a stream, the water temperature can be high enough to kill fish and other stream inhabitants. If instead, rainwater falls on soil or vegetated areas, much of it soaks into the ground and travels to the stream through the cool underground. What land type makes up the stream's watershed?

   a) Largely undeveloped and rural, few houses — 5 points
   b) Rural, but with some suburban development — 4 points
   c) Largely agricultural — 3 points
   d) Largely developed, with a few undeveloped areas — 2 points
   e) Fully suburban and/or urban; almost no undeveloped areas — 0 points

Investigation Score: _____ out of 35 points

STREAM SURVEY
Water Quality Investigation Group

INTRODUCTION

Every living thing has conditions that it can and cannot tolerate. Just as you cannot survive a lack of oxygen or temperatures that are extremely hot or abnormally cold, stream organisms are sensitive to changes in the water in their stream. One of the biggest factors affecting species living in the water is poor water quality caused by high temperatures, sediment (dirt), acidity, toxics or low dissolved oxygen. What would cause a stream to become too hot for aquatic organisms to live, or too toxic for them to survive? Why would dissolved oxygen, usually a normal part of water, disappear? The following questions will help you to determine if your stream has water quality problems and, if it does, what might be causing those problems.

MATERIALS

Your group will need:

- Dissolved oxygen, nitrate, phosphate, and pH testing kits
- Thermometer

1. Measure the temperature of your stream at the surface and at the bottom at 25 meter intervals along the stream. Even though different species of fish require different temperatures of water, all fish are stressed by rapid changes in temperature and temperatures above 32 degrees Celsius (C), which is approximately 90 degrees Fahrenheit (F).

   Temperature changes between morning and night often occur quickly in the summer, so even though your temperature might be fine today, your stream may still become too hot during the summer! Your class should chart the change in temperature throughout the day, but if this is not possible, pick your answer from choice a or b.

   At this moment, the average temperature in your stream is: _____

   a) Temperature is fine today – under 32 degrees C or 90 degrees F — 0 points
   b) Too hot for most organisms – at or over 32 degrees C or 90 degrees F — -5 points
   c) Temperature rose or fell more than two degrees C during the day — -5 points

2. Just like you, fish and aquatic species need to breathe! The amount of dissolved oxygen in the waters of your stream will be an important indication of what can live there. Measure the dissolved oxygen in your stream by using the dissolved oxygen chemical test kit.

   The measured dissolved oxygen of your stream is: _____

   a) Good for growth and activity: more than 5 ppm (parts per million) — 5 points
   b) Stressful for many aquatic organisms: 3-5 ppm — 3 points
   c) Stressful for most aquatic organisms: 2-2.99 ppm — 1 points
   d) Less than 2 ppm: will not support most fish if condition persists — 0 points

3. Now you will figure out the "percent saturation" of your stream to see how much oxygen it has compared to how much oxygen it should have. The chart below tells you how much oxygen your stream could have at different temperatures. As you can see, the hotter the water, the less oxygen it can hold – this means that in hot weather, there is more chance that fish will become stressed.

   Use the following formula to figure out your stream's % saturation:

$$\frac{\textbf{measured dissolved oxygen}}{\textbf{potential dissolved oxygen}} \textbf{ X 100 = \% saturation}$$

TEMPERATURE (in degree Celsius)	POTENTIAL DISSOLVED OXYGEN (in ppm)
0	14.6
5	12.8
10	11.3
15	10.1
20	9.1
25	8.2
30	7.5
35	6.9

The percent saturation for your stream is: _____ %

a) 80% to 100% of the potential dissolved oxygen — 5 points
b) 60% to 79% of the potential dissolved oxygen — 3 points
c) 40% to 59% of the potential dissolved oxygen — 1 points
d) Below 40% of the potential dissolved oxygen — 0 points

4. If a stream is very clear but you see very little life in it and there seem to be no other significant problems, it could mean your stream is too acidic. Old mines, certain chemicals draining into streams, or acid rain from car exhaust and factories can make streams too acidic. *Since pH can change, your stream might have a pH problem that you can't detect at this time.* Measure pH using the test kit to determine your score for this question.

   The measured pH of your stream is: _____

   a) 6.5 - 8.2: Perfect for most organisms — 5 points
   b) 5.0-6.5 or 8.2-9.0: Not directly harmful to fish, but may harm delicate species or have indirect effects due to chemical changes in the water — 2 points
   c) 4.5-5.0 or 9.0-10.5: Harmful to some fish; most eggs will not hatch; most insects absent — 1 points
   d) Below 4.5 or above 10.5: Lethal to most fish — 0 points

5. Sewer lines often run next to streams. If these sewer lines are exposed they can break and spill untreated sewage into the waterway. Do not touch any evidence of spilled sewage!

   a) The stream shows no sign of sewer pipes. If present, they are buried. — 5 points
   b) There is exposed pipe, but no part of the pipe appears to have any damage and all manhole covers are secure. — 3 points

c) There is evidence of past seepage (algae, toilet paper, etc.), a manhole cover is not tightly sealed, and/or the pipe looks worn. Possibly an odor. — 1 points

d) Untreated sewage is flowing from a broken pipe or uncovered manhole. — 0 points

6. Pipes releasing colored, odorous, murky, warm liquids leave unusual odors, scum, or foam on the surface of the water. If there are pipes entering your stream, check to see if they are releasing liquid into the stream. If there is nothing coming out of the pipe at this time, look for foam, oil, or other substances on the surface of the water near the pipe. Do not touch any substance leaking from a pipe!

a) No pipes can be seen. — 5 points

b) There are exposed pipes, but nothing is coming out of the pipe at this time and there is no evidence of harmful substances in the water. — 3 points

c) Nothing is coming out of the pipe at this time, but there is foam, oil, scum, or other unusual substances in the water. — 1 points

d) A colored, odorous, murky, or warm liquid is coming out of the pipe. — 0 points

7. Nutrients like nitrates and phosphates enter the water from human and animal waste, decomposing organic matter (like leaves), and fertilizer. Too many nutrients in the water cause algae to grow rapidly. As the algae grows and dies, it blocks the sunlight and uses up the oxygen in the water. If you have nitrate and phosphate test kits, measure the amount of these nutrients in your waterway.

a) Levels of both are below 1 part per million (ppm) — 5 points

b) Levels of both are between 5 and 1 ppm — 3 points

c) If at least one test result is between 9 and 5.1 ppm — 1 points

d) If either test result is greater than 9 ppm (not safe to drink) — 0 points

8. Trash: Although most trash looks ugly trash can also harm water quality. In your waterway:

a) There is no, or very little trash of any sort to be seen. — 5 points

b) Trash is present, but it is all paper, plastic, or glass; no rusting metal, oil cans or batteries. — 3 points

c) Plastic bags, rusting metal, oil cans and/or batteries are present. — 1 points

d) Industrial waste (large drums of toxic materials) or sewage waste is present at the site. — 0 points

Investigation Score: _____ out of 35 points

STREAM SURVEY
Habitat Investigation Group

INTRODUCTION

Chances are, when you wake up in the morning, some sort of roof, walls, and floor surrounds you. You then ride some sort of moving vehicle to another structure, where you spend most of the day. Houses, apartments, cars, schools, sidewalks, swimming pools, movie theaters, and libraries are a few of the things that make up a human's habitat. Aquatic species require certain things to make up their habitat as well. When they do not have access to the habitat they require, it is very difficult for aquatic species to survive. The following questions will help you to determine if your stream offers good habitat for aquatic organisms.

MATERIALS

Your group will need:

- Meter stick
- An orange, bouncy rubber ball, or ping pong ball
- Stopwatch, or a watch with a second hand

1. Eroded streambanks are a sign that runoff enters the stream quickly and in large, uncontrolled amounts. Vegetation, boulders, and tree roots help to hold soil in place and prevent erosion. Signs of streambank erosion include steep, crumbling banks, with raw or exposed soil. Which choice describes the banks of your stream?

   a) Little to no erosion; boulders, shrubs, trees, and vegetation present. — 5 points
   b) Small areas of erosion: 10-30% of the bank shows signs of erosion. — 3 points
   c) Streambanks are quite steep and 31-60% show bare, eroded soil. — 1 points
   d) 61-100% of the banks have bare, eroded soil; banks look "raw" and have no vegetation. Banks are very steep. — 0 points

Note: If your stream has a rocky bottom, complete questions 2R and 3R. If your stream has a muddy bottom, complete questions 2M and 3M.

2R. In a rocky bottom stream habitats, like very shallow pools, sandbars, and islands without vegetation, experience sediment build-up behind rocks and logs when there is heavy erosion of the land around the stream. This movement of sediment can smother aquatic organisms and plants when it settles on the bottom. The stream you are studying:

   a) Has no or very few islands or sand bars; less than 5% of the stream bottom is covered by sediment. — 5 points
   b) Has some sediment built up in the stream and along its banks. 5-30% of the stream bottom is covered by sediment. — 3 points
   c) Has large sandbars and sediment build-up behind logs, branches, and rocks; 31-50% of the bottom is covered by sediment. — 1 points
   d) Has very obvious sediment build-up and more than 50% of the bottom is covered by sediment. — 0 points

2M. In a muddy bottom stream, sediment may collect until it has actually filled in pools and reduced the flow of water to a trickle. During storms, this heavy sediment build-up moves from one part of a stream to another, smothering aquatic species and plants. Choose the answer that describes your stream:

a) Less than 20% of the bottom is covered with sediment; only minor amounts of sediment collected in snags and on vegetation. 5 points

b) 20-50% of the bottom is covered with loose sediment; some sediment in snags and vegetation. 3 points

c) 51-80% of the bottom is covered with loose sediment; sediment nearly fills shallow pools. 1 points

d) Stream is reduced to a narrow channel; mud, silt and/or sand fills pools and stops or almost stops the flow of water. 0 points

3R. Fish and their eggs require a variety of habitats to live in a stream. Prime habitats for rocky bottom stream fish include different sized rocks (from as big as your head to as small as a marble), plants growing in the water, logs greater than four inches in diameter, fallen tree branches, clumps of roots, and areas to hide under the streambank. What answer best describes your stream's habitat?

a) At least half of the stream is a mix of large rocks, gravel, logs, tree branches, undercut banks, etc 5 points

b) 31-50% is a mix of appropriate habitat 3 points

c) 10-30% mix of habitat 1 points

d) Less than 10% stable habitat; lack of habitat is obvious 0 points

3M. Fish and their eggs require a variety of habitats to live in a stream. Prime habitats for muddy bottom stream fish include fallen trees and tree branches, submerged logs, areas to hide under the streambank (undercut banks), root mats, and plants growing in the water. Rocks and gravel may or may not be present. What answer best describes your stream's habitat?

a) Greater than 40% of the stream contains a mix of branches, submerged logs, undercut banks and other habitat 5 points

b) 21-40% of the stream contains a mix of appropriate habitat 3 points

c) 10-20% of the stream contains a mix 1 points

d) Less than 10% stable habitat; lack of habitat is obvious 0 points

4. Streams naturally curve and meander. When streams are straightened or the streambanks are hardened by man-made ditches, culverts, and channels, the water moves much more quickly, often increasing erosion downstream and destroying habitat. The stream you are studying:

a) Shows little or no evidence of being straightened or widened by man – it is a curving stream with natural streambanks. 5 points

b) Has 10-40% of its banks straightened or changed from their natural state 3 points

c) Is over 80% straightened or has 41-60% of its streambanks cemented 1 points

d) The streambanks are over 60% cemented or the stream is over 80% straightened; there are few or no places where aquatic animals could hide or feed 0 points

5. When water in a stream dries up or covers very little of the stream bed, there are fewer places for aquatic organisms to live. How much of the stream bed is full of water?

a) Water touches the banks of the stream on both sides and the stream bottom is underwater. 5 points

b) 75% of the stream is filled with water and less than 25% of the stream bottom is exposed. 3 points

c) Water fills 25-74% of the stream bed, much of the stream bottom is exposed — 1 points

d) Very little water is in the stream bed; the water present is mostly in still pools — 0 points

6. For a variety of different organisms to live in a stream, there must be a variety of habitats, including various depths and speeds of the water. Use procedures **a** and **b** to determine if your waterway has a variety of habitats.

   a) To determine the depth of water in your waterway, measure the water in various areas in the stream until you find the deepest and shallowest spots. "Deep" water is considered anywhere that is equal to, or greater than .5 meters (greater than 1.5 ft. deep). "Shallow" water is less than .5 meters (less than 1.5 ft) deep. Record the deepest and shallowest depths that you find here:

      Deepest: _____ Shallowest: _____

   b) To determine whether your stream has both slow and fast moving areas, measure and mark a one meter segment of the stream where the water appears to be moving the fastest and mark another one meter segment where the water seems to be moving the slowest. Time how long it takes an orange (or rubber bouncy ball or ping pong ball) released at the upstream end of each segment to travel to the downstream end of the segment. Calculate the rate (rate = distance/time) that the orange or ball traveled in meters/sec at each site. "Fast" water flows equal to or greater than .3 meters (1 ft) per second and "slow" water moves at less than .3 meters (1 ft) per second.

      Fastest: _____ Slowest: _____

   a) All four types of water can be seen (slow, fast, deep, and shallow) — 5 points

   b) Only three of the four — 3 points

   c) Mostly shallow and slow pools — 1 points

   d) Slow and shallow water only — 0 points

7. How many blockages (dams, etc.) exist in your study site that would prevent fish from traveling up and down the stream to their spawning and feeding sites? Check a map for blockages elsewhere on your stream.

   a) None — 5 points

   b) One small blockages that could be removed easily — 3 points

   c) One large, permanent blockage — 1 points

   d) More than two permanent blockages — 0 points

Investigation Score: _____ out of 35 points

STREAM SURVEY
Biology Investigation Group

INTRODUCTION

Macroinvertebrates are an important food source for many fish. Macroinvertebrates can also be good indicators of stream health, because some species are extremely sensitive to water quality. A lack of macroinvertebrates in what appears to be a healthy stream can indicate the presence of short-term, but disastrous water quality issues, such as extremely hot temperatures during the summer. Your group will be responsible for determining how many varieties of macroinvertebrates can be found in your stream.

MATERIALS

Your group will need:

- 4 fine metal mesh kitchen strainers
- 8 ice cube trays
- Magnifying glasses
- Shallow pan (for muddy bottom streams)
- Tweezers (optional)
- Knee or hip boots (optional)

After completing your macroinvertebrate survey, count the total number of species identified in each column and then multiply the total number by the correct constant (see the Macroinvertebrate Chart). Add the total number for each column and compare with these water quality ratings:

>22 = Excellent
17-22 = Good
11-16 = Fair
<11 = Poor

Biology (macroinvertibrate) score: _____

Macroinvertebrate Sampling Instructions

Rocky Bottom Streams:

1. Fill your ice cube tray with clear stream water. Select a riffle (shallow, fast-moving area with fist-size stones) and place your strainer or kick seine at the downstream edge of the riffle.
2. While one person holds the strainer, the other person should move upstream and dislodge macroinvertebrates by rubbing rocks and stirring up the bottom sediments and leaves. You can also dip the strainer into the bottom sediments to catch macroinvertebrates. If you remove rocks, be sure to return them to the stream immediately.
3. Pick up the strainer and bring it to the side of the stream. Use your magnifying glass, hands and tweezers to find and pick up (carefully) anything that moves. Place all samples in your ice cube trays, grouping macroinvertebrates that look the same in the same cube.
4. Repeat steps 1-3 two more times at the same location. If you have time, repeat the whole process at another site.
5. Identify the organisms that you have collected using the "Stream Insects and Crustaceans" card. Check off each macroinvertebrate species on your "Macroinvertebrate Chart" before releasing them into the stream.

Muddy or Sandy Bottom Streams:

1. Look for the following types of muddy bottom habitat:
    - Steep banks/vegetated margins: *overhanging vegetation, plants along the bank*
    - Silty (soft mud) bottom: *found where water moves slowly*
    - Woody debris with organic matter: *dead or living trees, roots, leaves, etc.*
    - Sand, rock, or gravel bottom
2. Fill a shallow pan with a thin layer of clear stream water before the stream gets muddy.
3. You should sample each of the existing types of habitat by scooping your strainer along one square foot of the habitat. When you scoop, use a jabbing motion to loosen organisms from the bank or the bottom of the waterway. Always move your strainer from the bottom to the surface of the water or upstream, so that your samples do not escape. Take ten scoops from steep banks/vegetated margins, three scoops from silty bottom, four scoops from woody debris with organic matter, and three scoops from sand, rock, or gravel bottom.
4. After every three scoops, dump the contents of your strainer into the shallow pan and separate the macroinvertebrates from the rest of the silt and debris. Put the organisms that you find into your ice cube trays.
5. When you have completed your sampling, identify your macroinvertebrates using the "Stream Insects and Crustaceans" card. Check off each macroinvertebrate species on your "Macroinvertebrate Chart" before releasing the organisms back into the water.

MACROINVERTEBRATE CHART

A healthy stream has many different kinds of macroinvertebrates. Therefore, you will be scoring according to how many varieties of macroinvertebrates you find, not how many of each you find. This means that three caddisfly larvae score the same as 17 caddisfly larvae. Still, it is a good idea to count the number of each type of macroinvertebrate you find.

Sensitive to Pollution	Somewhat Sensitive to Pollution	Tolerant of Pollution
_____ caddisfly larvae	_____ beetle larvae	_____ aquatic worms
_____ hellgrammite	_____ clams	_____ blackfly larvae
_____ mayfly	_____ crane fly larvae	_____ leeches
_____ right-opening snail	_____ crayfish	_____ midge larvae
_____ water penny	_____ damselfly	_____ left-pening snail
_____ riffle beetle	_____ dragonfly	_____ flat-coiled snail
_____ stonefly	_____ scuds	
	_____ sowbugs	
	_____ fishfly larvae	
	_____ alderfly larvae	
	_____ atherix	
Total varieties found _____	Total varieties found _____	Total varieties found _____
x 3 = _____	x 2 = _____	x 1 = _____

Total index value (add the final value for each column) = _____

Water Quality Rating:

>22: Excellent	11-16: Fair
17-22: Good	<11: Poor

RIVER SURVEY
Land Use Investigation Group

INTRODUCTION

How does the way we use our land affect the health of our rivers? As rainwater travels along our sidewalks and roads, it picks up everything and anything in its path. If the water can't seep slowly into the ground, it will dump everything it carries directly into our waterways. And, of course, if this flowing water picks up toxic or hazardous materials off the land, they will end up in our rivers as well. Fast moving runoff from the land can cause other problems for rivers. Erosion, for example, brings loads of sediment (dirt) into the river, where it covers prime habitat, blocks the sunlight needed by grasses, clogs the gills of fish, and smothers delicate fish eggs. Even the ways that people enjoy rivers – recreational boating and waterfront property – can contribute to the problems facing the health of a river. In this activity, your group will investigate the way land is used and developed around your river.

MATERIALS

Your group will need:

- USGS topographical maps, county maps, and/or satellite maps of the watershed showing land use
- Stormwater maps
- Tape measure

1. Well-vegetated banks are important for absorbing pollutants and keeping sediments out of the river. This area of vegetation is known as a "Buffer Zone," which can include any type of vegetation. Use a tape measure to measure how wide your river's buffer zone is at its smallest part. Which best describes the buffer zone of your river?

   a) At least 18 m (~54 ft.) wide
   b) Between 12-18 m (36-54 ft.) wide
   c) Between 6-12 m (18-36 ft.) wide
   d) Less than 6 meters (18 ft) wide

2. What materials make up the 18 meters surrounding the river?

   a) Mainly trees or wetlands
   b) Mainly shrubs or unmowed grass; some mowed lawns or agricultural crops
   c) Mainly mowed lawns or agricultural crops; some pavement or animal pastures
   d) Mainly pavement or animal pastures

3. Rivers are healthiest if the land that drains water into the river is well vegetated. Vegetation and soil absorb rainfall and then slowly release water into the river, causing controlled flows. Hard surfaces allow water to run rapidly into the river, causing excessive flows. Using a topographic, land use, or satellite map figure out what type of land makes up most of the rivers drainage basin?

   a) Forests, wetlands
   b) Unmowed fields and agricultural crops
   c) Mowed grass, houses, agricultural crops and pasture land
   d) Pavement, buildings, and other hard surfaces

4. Changes to the edges of the river can increase erosion and destroy valuable habitat. In particular, bulkheads along the edge of the water and channelization by rip-rap (large lines of rock lining the shore or in the water) change the structure and flow of the river. In your river:

   a) There is very little or no bulkhead or rip-rap
   b) There is some bulkhead or rip-rap
   c) There is heavy bulkheading
   d) The area is almost completely bulkheaded

5. If there are pipes, culverts, or drainage ditches entering the river, trace their path to where they begin by following them on foot or by looking at stormwater maps. Water traveling through these pathways is not filtered after it has entered them, so it carries debris and pollution into the river. Where do your pipes, culverts, or drainage ditches begin?
   a) Man-made wetlands or a natural area
   b) Stormwater retention pond; unmowed grass
   c) Agricultural crops and mowed grass
   d) Pavement, buildings, bare soil, pasture land

6. Rivers need to have ways to maintain stable water temperatures as the temperature of the air changes from day to day. Trees and shrubs covering the stream provide canopy cover, shady overhanging trees and shrubs that help to keep the river cool in the summer. Describe the amount of covering at your site.

   a) Shaded: full canopy cover
   b) Partly shaded: over half covered with a canopy
   c) Partly open: some canopy cover
   d) Open: very little canopy cover

7. Rivers are used by man for a variety of purposes, some of which can affect the river's overall health. On your section of river:

   a) There is no evidence of human influence
   b) The river has been influenced by recreational use.
   c) The river has been influenced by housing or industry
   d) Dredging or straightening has influenced the river and changed its shape.

SCORING

1. Count up the number of each letter that you circled and record them below:

   a _____ x 3 points each = _____

   b _____ x 2 points each = _____

   c _____ x 1 point each = _____

   d _____ x 0 points each = _____

2. Add up your totals for each letter. Your total score = _____

RIVER SURVEY
Water Quality Investigation Group

INTRODUCTION

Every living thing has conditions that it can and cannot tolerate. Just as you cannot survive a lack of oxygen or temperatures that are extremely hot or abnormally cold, aquatic organisms are sensitive to changes in the water in their river. The biggest factors affecting species living in the water are habitat loss and poor water quality caused by acidity, toxins, or low dissolved oxygen. What would cause a river to become too toxic to survive? Why would dissolved oxygen, which is usually a normal part of water, disappear? The following questions will help you to determine if your river has water quality problems and, if it does, what might be causing those problems.

MATERIALS

Your group will need:

- Dissolved oxygen, nitrate, phosphate, and pH testing kits
- Thermometer, bottom sampler, paper and pen, rubber gloves

1. Measure the temperature of your river at 25 meter intervals along the site. If it is possible, measure the temperature at the top of the water as well as deeper in the water (but don't fall in!) Normally, the cooler the water, the better it is for aquatic species, but water temperature less than 20 degrees Celsius is considered optimal for most species. What temperature range does your river fall into?

   a) Less than 20 degrees Celsius
   b) Between 20 and 25 degrees Celsius
   c) Between 25 and 30 degrees Celsius
   d) Greater than 30 degrees Celsius (Lethal for many organisms)

2. Just like you, fish and aquatic species need to breathe! The amount of dissolved oxygen in the waters of your river will be an important indication of what can live there.

   What is the dissolved oxygen level in your waterway? _____

   a) Good for growth and activity: at least 5 ppm (parts per million)
   b) Stressful for many aquatic organisms: 3-5 ppm
   c) Stressful to most aquatic organisms: 2-3 ppm
   d) Will not support fish: below 2 ppm

3. If a river is very clear but you see very little life in it and there seem to be no other significant problems, it could mean it is too acidic. Old mines, certain chemicals draining into streams, or acid rain from car exhaust and factories can make rivers too acidic. What was the pH of your river?

   a) 6.5-8.2: Perfect for most organisms
   b) 5.0-6.5 or 8.2-9.0: Not directly harmful to fish, but may harm more delicate species or have indirect effects due to chemical changes in the water
   c) 4.5-5.0 or 9.0-10.5: Harmful to some fish; most eggs will not hatch; most insects absent
   d) Below 4.5 or above 10.5: Lethal to all fish

4. Unpleasant odors in the waters or sediment can mean that oils, chemicals, or sewage have been dumped into your river. Take a sample of the bottom sediments from your river and

describe its appearance and smell. Wear rubber gloves and wash your hands after touching the bottom sediments.

a) Sandy, no smell
b) Sand mixed with dark mud
c) Mostly mud, but not smelly
d) Anaerobic (no oxygen): thick black mud, smells like sulphur or rotten eggs

5. Pipes releasing colored, odorous, murky, warm liquids leave unusual odors, scum, or foam on the surface of the water. If there are pipes entering your river, check to see if they are releasing liquid. If there is nothing coming out of the pipe at this time, look for foam or other substances on the surface of the water near the pipe. Do not touch any substance leaking from a pipe.

   a) No pipes can be seen
   b) There are exposed pipes, but nothing is coming out of the pipe at this time and there is no evidence of harmful substances in the water
   c) Nothing is coming out of the pipe at this time, but there is foam, oil, scum, or other unusual substances in the water
   d) A colored, odorous, murky, or warm liquid is coming out of the pipe at this time

6. Fish found in the river with growths, decaying fins, unnatural spots or marks, and other signs of disease can be a sign of unhealthy water quality. If you used a seine net to catch fish, what percentage of the fish you caught had these unusual markings? (If you did not catch any fish, skip this question and do not score it.)

   a) none
   b) 1-10%
   c) 10-30%
   d) more than 30%

7. The presence or absence of SAV (Submerged Aquatic Vegetation, or underwater plants) can tell you a lot about your river's overall water quality, because SAV need light and clean water to grow. SAV, if present, also help to keep the water clean and provide habitat for aquatic species. **Sketch your river, and fill in the areas where SAV are present.**

   a) Thick, abundant SAV covers the shallow areas of the river
   b) Some SAV, but it tends to be thin and scraggly
   c) Very little SAV
   d) No SAV present at all

SCORING

1. Count up the number of each letter that you circled and record them below:

   a _____ x 3 points each = _____

   b _____ x 2 points each = _____

   c _____ x 1 point each = _____

   d _____ x 0 points each = _____

2. Add up your totals for each letter. Your total score = _____

RIVER SURVEY
Habitat Investigation Group

INTRODUCTION

Chances are, when you wake up in the morning, you wake up with some sort of roof, walls, and floor surrounding you. You then board some sort of moving vehicle that takes you to another structure, where you spend the rest of the day. Houses, apartments, cars, schools, sidewalks, swimming pools, movie theaters, libraries … these are just a few of the things that make up the habitat that most people require to make up a healthy life. Aquatic species require certain sorts of habitats to lead a healthy life as well. When they do not have access to the habitat they require, it is very difficult for aquatic species to survive. The following questions will help you to determine if your river offers adequate habitat for aquatic organisms to live.

MATERIALS

Your group will need:

- Secchi disk
- Tape measure

1. Many species that live in tidal rivers are benthic organisms – that is, they like to live at the bottom of the river. Many other species rely on these bottom dwellers as food. For this reason, it is important that there be a variety of different substances (or substrates) on the bottom of the river, so that all organisms can find the habitat that they need. Examine the bottom substrate of your river in at least five locations.

   a) **Excellent:** a combination of sand, rock, and shell; almost no mud or muck
   b) **Good:** only two types of substrate found; some mud or muck
   c) **Fair:** only one type of desirable habitat (sand, rock, shell) found
   d) **Poor:** almost entirely mud or muck

2. No matter what the composition of the bottom of your river, large deposits of sediment from the land can smother fish eggs and oysters and clog the gills of some fish. It will also prevent light from penetrating the water and reaching the SAV. Use your secchi disk or your body to determine how far light can penetrate into your river.

   The Bernie Fowler test: Choose two volunteers from your group to wade into the river until they can no longer see their toes. Once they are back on shore, use your meter stick to measure how far up the water came on their bodies. This number is called your Bernie Fowler depth.

   The Secchi disk test: Find a deep spot in the water (off a dock) and lower your secchi disk until you can no longer see it. Write down the distance from the disk to the surface of the water. Raise the disk until it reappears and write down that distance. Take the average of the two distances – this number is called your Secchi depth.

   a) Your Bernie Fowler or Secchi depth was at least five feet
   b) Your depth was between three and five feet
   c) Your depth was between one and three feet
   d) Your depth was less than one foot

3. It is important that species living in your river have places to hide! SAV (underwater grasses) and submerged logs provide terrific hiding places. In your river:

a) SAV or submerged logs make up more than 50% of the shallow water area
b) SAV or submerged logs make up 20 - 50% of the shallow water area
c) Hiding places are mostly submerged logs; almost no SAV
d) There are few or no hiding places at all

4. If your river is blocked by a dam without a fish ladder or other obstruction, many fish will not be able to get upstream to their spawning habitat. If they cannot reach their spawning habitat then they will not be able to lay their eggs and repopulate their species. How many dams or blockages do you know of on your river?

   a) None
   b) One blockage that can be easily navigated by fish
   c) One large blockage, or two that can be easily navigated
   d) More than two dams or blockages that cannot be navigated by fish

5. When people alter the physical characteristics of rivers by straightening the river, constructing concrete embankments, or diverting the river away from its natural course, we automatically influence the organisms that live in the river. Look for evidence of changes to the physical structure of your river.

   a) River shows no sign of human influence
   b) River has been straightened or diverted in places, but banks are not concrete
   c) River has been straightened or diverted in places, and has concrete embankments
   d) River has been straightened or diverted with concrete embankments and bottom for entire length of section

6. The edges of the river can provide particularly valuable habitat for many aquatic species such as blue crabs, small fish, and terrapins. Describe the banks of your river:

   a) Edges of the river are made up of natural sandy beaches, wetlands, and other vegetation
   b) Edges are mainly natural but have some man-made sandy beaches
   c) Edges are mostly man-made beaches and rip-rap or breakwaters
   d) Edges are mainly covered with rip-rap and bulkheading

SCORING

1. Count up the number of each letter that you circled and record them below:

   a _____ x 3 points each = _____

   b _____ x 2 points each = _____

   c _____ x 1 point each = _____

   d _____ x 0 points each = _____

2. Add up your totals for each letter. Your total score = _____

FINAL ANALYSIS

1. Describe your group's investigation and explain what you learned about your waterway.

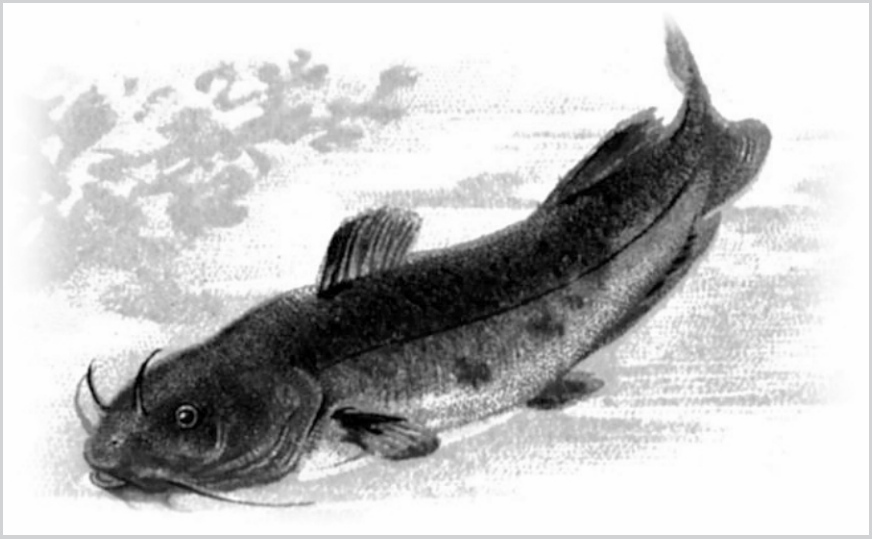
2. List the areas where your waterway scored well and where it scored poorly:

Scored Well	Scored Poorly

3. Write an analysis of you waterway's overall condition. Conclude your analysis with a paragraph about what you and your classmates can do to improve the condition of the river.

Going with the Flow

T E A C H E R P A G E S



OVERVIEW

The first step in developing your students' sensitivity and awareness of North Carolina's waterways is teaching them how they are connected to them. In this activity, your students will use maps to find their location in a river basin, learn about the river basin concept, and study how water travels from one place to another. They will also study some of the possible influences that human activity can have on water quality as the river flows from its headwaters to the ocean.

ESTIMATED TIME: 1½ hours

LEARNING OBJECTIVES

- **Science**: *Science as Inquiry*
- **Social Studies:** *Information Acquisition Skills; Group Participation Skills*
- **English Language Arts:** *Acquisition, interpretation, and application of information*

VOCABULARY

land forms, land use, river basin, waterway, runoff

MATERIALS

- County or city maps
- NC State map
- NC River Basins map
- Satellite map (optional)
- Set of magic markers or dry erase markers
- Stickers (optional)
- Pencils and paper

TEACHER PROCEDURE

1. **Drawing the map:**

   - Your students will draw a sketch on the student worksheet of their school and the nearby streams, creeks, rivers, and other water bodies. It may be helpful to walk with your students around the area that they should include on their maps. If there aren't any waterways around your school, then you could take your class to a local park with a creek or stream and have them use that area for their sketch and reference point throughout the activity.
   - Make sure your students label the parts of the map and include a key, if appropriate.
   - On their maps, students should use arrows to mark the direction water flows.
   - To mark the direction water flows from their school, have the students pick 10 points to mark on their map. They will probably need to be outside to do this.

2. **Using maps in the classroom:**

   - Break the students into small groups of 3 to 4 students. Give each group a city or county map, a watershed map, or a satellite map. Have the students complete the section using the maps as resources and then swap with another group.
   - If you do not want your students to draw on the maps, then laminate the maps and have them use dry erase markers or photocopy the sections that they need and only let them draw on the copies of the maps.

3. **Wrapping up:**

   - Discuss the path of water in your area, within the boundaries of your river basin, the major cities and towns the waterways travel past, and what type of influence these communities might have on water quality in your river basin and eventually the North Carolina's sounds and the Atlantic Ocean.

Hint: The NC Atlas and Gazetteer includes topographic maps of the entire state and is available at most convenience stores and outdoor sporting good stores. It is produced by DeLorme Press. Contact them at 800-452-5931 for more information.

JOURNAL ENTRY

- Ask your students to imagine they could travel through your river basin 250 years ago and to describe what they would see. Ask them to describe the same area 1000 years ago.

EXTENSION IDEAS

- For further discussion and research use the NC Department of Environment and Natural Resources, Office of Environmental Education's "Discover your Ecological Address" activity. This provides you with an in depth list of topics and resources with which to investigate your river basin further. For more information about this activity contact NC DENR.
- Use the special edition of Wildlife in North Carolina magazine called *The Rivers of North Carolina* to research your river basin. Students can use the magazine to focus on their river basin or all the river basins in North Carolina. They can research facts or interesting items and use them to create a "River Basin Fact Sheet" or a graphic mosaic or mural of their river basin. For more information contact the NC Wildlife Resources Commission.

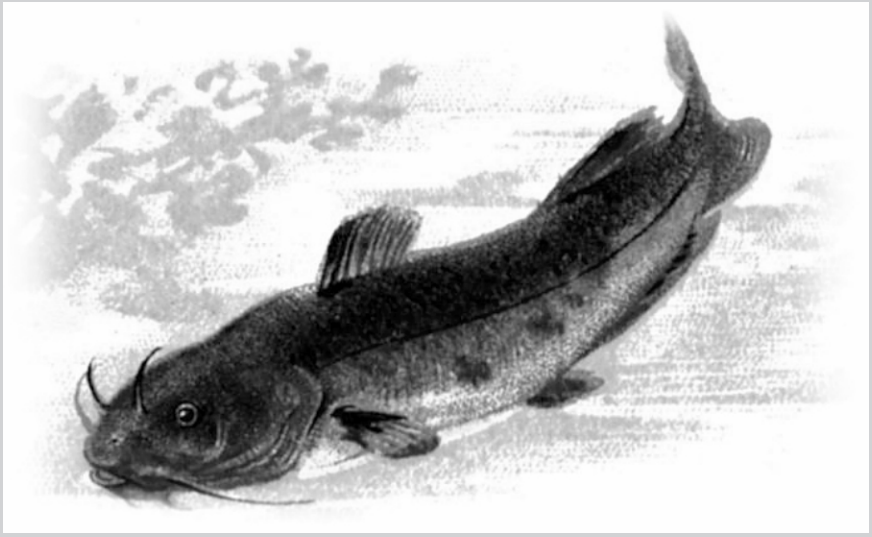
EDUCATIONAL RESOURCES

DENR
Office of Environmental Education
800-482-8724
email:
ncee@mail.enr.state.nc.us
web:
http://www.enr.state.nc.us/ENR/ee

The Rivers of North Carolina
NC Wildlife Resources Commission
1712 Mail Service Center
Raleigh, NC 27699-1712
919-733-7123

Going with the Flow

S T U D E N T P A G E S



INTRODUCTION

North Carolina is just full of water! Streams, creeks, rivers, and sounds … it seems like there is a waterway around every corner. Think about the area around your home or school – chances are, there is a little stream or creek within walking distance. However, most people never stop to think about where this flowing water has come from or where it might be going. In this activity, you will explore the concept of a river basin, which is the land and waterways that carry water into a stream, river, or sound. Because of the shape of the land (the hills and valleys, for example), researchers have figured out where all of the water in one area will go. This enabled them to draw boundaries for North Carolina's river basins. In a river basin all of the water eventually flows to the same place. You will be investigating your river basin by exploring the waterways in your neighborhood and local environment.

PROCEDURE

In this section you will find out more about your river basin.

1. First of all, let's find out what you already know about your river basin. In the space below, sketch your school and the nearby creeks, streams, rivers, ponds, and lakes. Label the different parts of your sketch and include a key if necessary.

2. If you went outside your school and dropped a bucket of water, where would it flow if it traveled along the ground? Pick 10 spots around your school, draw arrows on your sketch to show where water flows from your school.

   Your teacher will pass out maps to your small group. Your teacher will give you instructions about how to mark on your maps. Make sure to follow these instructions carefully. You will use the maps to answer the rest of the questions.

COUNTY OR CITY MAP

3. Find your school on the map and mark it on the map. You teacher will tell you how to mark it.
4. Locate the waterways near your school and record their names in the space below.

STATE MAP

5. Take a look at the North Carolina state map and find the county you live in. Find your local waterways and use a pencil to follow the path that water takes as it flows from your school, down local waterways, to join the major river in your river basin.
6. Pick at least one of your local waterways and list, in order, the other waterways it flows into as it heads to the main river.

7. Again, in order, list the towns, cities, and other areas the local waterway flows through before it gets to the main river.

RIVER BASINS MAP

8. What is the name of your river basin and its major river?

_____

9. Follow the path of the major river in your basin to the sounds. What is the name of the sound that your river flows to?

_____

SATELLITE MAP (or state map)

10. Use what you have learned so far to fill in the blanks.

    Your river basin is made up of every stream, creek, river, and land surface that brings water into the _____ River. Everything that goes down the drain or runs off the land within the entire river basin eventually makes it way into the _____ Sound. List as many different things as you can think of that could run off the land or go down the drain and end up in the water.

If you have a satellite map of a river basin, use the different land uses shown on the map to help create your list. Most satellite maps show agriculture, developed lands, wetlands, and forests using different colors or shapes – make sure you know what the colors represent on your map.

11. Of the things you listed, which do you think would be harmful to the water and its inhabitants? Beside each thing that you listed, note whether you think it would be "harmful," "neutral," or "helpful" to the water and the organisms that live in the water.

12. Return to the sketch you drew at the beginning of this activity. What things would you add to your sketch if you were trying to show how things on the land affect the water?

_____

_____

_____

_____

_____

_____

_____

_____

CHALLENGE

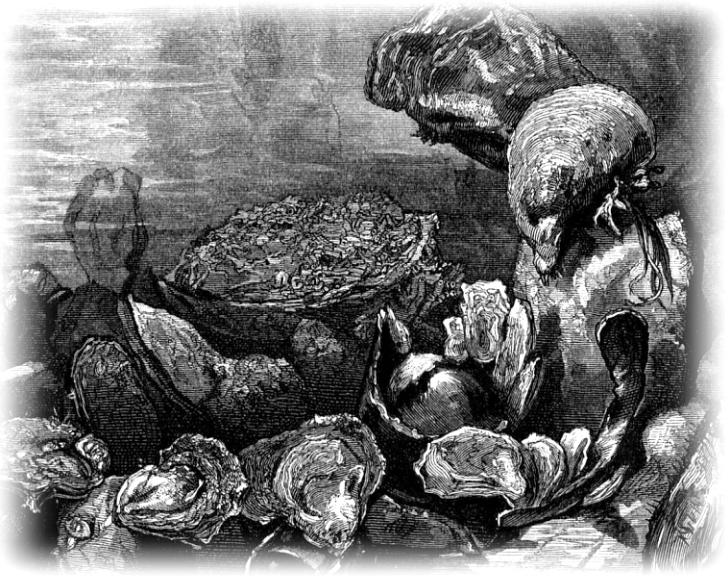
Without looking at a map, try to draw and label the waterway near your school and all of the other waterways it flows into before it reaches the sound. Try to add in the cities, towns, and land forms it flows past as it travels toward the sound. Then create a definition of a river basin to explain the concept to the rest of the class.

SECTION TWO

The Estuary and You

Oysters in a Clear Sound

T E A C H E R P A G E S



OVERVIEW

In this activity, students will create a time line that illustrates the history of the oyster in the North Carolina sounds. They will consider the importance of oysters to North Carolina through a hands-on investigation of the oyster's filtering power.

ESTIMATED TIME: 3 hours

LEARNING OBJECTIVES

- **Science**: *Nature of Science; Science as Inquiry; Science and Technology*
- **Social Studies:** *Information Acquisition Skills; Problem solving, decision-making, and planning; Group Participation Skills*
- **English Language Arts:** *Acquisition, interpretation, and application of information*
- **Mathematics:** *Measurement*

VOCABULARY

filter, habitat value, oyster bar, oyster dredge, oyster reef, oyster tongs, spat

MATERIALS

For the class:

- National Geographic video of oysters filtering (if available)
- Materials for oyster demonstration: North Carolina Oysters (at least 5), 2 aquariums (or large, clear pickle jars), sound water (or dechlorinated fresh water salted with sea salt to the appropriate salinity), mud, silt, and algae water (optional)
- "Oysters: food filter, and fish habitat" (background reading)

For each group of three students:

- Chart "North Carolina Oyster Harvest by Season" (in student pages)
- Large paper and art supplies for time line
- ***Materials for building filters***: cotton balls, gauze or cheese cloth, dried beans, rubber bands, sponges, coffee filters, straws, funnels, oil/gasoline filters, strainers, newspaper, etc.
- ***Materials for testing filters***: several tablespoons of mud, silt, and algae water (optional), long stirring rods, buckets for waste water, 1 uniform measuring device (500 ml graduated cylinder or measuring cup), fresh water
- 1 watch with a second hand

BACKGROUND

While most of us think of oysters as an hors d'oeuvre, oysters actually offer much more to the residents of North Carolina. Here's what North Carolina Sea Grant researchers had to say about oysters:

> *Growing amongst the oysters were shrimp, blue crabs, pinfish, oystertoads, sheepshead and skilletfish, schools of mullet and killifish, sponges, marine worms, sea squirts, seaweeds, and a 3½-inch spiny lobster … yet oysters do more than attract other beneficial organisms. They can reduce the amount of algae in the water. Theoretically, a single oyster can filter 25 to 50 gallons of water a day. That may not seem like much, but theorists say that enough oysters grew in the Chesapeake Bay at the turn of the century to filter the entire bay in 3 to 5 days. The number of oysters left today take almost a year to accomplish the task.* (*Coastwatch*, NC Sea Grant, Sept/Oct 1995)

The ability of oysters to perform these functions and support a commercial fishery has changed dramatically over the last 150 years. Before WWI, dredging had depleted much of North Carolina's oyster stock and flattened many of the oyster beds, removing valuable habitat for oysters and other organisms. However, the population was able to rebound during the war, because of reduced harvest pressure. Unfortunately, during WWII North Carolina's oyster population was not able to regenerate itself effectively (as it did during WWI). In fact during WWII the oyster stock continued to decline, because of disease and poor water quality. Oysters settling on the flattened beds became susceptible to suffocation by the increased sediment and nutrient pollution that accumulated on the sound floor. Some scientists believe that this exposure to pollution and sedimentation weakened the oyster's immune system, leaving it vulnerable to 2 diseases, MSX and Dermo. Both diseases kill oysters as they are reaching maturity. These diseases were particularly harmful to North Carolina's oyster stock during the late 1980's, because of hot and dry weather. The hot and dry summers of this period increased the salt content of the sounds by reducing the amount of freshwater flowing from the rivers, and allowing the onset of these diseases. As oysters – now reduced from their abundant numbers – are increasingly diminished by disease, pollution, and fishing pressure, the sound's ability to take care of itself also declines.

In this activity, students will develop a time line mapping changes in the oyster harvest over the last hundred years, which reflects changes in NC's oyster population.

They will then begin to answer the question, "Why are oysters important to North Carolina sounds?" by constructing their own filtering device and comparing its efficiency and cost to that of an oyster.

TEACHER PROCEDURE

Part I

1. Divide your students into cooperative groups of 3 for this activity. Assign each group a small section of the attached "North Carolina's Oyster Harvest By Season" to graph using markers and large paper. Be sure that each group's graph is the same size and uses the same scale, so that they can be put together to form a class time line. If you have time, each group can graph the entire time line.

2. Your students will gain a deeper understanding of the oyster's history if you have different groups research events on the time line and present their research to the class. In particular, the schism between North Carolina and Chesapeake Bay oyster harvesters at the end of the 19th century, the effects of hurricanes, and the impact of the diseases, MSX and Dermo, will give your students insight into the oyster's troubled history. For more information about oysters, refer to the Educational Resources section at the end of the Teacher's Pages.

Part II

3. In this section, your students will build filters to compete with the oyster. The oyster filtering demonstration is a vivid way to show your students the oyster's powerful ability to clean and filter water. Once you have obtained the right materials, the demonstration is not hard to set up. If you can't do the demonstration, you can show your students the video of oysters filtering or discuss the fact sheet: "Oysters: Food, Filters, Fish Habitat" instead. The important information for your students is that adult oysters can filter approximately 2 gallons of water per hour.

4. **Setting up the demonstration:**

   - Obtain live oysters from a convenient source. Often a grocery store or seafood market near you will have live oysters in good shape.
   - Fill 2 aquariums with water – ideally, water from the sound or from a river that supports oysters. If you do not have access to a body of water that supports oysters, you may use stream or dechlorinated tap water mixed with sea salt to the correct salinity for oysters. Oysters can survive in salinities ranging from 12 ppt (parts per thousand) to full salt water. Add at least 12 ml of salt for every liter of water in the aquarium. Sea salt is available at most pet and aquarium supply stores.
   - Allow your oysters to acclimate to the aquarium for 24 hours so that they will be ready to filter when you do your demonstration. Oysters can be temperamental when they have been out of their natural habitat for some time.
   - If you plan to keep your oysters in the aquarium for more than a day or so, you should set up a bubbler system to oxygenate the water and a filter to get rid of toxic ammonia. Since oysters require massive amounts of algae to survive, we suggest that you do not keep them long.

5. **Conducting the demonstration:**

   - Add your oysters to 1 aquarium; leave the other without oysters to serve as a control. Once your oysters have acclimated to the salinity, have your students add algae (if available) and/or small

amounts of dirt and silt to both aquariums until the water is cloudy. Oysters can filter sediments and algae that are suspended in the water, but they will not filter sand or clay. Keep track of how much you add so that your students can duplicate the amount for their own filtering device.

- If your oysters are healthy (and not traumatized from their move) they should filter the water crystal clear within hours of when they begin filtering. Each oyster filters, on average, 2 gallons per hour.
- To determine the rate at which oysters filter, students should begin timing when the oysters open their shells to start filtering and stop timing when the water is clear. They will compare the results to their own filters' times later.

6. **Building the filters:**

   The filter-building section of the activity is designed to be student directed, but you will need to coordinate the building and testing of the filters.

   - You may either provide, or have your students provide, the materials for the filter. Set up stations where students can build and test their filters, or conduct the experiment outside to minimize classroom mess.
   - Divide the students into equal groups, including 1 group of judges. Emphasize the guidelines in Part II.
   - Put a time limit on filter construction time and perhaps use scoring to reflect that the less time they take to build the filter the more points it is worth in this category.

7. **Judging the filters:**

   Have the judges oversee the tests, making sure each filter is tested in the same manner, and record the results on a large poster or the chalkboard.

Helpful Hints:

- There are several places where students must convert gallons to liters or liters to gallons. There are approximately 3.8 liters in a gallon; a liter is .264 of a gallon.
- The chart in Part III asks students to consider the economic and ecological advantages or disadvantages of oysters. To extend this section, you may want your students to research and calculate the cost of raising oysters versus building filters, rather than just list the possible expenses.
- If you want all of your students to participate in building filters, then ask other people from your schools to be judges or, after the filters are completed, pull 1 student from each group to be a judge.

JOURNAL ENTRY

Pose the following task to your students. Often, products are marketed through advertisements in magazines and newspapers. Based on this activity, do you think that your filtering device or the oyster is a better bargain? Create an advertisement that would persuade people to "buy into" either the oyster or your filtering device.

EXTENSION IDEAS

Have the students create a budget for filter materials. Put a price on each of the materials and give the students unlimited monies with which to buy the materials, but award points for the least expensive filter. Remind your students that oysters filter for free and ask them who they think will pay for expensive filters (taxpayers, etc.).

Both oyster larvae and adult oysters suffocate in excessive silt or sediment. For this reason, it is crucial that we preserve and build new oyster reefs and bars to provide habitat that is off the bottom and away from the silt. You can demonstrate this to your students by taping cards under each seat with different possible landing places written on each card. Suitable habitat cards can include: old oyster shells, other shells, rocks, clay, and other hard, elevated surfaces. Unsuitable habitat cards can include: muddy bottom, sandy bottom, silty bottom, mud, and muck. Tell your students that they are a bunch of free floating oyster larvae getting ready to settle on the bottom of the sound and the card under their chair tells them what they land on. Ask each student to guess whether or not he or she survives on this substrate. Have the non-survivors sit down:

- To demonstrate the effects of sedimentation, increase the proportion of unsuitable substrate over a week's time, until only a few of the "larvae" land on hard substrate and survive.

EDUCATIONAL RESOURCES

"The Eastern Oyster"
North Carolina Sea Grant

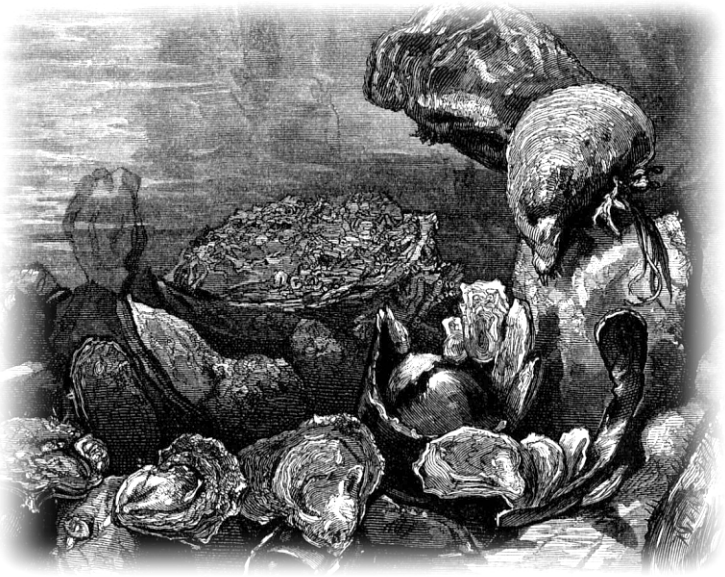
"The Life of the Seashore"
(Our Living World of Nature)

National Shellfish Association
www.shellfish.org

Bridge Teacher Resource Center
www.vims.edu/bridge/molluscs.html

Oysters in a Clear Sound

STUDENT PAGES



INTRODUCTION

What aquatic species has been worth its weight in gold in North Carolina?
What aquatic species provides a home for many other creatures?
What aquatic species eats dirt and hangs out in bars?

If you guessed the oyster, you are absolutely right! Beneath the drab and lumpy shell of the oyster lies a very colorful history. In addition to its popularity as a tasty meal and its economic importance to North Carolina's commercial fishery, the oyster has helped to keep the sounds and estuaries clean and to provide a place for many North Carolina species to find shelter, food, and hiding spots. In this activity you will answer two questions: "What has happened to the oyster?" and "What does the oyster's scarcity mean for North Carolina sounds?" To answer these questions, you will develop a time line showing the oyster's history, investigate the oyster's ability to filter, and compare your own filtering device to the filtering ability of the oyster.

MATERIALS:

Your group will need:

- Chart: "North Carolina's Oyster Harvest by Season" (attached)
- 1 sheet of large paper and art supplies (magic markers or crayons)
- Materials for building filters (collect from your teacher)
- Materials for testing filters (collect from your teacher)
- A watch with a second hand

PROCEDURE

Part I

What has happened to the oyster during the past one hundred years? Investigate the colorful history of the North Carolina oyster to answer this question!

1. In your small group, use the data from "North Carolina Oyster Harvest by Season" to draw a line graph representing one part (assigned by your teacher) of North Carolina's oyster harvest between 1887 and 1997. Each group's graph will be connected to form a complete time line, so make sure you are using the correct size and scale for your graph.
2. What conclusions can you draw from your class' time line about the history of North Carolina's oyster harvest?

_____

_____

_____

_____

_____

3. The following list describes some of the events and regulations that have had an impact on oysters during the past 100 years. Plot these events on your class time line.
    - **1891:** North Carolinians requested state assistance to prevent Chesapeake Bay fishers from dredging and harvesting NC oysters.
    - **1903:** Fishing pressure, disease, and diminished water quality contributed to an overall decline of the fishery.
    - **1907:** Those involved in the oyster industry formed the Oyster Growers and Dealers Association of North America, which is now called the Shellfish Institute of North America.
    - **1909:** NC dredging area was greatly reduced and only dredging by sail boat was allowed.
    - **1918:** WWI allowed regrowth of oyster populations in NC. As a result dredging areas were re-opened.
    - **1931:** Power-dredging began in NC.

- **1944:** WWII allowed regrowth for about 20 years because of harvest restrictions. But as a result of disease and poor water quality the oyster stock was not replenished, as it was during WWI.
- **1954:** Hurricane Hazel (Category 4) decreased the oyster harvest for several seasons.
- **1987-1988:** Red Tides caused the fisheries to be closed in NC, but it did not harm the oyster stock.
- **1988:** The diseases MSX and Dermo, which are found in NC coastal waters, were particularly harmful during the late 1980s because of the hot and dry weather.
- **1996:** Hurricanes Bertha and Fran washed large of amounts of organic debris into the sounds. The organic debris absorbed much of the oxygen needed by shell fish. Furthermore, the winds and high tides pushed many young larvae oysters into unsuitable habitats.
- **1988 to present:** Oyster harvests in NC have decreased almost every year since 1988.

4. Choose 2 of the events plotted on your class time line and explain how each has affected the oyster harvest. Support your explanations with evidence from the data and other things you have learned about oysters or shellfish harvest.

   a)

   b)

5. List the possible consequences of the current trend that your time line shows. Who and what might be affected by the scarcity of oysters in North Carolina's coastal waters?

Part II

In this section, you will attempt to out-filter the oyster with your own filtering device!

6. One of the most important functions of the oyster is its ability to filter sediments and pollutants out of the water. Your teacher will either conduct a filtering demonstration using

live oysters or will show you a video of oysters filtering dirty water. Start timing when the oysters open their shells and stop timing when the water is clear. Record the time it takes for the oysters to filter the water, and then determine their filtering rate.

Amount of water in the tank: _____

Time to completely filter the tank: _____

Rate that oysters filtered tank: _____ liters/hour

7. While your oysters filter their aquarium water, your group will build the best filtering device possible using the materials provided by your teacher. The filtering ability of your device will be compared to the oyster in terms of effectiveness (how clean it makes the water) and speed. You can build your machine in whatever way you think is best, but you must follow the guidelines listed below:
   - You must draw a plan or "blueprint" of your device before you begin to build it.
   - Your device must have a name.
   - Your device must be designed to clean dirty water that is poured through it as quickly and efficiently as possible.
   - The water must flow through your filter into a container which will hold all of the water and not allow the water to spill onto the table.
   - Your device does not need to use all of the materials provided.
   - You must test your device before the final exhibition.
8. When you are finished building your device mix a cup of water and a tablespoon of dirt. Pour this mixture through your filter. You will use this same mixture when your filter is judged.
9. Your group will pour the dirty water mixture over your filtering device into a container. You will have 1 minute to filter as much of the water as possible.
10. Consider what is more important: to filter as quickly or as effectively as possible. When you are finished building and testing your filter, answer the following questions:

    a) How much water did your device filter in 1 minute?

    b) Describe the clarity (clearness) of your water.

    Explain why your device did or didn't filter well.

c) An oyster can filter approximately 2 gallons (7.6 liters, or 7600 ml) of water per hour. Compare the rate that your device filters water to the rate that an oyster filters water.

d) Remember that oysters grow in bars, with lots of oysters living close together. So think about how much an entire bar could filter. Now think about how much water fills North Carolina's sounds. How much would a device that could filter all of North Carolina's sounds cost?

Part III

Use what you have learned from the first 2 sections of this activity to compare your filtering device to the oyster.

11. Fill in the chart below to compare an oyster and your filtering device.

	YOUR FILTERING DEVICE	THE OYSTER
RATE How long does it take to filter 2 gallons (7.6 liters) of water?		The oyster can filter approximately 2 gal. of water in an hour.
FUEL What is needed to power the filter (fuel, man power, habitat)?		
MAINTENANCE How often does it need to be cleaned or have its parts changed? Can it be used again and again?		
EXPENSE What costs would you need to think about if you wanted to use the filter in NC sounds and estuaries?		
BENEFITS What other purposes can the filter or the oyster serve?		

12. Many people around the state think that the oyster is the ultimate filtering device! After watching oysters filter and building your own filtering device, explain why you agree or disagree.

13. Even though oysters still face many problems, people around North Carolina coastal waters are finding ways to help bring oysters back to their former abundance by restoring oyster reefs and raising oysters in hatcheries and oyster gardens. Turn back to the time line that you constructed in Part I of this activity and add the years 1997 - 2000. Considering the efforts to restore oysters, but also the problems that oysters continue to face, draw an extension to the time line that predicts oyster levels until the year 2000. If your class has chosen to do an oyster project, add it to your time line as well.

14. Explain the extension you drew on your time line using your knowledge of the oyster's history. If your prediction shows a rise in the oyster population, explain what brought about the increase. If your prediction shows a further decline in oysters, explain what brought about the decrease. What would happen to oysters, fisherperson, and NC coastal waters if your prediction came true?

NORTH CAROLINA
OYSTER HARVEST BY SEASON

SEASON	POUNDS HARVESTED
1887	1,175,650
1888	1,129,980
1889	5,528,942
1890	4,458,075
1897	4,470,650
1902	5,645,928
1908	4,159,320
1910	1,834,058
1918	1,197,630
1923	3,089,146
1927	2,397,750
1928	2,286,610
1930	2,205,674
1931	1,500,571
1932	1,201,356
1934	1,160,700
1936	2,480,500
1937	1,940,900
1938	1,426,900
1939	1,055,600
1940	690,400
1945	1,707,100
1950	1,322,100
1951	1,531,900
1952	1,620,900
1953	1,525,300
1954	1,008,400
1955	731,000
1956	1,318,000
1957	1,086,500
1958	1,041,500
1959	1,311,000
1960	1,216,200
1961	1,209,100
1962	961,400

SEASON	POUNDS HARVESTED
1963	694,000
1964	727,700
1965	863,700
1966	726,209
1967	518,514
1968	402,959
1969	369,928
1970	381,978
1971	423,675
1972	470,112
1973	548,351
1974	558,821
1975	424,831
1976	333,315
1977	365,714
1978	449,544
1979	665,439
1980	723,099
1981	650,502
1982	611,998
1983	724,509
1984	724,557
1985	545,439
1986	745,548
1987	1,425,584
1988	913,100
1989	529,858
1990	328,850
1991	319,040
1992	293,956
1993	223,993
1994	197,905
1995	232,498
1996	219,411
1997	248,959

SPECIAL INSTRUCTIONS FOR THE STUDENT JUDGING COMMITTEE

1. Please pay attention to the directions. You can help to make this activity run smoothly.
2. Decide how you will score the filters by choosing 3 scoring areas. Possible score areas can include:
    - The clarity (clearness and cleanliness) of the water
    - The speed of the filter
    - How long it takes to create the filter
    - How few people are needed to make the filter work (not actually design and build the filter).
    - The cost of the filter
    - You can score by using points for each of the items either making points desired or not wanted.
3. You will be responsible for mixing and measuring the dirt and water for each filter during the trial run and the run that you will judge. You should use 1 cup of water and 1 tablespoon of dirt for each group. Mix new batches of muddy water for each group, otherwise the last group will probably end up with more dirt.
4. Create a chart on a large piece of paper or board (chalk or dry erase) that lists each filter and the 3 scoring areas that you have chosen.
5. Ask your teacher to help you assemble the tools you will need to test the filters:
    - A jug of water
    - A bag of dirt
    - A measuring device (cup or graduated cylinder and a set of tablespoons)
    - A stop watch
6. Instruct the groups to bring their filters to a central testing location.
7. Explain the scoring process to the participants of the competition.
8. Test and score each filter. Write the results on the chart. When all the results are recorded discuss the outcome and select a winner.

When Rain Hits the Land

T E A C H E R P A G E S

OVERVIEW

Students will do an experiment to determine how land surfaces affect the flow of rainwater as it travels through the river basin. Then they will consider how the surfaces in their schoolyard affect the flow of rainwater.

ESTIMATED TIME: 3 - 3 ½ hours

LEARNING OBJECTIVES

- **Science:** *Nature of Science; Science as Inquiry*
- **Social Studies:** *Information Acquisition Skills; Problem Solving*
- **Mathematics**: *Measurement; Geometry; Data*
- **English Language Arts**: *Acquisition, Interpretation, Application of Information; Critical Analysis and Evaluation*

VOCABULARY

erode/erosion, experimental control, experimental trial, groundwater, impervious, land use, percolation, pollutant, runoff

MATERIALS:

For each group of 4-5:

Part I:

- protractor
- ruler
- 2 gallon cardboard milk carton with one long side removed (see diagram)
- plastic cup with small holes in the bottom
- dirt (3 cups)
- sod (3" x 6" strip)
- grass or straw
- gravel (3 cups)
- sand (3 cups)
- pitcher or empty jug for pouring water
- pan or bucket for catching water
- stop watch
- containers of water or access to a sink

Part II:

- metal can (or other sturdy cylinder) with two open ends
- pitcher or empty jug for pouring water
- stop watch or clock with a second hand

Part III:

- sheet of large paper or posterboard
- markers, pens, crayons
- other art supplies, as needed

BACKGROUND

When rain hits the land, it either flows over the surface of the land or it is absorbed by the land. Whether rain becomes groundwater or runoff, depends on the type of land it encounters.

- Runoff forms when rainwater falls on *impervious* surfaces, which cannot absorb water. Impervious surfaces include concrete, asphalt, rooftops, and even compacted soil. As it travels over these smooth hard surfaces, runoff will pick up speed unless it encounters some type of resistance (i.e. vegetation or loose soil). The type of land surface and the slope of the land determines the volume and the rate of runoff. Flowing towards waterways, runoff can erode land and pick up pollutants, such as oil and fertilizers. The faster the runoff and the greater its volume, the more pollutants it can carry to the rivers and sounds, and the more flooding and erosion can occur.
- In contrast, groundwater forms when rainwater falls on healthy soil or vegetated areas and is able to seep into the soil. In this case, water is absorbed and slowed, minimizing erosion, filtering out pollutants, and preventing flooding. Groundwater eventually seeps into our precious supply of drinking water and keeps streams and rivers flowing.

TEACHER PROCEDURE

Part I:

1. **Collecting materials:**
   - This experiment requires a fairly large quantity of materials. Most of these materials are inexpensive and may be collected at home. You may wish to distribute a list of materials to students a week in advance and instruct them to gather their own materials. It is probably easiest if you purchase the gravel and sod at your local hardware store or garden center.
   - The water will be added to the experiment by pouring it through a plastic cup with holes in the bottom. You should poke about 6 holes in the bottom of each cup, so that each group will have the same set-up and the students do not have to try to poke through the cup.
2. **Designing and Setting up the Experiment:**
   - Question 4 asks students to think about their experimental controls. Make sure that your students

understand experimental controls. For the purposes of this experiment, the only thing that should change from trial to trial is the type of material being tested. Everything else should be considered experimental controls and remain constant.

- Examples of the controls for this experiment include: how much of the material being tested is added, when they will start and stop the timer, where the water is added (do they move the cup around or hold it in one place until it is empty).Decide as a class or tell the students how much water to add. Every group should add the same amount of water for every trial, so that their results can be compared. Have students fill in the blank and complete the Amount of water added column on the "Runoff Data Table."
- Step 7 of the student procedure asks groups to choose an angle at which to incline the carton. You may want to assign each group a different angle, so the class can compare their results. Students will need to use a protractor to measure the angle between the level plane of the desk and the bottom edge of the milk carton.
- Questions 8 and 9 ask students to predict their results and step 10 asks for a write-up of the experimental procedure. Consider assigning these steps as homework or class work before the day of the actual experiment, if time is limited.
- Step 14 instructs students to graph the results of their experiment. If graphing is not something that they are familiar with, you may want to determine the axis and the type of graph students use. This is a good opportunity to involve the math teacher!
- To compare each group's results, create an overhead or poster with a data table containing each type of material and angle used. Also, to allow students to compare the results of their "Final-Set up" create another overhead or poster to record their results. Example of these tables can be found at the end of the Teacher's Pages.

Part II:

3. This part of the activity provides a very simple way to solidify concepts illustrated by the experiment in **Part I** by trying them out in the real world. You will need to take your students outside to explore their schoolyard. Before going outside check each group's data table and experimental controls list.
4. Allow a specified amount of time for groups to conduct a percolation (also known as a "perc") test on each of the land surfaces they have chosen. This involves pouring a specified amount of water onto various surfaces and recording the amount of time it takes for all of the water to soak into the ground each time. As noted in the Student Pages, if the water has not soaked in after 5 minutes, the surface is considered impervious. Therefore, 5 minutes might be a good time limit for each surface.

Do not allow your students to press down on cans that have sharp edges. Carefully select the cans and have them use work gloves or folded towels to push down on the cans.

5. Students can add the results of their perc tests to the schoolyard maps that they will make in **Part III**.

Part III:

6. In this part students will map land use around the school. They might like to share their maps with another class or display them on a bulletin board so that others can see what they've learned about their surroundings.

JOURNAL ENTRY

- Ask your students to imagine the whole state of North Carolina, if the streams, creeks, and rivers have been paved with concrete. Then write a paragraph or two describing what would happen to these waterways when it rained.
- The next time it rains in your neighborhood, ask your students to take a walk or look outside your window and notice what's happening on the ground. Ask them to write a description of where you see the water flowing (and how fast) in streets, sidewalks, streams, gutters, and yards. Ask them to list reasons for the things that are happening as rain hits various land surfaces.

EXTENSION IDEAS

- A perc test can be done anywhere quite easily. Another way to extend this activity is to ask students to conduct a test of their own backyards or neighborhoods and report their findings to the class.
- A nice way to follow up this activity is to create a flyer or presentation to teach other students and/or family members about schoolyard land use. Students might focus on how the area affects runoff, making suggestions for improvement or drawing positive attention to an effective design.

EDUCATIONAL RESOURCES

DENR - Office of Environmental Education
800-482-8724
email:
ncee@mail.enr.state.nc.us
web:
www.enr.state.nc.us.ENR.ee

Division of Soil and Water Conservation
PO Box 27687
Raleigh, NC 27611
919-733-2302

Sample Data Tables

Example of a Class Results Data Table *

	10 Degrees		20 Degrees		30 Degrees		40 Degrees	
Grass								
Dirt								
Sand								
Sod								
Gravel								

Have students record their speed in one half of the column and the amount of water collected in the other half.

Example of a Final Set-up Results Data Table

Three materials added	Speed	Amount of water collected

When Rain Hits the Land

S T U D E N T P A G E S

INTRODUCTION

Think about what happens when rain hits the land. Imagine a rainstorm in a forest – the plants, trees, leaves, and soil soak up the water. Water that is absorbed by the soil becomes part of our groundwater supply and eventually our rivers. These two sources supply much of the water that comes from the faucets in our homes and schools. Now imagine the same rain falling on a road or parking lot. These surfaces are solid, so water either sits in puddles and evaporates or flows to a place it can be absorbed or a waterway. As water travels, it can erode soil and pick up pollutants. Erosion happens when water washes away soil. Water can easily erode soil that is not protected by the roots of plants and trees. The amount of erosion or pollution picked up by the runoff depends on how much rain has fallen or the speed of the runoff. What makes water flow across a surface faster? You will work with your group to answer this question by testing several land surfaces and carefully recording your observations.

MATERIALS:

For each group of 4-5 students:

Part I:

- Protractor
- Sod
- Sand
- Ruler
- Grass
- Dirt
- Gravel
- Stop watch
- Pan or bucket to catch water
- Cardboard milk carton with one long side removed
- Plastic cup with small holes in the bottom
- Measuring cup or graduated cylinder for pouring water
- Runoff Data Chart

Part II:

- Metal can or sturdy cylinder with two open ends
- Pitcher or empty jug for pouring water
- Stop watch
- Paper and pencils

Part III:

- Sheet of large paper or posterboard
- Markers, pens, and crayons
- Other art supplies, as needed

PROCEDURE

Part I:

In this section you will design and run an experiment to find out how different land surfaces affect the runoff rate and amount of runoff when water hits that surface.

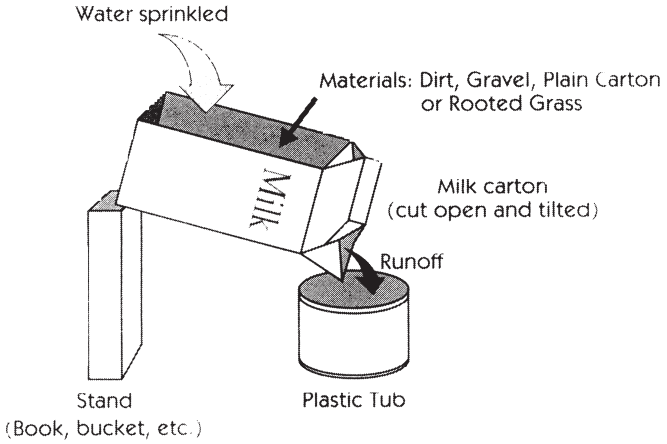
1. Read the introduction to this activity. Explain how a stream near a paved area might be affected by a rainstorm.

2. What would you expect to be different if the stream were near a forest like the one described in the introduction?

3. Your group will be designing an experiment to test what happens when water falls on different surfaces. Write down five different types of surfaces rain could fall on. Mowed lawn would be a good example.

Things to Know for the Experiment:

You will set up your experiment using the diagram below as a model. Study the model to get ready for your experiment.



- To test different surfaces you will fill the milk carton with three different materials. Each time you test a different surface, it is known as an experimental trial. (To help remember this term, you are trying to figure out what happens with different materials in each trial.) The materials you use in each trial will represent things that rain could really fall on. For example, if your group uses sand you could be representing rain falling on a beach.
- The goal of each trial is to figure out how much water runs off a surface and how long it takes for the water to run off. Therefore, you will catch your runoff and time it for each trial.
- After you fill the milk carton, you will create a mini rainstorm with a plastic cup with holes poked into the bottom. To be able to compare everyone's results, every group will need to add the same amount of water. You will add _____ of water for each trial (Remember units!). Fill in this amount on the Runoff Data Table under the Amount of Water Added column.
- Because you will be using three different surfaces, the type of material you use should be the only thing you change each time. Everything that you do the same way for each trail is called an experimental control.

4. Make a complete list of your experimental controls.

5. All groups will run their first trial on the plain surface of the milk carton. What land surface do you think the bare carton represents?

_____

_____

6. Your group will test three other materials. Pick three materials from the list below and record them on the Runoff Data Table.

Dirt Grass Sand Sod Gravel

7. The speed of runoff is determined by the type of surface AND the slope of the land it flows over. Therefore, each group in your class will set up their experiment with their carton at a different angle to represent different slopes of the land. Write down which angle you will use in every experiment. (Your teacher will either give you a range to choose from or assign you a specific angle.)

_____

Note: Because you will use the same angle in every trial, this will be one of your controls!!

8. Predict how your angle will affect the results of your experiment.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

9. Before running your experiment, predict which of your testing materials will produce the fastest and most runoff.
    - Rank the materials from 1 (fastest/most runoff) to 4 (slowest/least runoff).
    - Give a brief explanation for your answer in the column labeled "Why?"
    - Don't forget the plain surface of your milk carton as one of the materials.
    - Record the rank for each material in the Runoff Data Table.

MATERIAL	WHY?
1.	
2.	
3.	
4.	

PREPARING FOR THE EXPERIMENT:

Each person in your group will be responsible for a certain job in the experiment. Use the descriptions below to decide who will be in charge of each job. Write that person's name next to their job.

JOB TITLE	DUTIES	NAME
Water Manager	Measures water quantities; Sprinkles water for each trial; Disposes of wastewater as instructed.	
Timekeeper/Recorder	Times each trial; Records all data in the chart; Makes sure the group finishes the activity on time.	
Materials Manager	Organizes all materials; Places materials in the milk carton each time; Cleans the carton after each trial; Returns all of the materials after use.	
Quality Control	Makes sure the procedures are followed correctly; Makes sure everyone has a chance to speak; Makes sure everyone understands.	
Clean-up Crew	Washes materials, desktops, and floor area; Returns all materials to the right place.	EVERYBODY, assign each group member a clean-up job!!

10. Use the information from the previous steps and questions to write a plan for conducting your experiment. Write out a step by step plan for your experiment on a separate piece of paper and check it with your teacher when you are finished. Remember to include:

    - How you will keep the angle you are testing the same for each experiment.
    - When you will start and stop the stop watch.
    - How much water you will use.
    - How much of each material you will use.

    Conduct your experiment following your group's plan. Record all data in the Runoff Data Table below:

RUNOFF DATA TABLE

MATERIAL	PREDICTED RANK	AMOUNT OF WATER ADDED	AMOUNT OF WATER COLLECTED	TIME (for runoff to slow to one drop every 3 seconds)	OBSERVATIONS
FINAL SET-UP					

11. Once you have finished your experiment, use the results from each trial to mix materials in an attempt to make the slowest and least possible runoff.

    - **You must follow two new rules:**

        1. You must tilt your carton at a 20 degree angle.
        2. You may only fill you carton a total of 3 cm full with materials. List the materials you will use in the Runoff Data Table under Final Set-up.

    - Keep all of the other experimental controls.
    - Record your results.
    - You will record your results on a poster or overhead.

12. Compare your results with other groups.

    For each angle, which material resulted in the least amount of runoff? In other words, which material absorbed the most water?

    _____

    Which angle resulted in the most runoff?

    _____

    What was the best combination for slowing and reducing runoff? Which group had the slowest time and least amount of runoff?

    _____

13. Look back at your predictions that you made for each material. How accurate were your predictions? How did your predictions differ from actual results?

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    _____

14. On your own, use graph paper to create a graph that shows how different materials affect the speed and amount of runoff. Be sure to label all parts of your graph.

15. Give examples of land surfaces in your schoolyard that could be represented by the materials you tested.

16. a) Based on what you learned about land surfaces in your experiment, which land surface around your schoolyard would have the most or fastest runoff after a rainstorm?

    b) Which land surface around your school would have the least or slowest runoff after a rainstorm?

Part II:

Now that you have learned more about runoff, you will get to test surfaces around your school. Complete steps 17 through 20 before you go outside, so that you will be ready for the experiment.

You will be conducting a percolation test (also called a "perc" test) in this activity. Some hints for a successful experiment include:

- You will push a metal can into the ground. Be careful not to push down on sharp edges!! The bottom of the can should be far enough into the ground, so that water can not escape.
- You will record the amount of time it takes for water to soak into the ground. If after 5 minutes the water has not soaked into the ground, it is considered an impervious or compacted surface.
- Before your group goes outside, decide who will be responsible for the following tasks: timing the experiment, recording the data, pushing the can into the ground, pouring the water, and observing the water as it soaks in, and letting the timer know when to stop and start the experiment.

17. List your experimental controls for this experiment.

18. How much water will you pour at each location?

_____

19. When will you start and stop the timer?

_____

_____

20. You will create your own data chart for this experiment. On a separate piece of paper, create a data chart to record the land surfaces and the time that each one takes to absorb the water. Refer to the Runoff Data Table if you need some ideas for creating a data table.
    - You are ready to go outside and test four surfaces around your school. Record your results on your data table. Describe the type of surface you are testing carefully.
21. Summarize the results of your "perc" test. Which surfaces soaked up water quickly? Which surfaces did not absorb water?

_____

_____

_____

_____

Part III:

In this section, you will examine the different types of land uses around your school. We define land use as the land and whatever is on it, man-made or natural. Examples of land uses include agriculture or wetlands.

22. With your group, decide how you will show different land uses on your map. On another piece of paper, create a key for your map that makes it easy to identify the different land surfaces you will be marking. A good key will make your map easy to understand!!
23. On a large piece of paper, draw your school yard. Mark off sections of different land uses. Include a space for your key.

FINAL ANALYSIS

List the different land uses that you found in your school yard. Decide whether water would more likely "runoff" or "soak in" when it hits the surface, and check the box under the appropriate column.

LAND USE	RUNOFF	SOAK IN

In general, do you think your schoolyard is good at soaking up runoff or not? That is, are most surfaces able to absorb water or are there a lot of solid surfaces surrounding your school?

Schoolyard Report Card

T E A C H E R P A G E S

OVERVIEW

In this activity your students will evaluate the condition of their schoolyard by using their observation skills and what they have learned in previous activities. The assessment consists of a series of questions and observations that will allow your class to grade their schoolyard environment.

ESTIMATED TIME: 1 hour

LEARNING OBJECTIVES

- **Social Studies**: *Information Acquisition Skills; Intrapersonal Skills; Group Participation Skills*
- **English Language Arts:** *Critical Analysis and Evaluation*

VOCABULARY

biodiversity, downspout, erosion, faucet aerators, impervious surfaces, diversion block, runoff, toilet dams

MATERIALS:

For each group of 4:

- A copy of *Schoolyard Report Card*
- Pencils and scrap paper

BACKGROUND

Learning about the environment doesn't have to mean traveling far away into mountains or to the coast. Quite often, there is much to discover in your very own backyard. The great thing about studying things close to home is that if the problems are close to your home, you and your students may be able to help solve them. This activity focuses on the environment immediately surrounding your school. By examining the set-up of the school and the landscape around the school, your students will begin to identify problems and develop solutions to reduce the environmental impact of their school.

TEACHER PROCEDURE

1. Students will once again work in small groups. Before they go outside, you will want to define boundaries around the school.
2. Some of the questions require students to talk with school employees (a principal or maintenance person, for example). Decide ahead of time when the appropriate time will be for students to locate this person and/or send 1 person from each group. Or, you may choose to invite these "consultants" to come to your classroom.
3. Upon completion of this assessment, students are asked to brainstorm ways to improve things that lowered the score of their schoolyard. Consider a full class brainstorm session once they have had time for small group discussions. If you are going to do a schoolyard restoration/ habitat project, this will be a good time to get students involved and excited from start to finish!
4. If you need to adjust the grading scale because a number of questions were not applicable, try using a percentage to total the points, or reduce the total score possible by 5 points for each N/A response. Then adjust the grading scale accordingly.
5. For the Final Analysis, students are asked to complete the "Problems and Solutions Chart" use the chart on the following page for examples or to begin a class brainstorming session.

JOURNAL ENTRY

- Ask students to design the ideal schoolyard. Encourage them to take into account what they've learned about a healthy environment. Things to think about include: biodiversity, habitat, runoff, water quality, and recreational or educational values. Either write a description of an ideal schoolyard or draw a picture.

EXTENSION IDEAS

- Use *Schoolyard Report Card* as a guide to create an evaluation of the area immediately surrounding your house or apartment building. Are there things that you can do in your own yard or neighborhood to reduce runoff, conserve water, or make other improvements?
- When you have determined what things around your schoolyard might be changed to make environmental improvements, design and build a model of the ideal school and surrounding yard. Your model can be as creative as you like, but it must be practical. For example, unless you plan to create an alternative mode of transportation for teachers and students at your Ideal Academy, you must plan on parking for at least *some* cars and buses. Try to make your model as environmentally friendly as possible, by re-using "trash" to represent parts of the Ideal Academy.

EDUCATIONAL RESOURCES

National Resources Defense Council
50 Simple Things
40 West 20th Street
New York, NY 10011
For titles including:
50 Simple Things Kids Can Do to Save the Earth
and *50 Simple Things Kids Can Do to Recycle*

Backyard Wildlife Habitat Programs
National Wildlife Federation
8925 Leesburg Pike
Vienna, VA 22184-0001

PROBLEMS & SOLUTIONS

(Sample Student Responses)

PROBLEM		POSSIBLE SOLUTIONS
Paved Surfaces	→	Slow runoff from paved surfaces by planting vegetation between the pavement and a body of water or drainage site.
Runoff	→	Paint storm drains to educate, plant vegetation, create buffer zones.
Driving Cars	→	Car-pooling, biking, walking, and public transportation plans or campaigns.
Using too much water	→	Install water-saving devices, develop conservation programs, and a way to educate others on water-saving methods.
Fertilizers	→	Conduct soil tests and advocate proper fertilizer use in the schoolyard or on community lawns.
Sediment	→	Identify specific problems in the schoolyard, possibly plant vegetation (depending on source of sediment).
Nutrients	→	Problem too broad. Specify the source of the problem.
Erosion	→	Plant trees, shrubs, over bare patches of soil with vegetation, gravel, or mulch.
Lack of Knowledge	→	Educate through campaigns, bike weeks, letters, presentation, cross-age teaching, and providing models.

Schoolyard Report Card

S T U D E N T P A G E S

INTRODUCTION

You've learned quite a lot about runoff, groundwater, erosion, and many other factors that affect water quality. In fact, you could probably already say a lot about the environmental quality of your own schoolyard! This activity will give you a chance to grade your schoolyard. You will go outside with your classmates and answer the questions in this activity, based on what you see around your school. You might find some things that need improvement and then get a chance to work with your school's teachers and staff to a plan project that would help your schoolyard and your local waterways.

MATERIALS:

Your group will need:

- A copy of *Schoolyard Report Card*
- Pencils and scrap paper

PROCEDURE

1. Before you go outside, assign someone in your group to record your answers on the report card.
2. Your teacher will set boundaries for you. Stay within them!
3. If you decide that a question is not relevant to your school, circle the N/A (not applicable) option and explain why the question doesn't make sense for your schoolyard.
4. Some of the questions may require you to talk with school staff members (someone in the maintenance department, for example). Be sure to get permission from your teacher to do this and plan a way to meet with these people.
5. Go to it!

THE SCHOOLYARD REPORT CARD

Section 1: Runoff and Erosion

1. What type of surface receives the water from your school's roof downspouts?

   a) a patch of rocks or concrete diversion block on top of vegetation or mulch — 10 points
   b) directly onto mulch or vegetation — 7 points
   c) pavement or ground that is eroding — 3 points
   d) onto the ground, near a waterway without a buffer — 0 points
   e) N/A _____

2. Looking at your schoolyard, estimate what percentage of the ground contains land surfaces that are impervious, which means they cannot absorb water. Concrete is an example of an impervious surface.

   a) less than 10% — 10 points
   b) between 10% and 25% — 5 points
   c) greater than 25% — 0 points
   d) N/A _____

3. Pathways and heavily trafficked areas where vegetation cannot grow are:

   a) covered with a surface that can filter or absorb (like wood chips) — 10 points
   b) covered with an impervious surface such as cement or asphalt — 5 points
   c) bare, exposed soil — 0 points
   d) N/A _____

4. Look for patches of bare soil and signs of erosion, like areas where rainwater has carved out ditches or soil has splashed onto windows or walls. The schoolyard has:

   a) very little erosion and few patches of bare soil — 10 points
   b) several patches of bare soil or areas where soil is eroding — 5 points
   c) large patches of bare soil and extension erosion — 0 points
   d) N/A _____

Section 2: Vegetation

1. How much of the grass and vegetated areas in your school are regularly mowed?

   a) less than 50% — 10 points
   b) between 50% and 80% — 5 points
   c) over 80% — 0 points
   d) N/A _____

2. The land surrounding places where water drains and collects such as storm drains, drainage ditches, and streams are:

   a) well vegetated with trees and shrubs — 10 points
   b) vegetated with unmowed grass — 7 points
   c) mowed grass — 3 points
   d) bare soil, pavement, or concrete — 0 points
   e) N/A _____

3. Ask your school's lawn service or school maintenance staff how the mowed grass on the school's grounds are fertilized.

   a) grass clippings are left on the grounds as natural fertilizer — 10 points
   b) lawn fertilizers are used according to a formula derived from soil tests — 7 points
   c) lawn fertilizers are used according to instructions — 3 points
   d) lawn fertilizers are applied randomly — 0 points
   e) N/A _____

4. Generally, how well is the schoolyard vegetated with trees and bushes?

   a) trees and bushes cover a significant part of the schoolyard — 10 points
   b) trees and bushes dot the landscape of the schoolyard — 5 points
   c) there are few or no trees on the schoolyard — 0 points
   d) N/A _____

Section 3: Education

1. How many storm drains are labeled,"Don't Dump, Drains to a Local Waterway" to let people know that substances that go into the storm drain end up in local waterways?

   a) all storm drains are labeled — 10 points
   b) a few storm drains are labeled — 5 points
   c) no storm drains are labeled — 0 points
   d) N/A _____

2. How many different ways are there at your school to learn about local water quality or the environment? (Different ways to educate might include posters, literature, classes, clubs, plays, assemblies, etc.)

   a) 3 or more — 10 points
   b) 1 or 2 — 5 points
   c) no education about the environment — 0 points
   d) N/A _____

3. Look for candy wrappers, soda cans, and other litter in the schoolyard that could wash into storm drains or streams when it rains.

   a) there is no litter in the schoolyard — 10 points
   b) some litter — 5 points
   c) a lot of litter — 0 points
   d) N/A _____

Section 4: Transportation

1. Determine the number of people employed at your school (teachers, maintenance staff, food service staff, administrators, etc.) by asking your principal or looking in a yearbook. Look at the school parking lot and determine the number of vehicles relative to the number of employees.

   a) there are 50% fewer cars in the parking lot than employees — 10 points
   b) there are 25% fewer cars in the parking lot than employees — 5 points
   c) there is about one car per employee in the parking lot — 0 points
   d) N/A _____

2. Are there bicycle racks at your school and do people use them?

   a) bike rack is full of bikes — 10 points
   b) school has a bike rack but there are very few bikes in it — 5 points
   c) school has no bike rack and there are no bikes in the schoolyard — 0 points
   d) N/A _____

3. Is there any reward or encouragement for teachers or students who walk to school, ride their bikes, carpool, or take public transportation?

   a) yes — 10 points
   b) no — 0 points
   c) N/A _____

Section 5: Water Conservation

1. Does your school use any water-saving devices such as faucet aerators, toilet dams, low-flow showerheads, or garden hose nozzles?

   a) The school uses 2 or more different types of water-saving devices — 10 points
   b) The school uses 1 type — 5 points
   c) There are no water-saving devices — 0 points
   d) N/A _____

Survey at least 10 people about their water conservation practices at home.

2. Find out how many people have installed water-saving devices in their homes. At least half of these people have installed:

   a) 2 or more water-saving devices at their residence — 10 points
   b) At least 1 water-saving device — 5 points
   c) No water-saving devices — 0 points
   d) N/A _____

3. Find out how many ways each person conserves water, such as turning off the water while brushing their teeth, collecting water from their showers to water plants, taking 5-minute or shorter showers, or putting drinking water in the refrigerator to cool instead of letting the faucet run.

   a) At least half of the people do 2 or more of these things — 10 points
   b) At least half of the people practice 1 water conservation technique — 5 points
   c) At least half of these people do not conserve water — 0 points
   d) N/A _____

BONUS QUESTION

Are there any projects completed or in progress at the school that are aimed at reducing pollution?

a) 3 or more projects on school grounds — 10 points
b) At least 1 project — 5 points
c) There are no projects at the school — 0 points

SUMMARY

Add up the points and use the key below to determine the grade for the area(s) you surveyed at your school. If you marked several questions as "not applicable," adjust the grading scale as necessary.

A = 100 and above

B = 80-99

C = 55-79

D = 30-54

F = below 30

How did your school rate in its land use practices? Grade: _____

FINAL ANALYSIS

1. If your school did not score an A, why not? Which of the five sections had the poorest results?

2. List below three areas or conditions that could be improved to give your school a better report card.

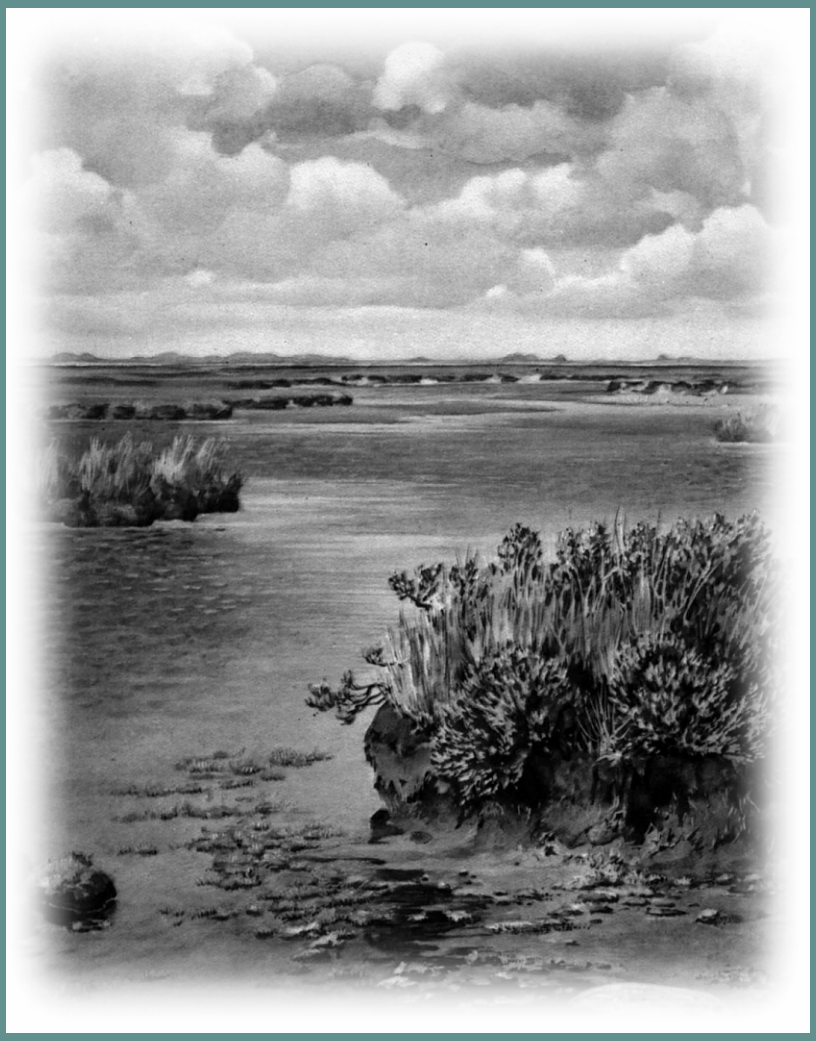
3. Think about what you would do to make these improvements if you could. In your small groups brainstorm solutions to problems that you've identified in this activity. Use "Problems and Solutions Chart" on the next page to list every idea you come up with. You will be sharing these ideas with the rest of your class.

PROBLEMS & SOLUTIONS

PROBLEM	→	POSSIBLE SOLUTIONS
	→	
	→	
	→	
	→	
	→	
	→	
	→	
	→	
	→	

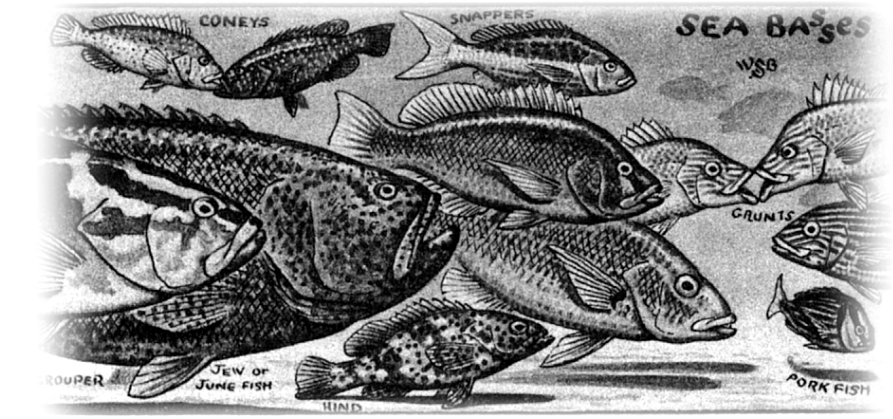
SECTION THREE

Watershed Worries



Net Results

T E A C H E R P A G E S



OVERVIEW

Students will study and replicate a model of some of the factors affecting fisheries populations in the North Carolina coastal estuaries referred to as the Sounds. Through a game, they will investigate how decisions by commercial and recreational fisherpeople, scientists, and lawmakers influence and are influenced by economics and the abundance or scarcity of fish and shellfish stocks.

ESTIMATED TIME: 2 hours

LEARNING OBJECTIVES

- **Science:** *Nature of Science; Science in Personal and Social Perspectives*
- **Social Studies:** *Problem-solving, decision-making, and planning; Group Participation Skills; Civic Affairs*
- **English Language Arts:** *Critical Analysis and Evaluation*
- **Math:** *Measurement; Data, probability, and statistics*

VOCABULARY

abundance, aquaculture, commercial fisherperson, depletion, estuary, harvesting, harvesting gear, moratorium, over-draft, natural mortality, recreational fisherperson, regulation, replenishment, scarcity

MATERIALS

For each group of 6-8 students:

- *Fishery Factor* cards (in back of student activity)
- Role cards and data charts (in back of teacher's pages)
- 2 open top containers (500 ml or larger bowls, shoe boxes, tupperware)
- 500 ml of dried pinto or small kidney beans
- 1 graduated cylinder (250 ml or larger)
- 4 measuring spoon sets (one set for each commercial and recreational fisherperson)
- 4 cups 50 ml or larger – paper cups work well (one per commercial and recreational fisherperson)
- 1 funnel with an opening large enough to let beans through (or a piece of paper rolled into a cone)
- Paper and pencils

BACKGROUND

Whether the topic is catch restrictions on the blue crab or reducing the available number of commercial licenses, fisheries management is almost always a contentious topic for citizens, scientists, commercial fisherpeople, lawmakers, and recreational harvesters alike. Yet, these groups want the same thing – populations of fish and shellfish that support and will continue to support viable commercial and recreational harvesting industries.

Unfortunately, sometimes the scarcity of a resource makes polite cooperation difficult to achieve. When the devastating impacts of a hurricane, new and more efficient harvesting gear, or a loss of habitat reduces populations, the resource may dwindle, but the demand for it continues to increase. The tough choices arising from this scarcity are the heart of current fisheries management debates.

In this activity, students grapple with these decisions through a game that illustrates how harvesting pressure, regulations, and other factors affect and are affected by the fisheries populations. By witnessing the rise and fall of a population in response to their actions and attempting to reach a compromise that is acceptable to everyone, students will gain an understanding of the challenges facing fisheries management.

TEACHER PROCEDURE

Part I (Preparing for the game):

1. Instruct students to complete **Part I** in pairs. **Part I** introduces the factors that influence fisheries populations through a model called the "Bottle Model." The game in **Part II** is based on this model.
2. Collect and organize a set of materials for each group. This activity is written for groups of 6 to 8 students. This group size will allow each student to have an active role in the game. However, if you wish to approximate more closely the real-life proportions of lawmakers, commercial and recreational fisherpeople, you may want to play the game as a full class. To do this, you will need to modify the recommended starting population and harvesting levels described in teacher procedure 5 before starting the game. Other options when you have an extra student or 2 in a group are to add an extra fisheries scientist or an additional lawmaker or add new roles to the game such as a law enforcer (i.e. marine police), press or media people, or tourism director.
3. Photocopy 1 set of *Fishery Factor* cards for each group and cut each set into individual cards. A couple of cards

have been left blank, you may want to write your own card.

4. In the game, students will assume the roles of several people whose actions influence fisheries. Photocopy 1 Role Card for each student and divide each playing group according to the following roles:

   lawmaker (1 per group)

   fisheries scientists (1 per group)

   commercial fisherpeople (at least 3 per group)

   recreational fisherpeople (at least 1 per group)

Part II (Playing the Game):

5. Walk your full class through the following sequence once:

   - The goal of the game is to maintain a fishery that is stable enough to keep everyone in business for at least 10 rounds.
   - Divide students into groups of 6 to 8 and give each student a role card that explains his/her role in the game. Give each group a few minutes to explain and clarify their roles to the rest of the group.
   - Each group places 400 ml of beans in one of their containers which they should label "Sound." The beans in this Sound represent the stock of beanfish in the Sound. The rest of the beans go in the second container, labeled "Extra." To make the harvest more realistic, each group's Sound should be covered with a cloth so that the fishers cannot tell how much the stock has been depleted.
   - The game is played in 10 rounds, each representing a year. In each round, the commercial and recreational fisherpeople will *harvest* from the container, following the current harvesting laws. For the first round, commercial fishers are allowed to scoop 3 tablespoons of beans into their cup; the recreational fisherperson (who represents 25 fisherpeople) is allowed to take 2 tablespoons. These harvesting levels will change in subsequent rounds.
   - While the fishers count their catch, the fisheries scientist calculates the reproduction of the species for the round and adds the appropriate quantity of beans to the Sound. For every 1 ml remaining in the container, the stock reproduces 1 ml. (In other words, the scientist doubles the stock remaining in the Sound.) To keep the fishers guessing, you may want to set up a *Science Center* where the scientists can measure the beans away from their group.
   - Each student (except the lawmaker) must record their actions for this round on a data sheet on the back of their job card. Each bean harvested is worth $100 for the first round. Once recorded, all harvests for the round can be emptied into the "Extra" container and used by the fisheries scientist when he/she replenishes the stock in future rounds.
   - After the first round, you can apply the effects of supply and demand to the game. If fewer than 150 beanfish are caught commercially then the price per fish rises to $110. If more than 210 beanfish are caught commercially, the price per fish falls to $90.
   - All fishers and the fisheries scientists make verbal recommendations to the lawmaker as to the type and extent of regulations they feel should be in place in the upcoming year (round). The lawmaker records everyone's recommendation in his/her data sheet. When making recommendations or laws, students should consider the suggestions on their role cards. They should also remember that commercial fishers need to make $6000 each round or they go out of business.

- Based on the recommendations, lawmakers make laws that must be followed by all fishers in the next round.
- The round ends with the lawmaker drawing a *Fishery Factor* card that introduces additional and unexpected occurrences. If the instructions on a card conflict with the lawmaker's decision, the instructions on the card override the lawmaker's decision. Otherwise, both card instructions and laws apply.
- Repeat for 10 rounds then answer the questions in **Part III,** in the Student Pages.

Suggestions for a smooth game:

- Students may ask how to count broken or half beans. We suggest making any bean less than a full bean not count toward the total. You may explain that these beans are under legal harvesting size.
- Any bean that falls off the spoon during harvesting goes back into the Sound and does not count toward the student's harvest.
- To make sure that students are recording their harvests accurately, the fisheries scientist can count any person's harvest at any time. Anyone who has counted half beans or whose harvest is above the level recorded gets a $1000 fine.

Basic Rules for Net Results*

- Each group needs to have 1 Lawmaker, 1 Scientist, 3 Commercial Fishers, and 1 or 2 Recreational Fishers.
- Read your role carefully.
- Put **400 ml** of beanfish into your Sound.
- **Round 1:** Commercial Fishers harvest 3 tablespoons. Recreational Fishers harvest 2 tablespoons.
- Scientist calculates ***loss*** and ***reproduction***.
- Each player fills out his/her chart.
- Recommendations are given to the Lawmaker and the Lawmaker makes **new regulations**.
- Lawmaker draws a Fisheries Factor card.
- **Round 2** Begins!

** You may want to make a poster of the Basic Rules or give a copy of them to each group.*

JOURNAL ENTRY

- Explain to your class that the Bottle Model is only one representation of the way that replenishment and depletion influence a population. Ask your students to draw their own model of the way this process works and explain it!
- If your class has already chosen a service project, where would it fit in the Bottle Model? Have students add your project to the diagram and the impact they think the project could have on the population level in the bottle.

EXTENSION IDEAS

- This activity can be manipulated and modified to meet your classes' needs. Many roles could be added as mentioned in Part 1. Other changes such as using fish crackers to represent the fish or using different types of beans to represent by catch (fish caught other than the targeted species) can be added.
- Have students graph the data they collect (population and harvest) to investigate the following question: Does looking at harvest data really tell you how a species is doing? What are some of the problems associated with looking solely at harvest data when trying to determine the health of a species?

EDUCATIONAL RESOURCES

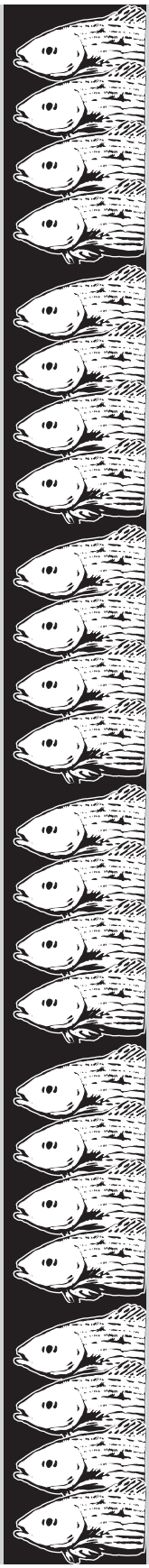
NC Division of Marine Fisheries
PO Box 769
Morehead City, NC 28577
www.ehnr.state.nc.us/ENR

Coastal Conservation Association
2030 Eastwood Rd.
Suite 3
Wilmington, NC 28403
910-256-0083

NC Wildlife Federation
PO Box 10626
Raleigh, NC 27605
919-833-1923

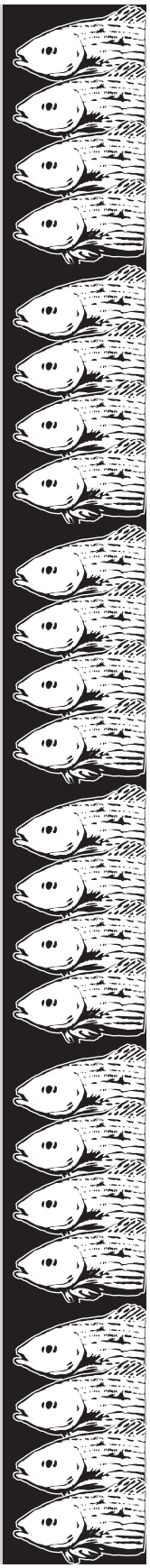
NC Fisheries Association
PO Box 12303
New Bern, NC 28561

FISHERY FACTOR



FISHERY FACTOR

FISHERY FACTOR



FISHERY FACTOR

FISHERY FACTOR

FISHERY FACTOR

FISHERY FACTOR

FISHERY FACTOR

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FISHERY FACTOR

FISHERY FACTOR

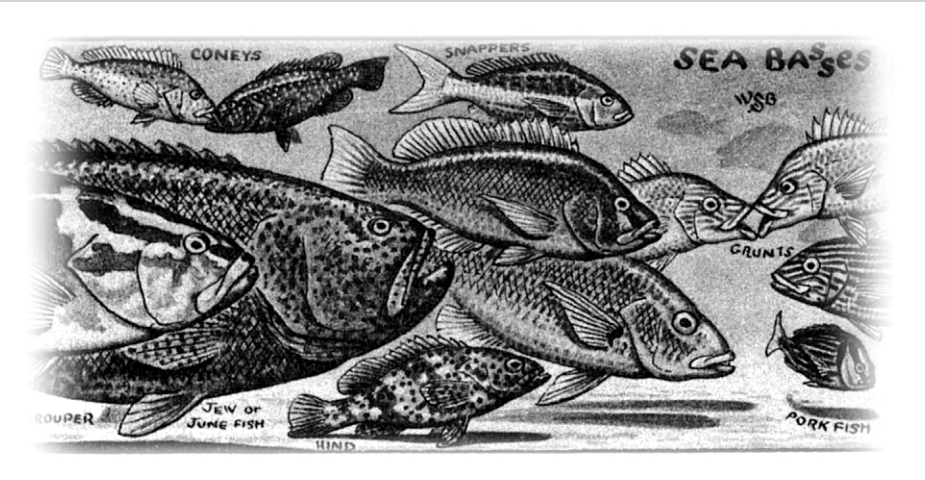
FISHERY FACTOR

FISHERY FACTOR

If commercial fisherpeople caught less than a combined total of 150 beanfish this round, not enough of the fish are making it to the market to meet demand for tasty beanfish. Consumers are willing to pay more for a bite of this scarce fish and will now pay $110 per fish. If commercial fishers caught more than a total of 210 beanfish this round, there is a surplus of beanfish at the markets. Seafood market owners are cutting their prices to get people to buy at their stores. Beanfish are selling for only $90 per fish. This card applies to every round.	The North Carolina General Assembly has called for a public vote (a referendum) on whether or not to reduce the amount of beanfish recreational fisherpeople are allowed to catch by reducing their scoop size. Use a show of hands to determine whether or not those fishing for recreation should use one scoop size smaller. Everyone may vote.
Each commercial fisherperson has the option of buying bigger, more efficient equipment for $2,000 that can be used until laws prohibit the use of such equipment. If you choose to make this purchase, subtract $2,000 from your earnings this round or use any surplus that you might have. In upcoming rounds, use one spoon size bigger than you used in the last round.	Everyone move one seat to the left and take over the job and data chart of the person whose seat you have just taken.
North Carolina students have been raising beanfish in their classroom. This week they released their fish into the Sound in an effort to restore the population. As a result of their project, the population in the Sound grows by 20 ml.	A disease from the Pacific Ocean is introduced to the Sound through ballast water that was released from a cargo ship docked in Morehead City. The disease is devastating to the beanfish population. Reduce the current beanfish population in the Sound byone third.
A hurricane and its tremendous rainfall washes tons of sediment into the Sound smothering delicate beanfish eggs and killing submerged aquatic vegetation (SAV), the preferred food of beanfish. Reduce the beanfish population in the Sound by 25%.	Recreational fisherpeople have just been shown how to perform careful catch, a technique where fish are caught, but then released back into the Sound unharmed. Recreational fishers: Start a new column for the number of fish, if any, you decide to release. Fish released may be put back into the Sound before the fisheries scientist calculates reproduction. Lawmakers may consider mandating careful catch in future rounds.
The removal of a dam opens up prime beanfish spawning grounds and, as a result, they have a bountiful reproductive year. Add 40 ml of beanfish to the Sound. The dam also opens up new areas for those fishing for recreation who are now allowed an additional scoop each round unless regulations change.	Students create a forest and wetland between a large mall and a local waterway. This vegetation helps to reduce the amount of sediment, oil, and nutrient runoff washing from the mall into the waterway. As a result, fewer beanfish die, leaving more to reproduce. Increase the population in the Sound by 10 ml.
Suddenly, New Zealand starts shipping beanfish to your area and they are just as good as yours. They are also cheaper that yours!! This drives the market value of your beanfish down $20 per fish for one round.	No changes this round.

Net Results

S T U D E N T P A G E S



INTRODUCTION

How much do you think a fish population varies from year to year? Hurricanes, rains, restored wetland habitats, the removal of a dam, or fewer fisherpeople are just a few of the reasons people may give for changes in fish population. Other people say there are simply natural cycles of scarcity and abundance. Of course it is really hard to know how much a population changes each year, because the fish are hidden below the water's surface.

In this activity, you will be studying the natural and human factors that influence the abundance of fish or shellfish in North Carolina's coastal waters referred to in this activity as *the Sound*. After you have learned something about how different factors interact to affect fisheries populations, you will play a game that shows how these factors affect the Sound populations and peoples' jobs and lives. **Your goal** is to work together to maintain a population of "beanfish" that is high enough for everyone to catch enough fish from year to year.

MATERIALS:

Your group will need:

- A copy of the "Bottle Model" diagram
- Role cards and data charts (attached to student activity)
- "Fishery factors" cards
- 2 containers (1 labeled the "Sound")
- 500 ml of dried beans
- 1 graduated cylinder
- 4 sets of measuring spoons
- 4 cups
- 1 funnel or piece of paper rolled into a cone shape
- Paper and pencils

PROCEDURE

Part I

1. Study the "Bottle Model" diagram attached to this activity. This model represents the ways that species are removed from the Sound (harvesting, habitat loss, natural causes) and put back into the Sound (natural reproduction and aquaculture). Natural populations go up and down over time. Give an example of how the factors on the "Bottle Model" might cause change in the population over many years.

2. Choose 1 faucet on the model and describe an event that could make the faucet flow faster. For example: *an event such as a heat wave could reduce the amount of oxygen in the Sound and increase natural mortality.*

3. If the event you described above did happen, what would happen to the population level in the bottle? Would the population be able to return to its original level after this event? How?

_____

_____

_____

_____

Part II:

Your group is going to play a game that illustrates the way that people, fish and shellfish populations, and laws interact and influence each other. In the game, you will represent some of the people – lawmakers, scientists, commercial fisherpeople or fishers (often called watermen), and recreational fisherpeople – who influence and are affected by fisheries regulations.

4. **Preparing for the game:** Your teacher will give each student a Role card. Your Role card includes a chart for you to fill out during the game. Read your role description carefully and ask your teacher any questions you might have. Explain your role to the other members of your group and listen as they explain their roles to you.

5. **Setting up the game:** Collect the rest of the game's materials from your teacher and distribute them among your group. Give the graduated cylinder to the fisheries scientist. Give each fisher (commercial and recreational) a set of measuring spoons. Label one of your containers "Sound" and put 400 ml of dried beans in this bowl. Cover your Sound with a cloth so that the exact level of beanfish cannot be seen. Label the other container "Extra" and put the rest of your beans in this bowl.

6. **Playing the game:**

   Round 1: Commercial fishers may take up to 3 tablespoons of beanfish from the Sound. Recreational fisherpeople may take 2 tablespoons. Each person should put their individual harvest in a small cup so that they can count it later.

   - After everyone has finished harvesting, fill in your data chart on the back of your Role Card. Check your Role Card to find out what this involves.
   - Once the beanfish have been counted, commercial and recreational fisherpeople pour their harvests into the "Extra" bowl.
   - Using the graduated cylinder, the fisheries scientist measures the remaining population of beanfish in the Sound and calculates their reproduction. For every 1 ml of beanfish remaining, the scientist transfers 1 ml of beans from the "Extra" bowl to the Sound. The fisheries scientist fills out his/her data chart.
   - Fisheries scientists and commercial and recreational fisherpeople give recommendations to the lawmaker. Check your Role Card for ideas.
   - The lawmaker decides which regulations (if any) harvesters must follow in the next round.
   - The lawmaker draws a "Fishery Factor" card and reads it to the group.

Round 2 - Round 10:

- Your group will repeat the procedure from Round 1 following the new instructions from the Fishery Factor card and any new regulations (if there are any) from the lawmaker.
- The worth of beanfish may change as the game goes on. If your class is including the impact of supply and demand in your game, the cost of beanfish will vary depending on how many are caught. If the total commercial catch is less than 150 fish, the cost per fish rises to $110 due to scarcity. However, if the commercial catch is more than 210 fish, the cost per fish falls to $90.

Every Round:

- The commercial fisherpeople must make $6000 each round to make a living. If a commercial fisher makes under this amount for a total of 3 rounds, he/she is out of business and out of the game. Surplus from good rounds can carry a commercial fisherperson through times of shortage. This means that if a commercial fisher makes $6500 in 1 round, $500 can be used to make up for a bad catch in another round.
- Recreational fisherpeople represent 25 fisherpeople. For everyone to catch a fish, you need to catch 25 beans each round.
- The most important thing to remember about this game is that <u>you</u> get to make most of the rules! You will need to come up with imaginative solutions as you encounter the challenges of fisheries management.

Part III:

After you have played ten rounds of the game **Net Results**, answer the following questions:

7. Summarize the results of the game. What trends did you see in the beanfish population over time?

_____

_____

_____

_____

8. Of the factors that increase and reduce the populations of species in the water, which can we control? Look back at the "Bottle Model" from *Part I* and circle the factors that people can control through various actions. Under each factor you circle, provide an example of an action that you, or other people, do or could do to decrease the flow from the faucet.
9. Describe 3 events, actions, or decisions in the game that most influenced the health of your fishery.

_____

_____

_____

10. List and explain 3 things that you would do differently if you were to play **Net Results** again. How do you believe these changes would affect the outcome of the game?

11. Because this was a game, or a model of a real-life process, there were many things that were not quite realistic. Even so, this game should have given you a good sense of the challenges, cooperation, and compromise involved in fisheries management. What other factors might influence the populations and catches if this experiment were done in real life?

12. This game deals with a very real issue: the role of laws in fisheries management. Think about how laws or regulations affected the commercial and recreational fisherpeople in your game. How did the regulations affect the fish population?

    Write a persuasive paragraph to a classmate explaining whether or not you think we need laws, such as those you saw in the game, to manage fisheries. Use examples and evidence from the "Bottle Model," the game, and any prior knowledge you might have to support your perspective.

LAWMAKER

Introduction to your role:

Your job is to make the laws that determine how many beanfish the commercial and recreational fisherpeople can take out of the Sound each year. Your goal is to listen to everyone's point of view about how the fishery is doing and then make regulations that are fair and sensible. It is a tough job, but someone has to do it! Ultimately, you are striving to keep the fishing industry healthy throughout the *entire* game.

At the end of each round, you will get a recommendation from each interest group (fisheries scientists, commercial and recreational fisherpeople). Although the recommendations may say completely different things, you need to use them to help decide which regulations to make.

What does the lawmaker do?

1. As the lawmaker, you can regulate fishing in a number of ways, the following are a few examples:
    - You can make everyone take fewer beanfish, or allow everyone to take more.
    - You can change the size of the equipment that commercial and/or recreational fisherpeople are allowed to use. (They all have a set of spoons with different sizes that you can choose from.)
    - You can also set different limits for recreational fisherpeople and commercial fishers.
    - As a last resort, you can set a moratorium for a round or more. A moratorium is a ban on all harvesting of the species and will allow the species to reproduce without being harvested.
2. The lawmaker is also responsible for enforcing the regulations he or she sets, when necessary. Here are a few examples of regulations you can set:
    - If the beanfish stock seems to be in wonderful shape, you can increase the amount everyone can catch or allow for an unlimited catch, where everyone can take as much as they want.
    - If you are afraid that the beanfish stock is becoming too low, you can forbid the use of tablespoons to scoop up beanfish. This means that commercial and recreational fisherpeople will have to use their smaller spoons, which do not catch as many beanfish.

Remember:

As a lawmaker, you take responsibility for many people's happiness, and sometimes for their financial survival. Commercial fisherpeople make a living by catching and selling beanfish. They are not making a decent living if they make less than $6000 per round. They will go out of business permanently if they make less than this for a total of 3 rounds. This means that severe restrictions, or a moratorium might put them out of business. On the other hand, commercial fishers depend on the existence of beanfish to catch, so over fishing might put them out of business in future rounds. Your goal is to find laws that will balance present and future needs.

You must draw a fishery factor card at the end of the round.

LAWMAKER'S CHART

ROUND #	Scientist's Suggestions	Commercial Fisherpeople's Suggestions	Recreational Fisherpeople's Suggestions	Final Decision for the Round
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

FISHERIES SCIENTIST

Introduction to your role:

You are the person who studies the Sound's fish populations. You are the expert who provides the hard facts to the lawmaker about how the beanfish population is doing. In this game, you are also the person who measures the fish left after each round and calculates how many get put back in to the Sound through natural reproduction. This means that you are the only person who really knows how the beanfish are doing. Your goal in this game is to make sure that there are always enough beanfish left in the Sound to replenish the stock after each round. In other words, you want to make sure that there will be a future for beanfishing in the Sound.

What does the Fisheries Scientist do?

1. To provide sound data to the lawmaker, you need to keep track of the amount of beanfish in the Sound before and after harvesting and beanfish reproduction. You will start the game by placing 400 ml of beanfish in the Sound.
2. After each round of harvesting, you will measure the amount of fish left and calculate how much the beanfish population will reproduce that year. To do this, you will add one ml of beans to the Sound for every ml of beans left. ***For example:*** if there are 95 ml of beanfish left in the Sound when harvest is finished, you will add 95 ml more. This will bring the total amount of beanfish up to 190 ml.
3. At the end of the round you will make a recommendation to the lawmaker, possible recommendations might be:
    - If you can see that the current regulations are allowing the beanfish stock to become seriously low, you can recommend that the lawmaker limit commercial fisherpeople to one scoop each per round or that the recreational fisherpeople use a smaller harvesting tool.
    - If you think that the beanfish are doing particularly well, you can recommend that the lawmaker allow them to harvest more beanfish.

Remember:

Since you are the only members of your playing group who actually measure the beanfish stock, you will need to explain to the others how the stock is doing. Most importantly, though, you need to convince the lawmaker to make regulations that will keep the stock healthy, and not bring it down to low levels.

FISHERIES SCIENTIST'S CHART

ROUND #	Amt. in Sound After Harvest (in ml.)	Amt. Added through reproduction (1 ml for each remaining ml)	Final Total After Harvesting and Reproduction (in ml.)	% Gained or Lost from Previous Round = 100 - (final total this rnd/ final last rnd x 100)
Example (final last round = 400)	150	150	300	100 - (300/400 x 100) = 100 - 75 = 25% lost
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

COMMERCIAL FISHERPERSON

Introduction to your role:

You make your living by catching beanfish from the Sound and selling them commercially. Your goal is to stay in business for the entire game, while obeying the laws and regulations set by the lawmaker.

What does a Commercial Fisherperson do?

1. To stay in business, you need to catch enough beanfish to make $6000 (your expenses) each round. For the first round, each bean is worth $100, meaning that you have to catch 60 beans in the first round. The worth of each bean may change throughout the game.
2. If you make more than $6000 in any round, you can save your surplus in your savings account for tighter times. If you make less than this amount in any round, you must make up the difference with surplus from another time or count the round as a strike against you. If you have a total of 3 strikes against you during the game, you go out of business and become a recreational fisherperson.
3. At the end of each round, you will give a verbal recommendation to the lawmaker, telling her/him how your business is doing and what you think should be done to keep you in business. Some things you might want to think about:
    - Should you be allowed to use bigger and better gear or take more scoops?
    - Should you or recreational fisherpeople be taking less?
    - Are you making enough money to make a living?
    - Do you want to save money in case times get tight?
4. To help you make these recommendations, you need to keep track of your harvests using the chart on the back of this page.

Remember:

If there are no fish, you will have nothing to catch and no way to remain in business. On the other hand, if regulations are too strict, you may go out of business anyway. You may work with other commercial fishers and/or the recreational fisherpeople, or you may wish to be secretive about your business. It's your choice.

COMMERCIAL FISHERPERSON'S CHART

ROUND #	Amount Harvested (# of beans)	Price per bean this round	Total Amount Earned (number caught x price)	Surplus: Amt. earned above (+) or below (-) $6000	Savings Account (total Surplus or overdraft)
Example (if you caught 87 beanfish)	87	$100	$8700	+$2700	$2700
Round 1					
Round 2					
Round 3					
Round 4					
Round 5					
Round 6					
Round 7					
Round 8					
Round 9					
Round 10					

RECREATIONAL FISHERPERSON

Introduction to your role:

You do not make your living fishing, but it is still very important to you. You fish for fun, because you like to eat beanfish, or because you like to make a little extra money by selling beanfish on the side. Even though each of you only catches a small number of beanfish, there can be so many of you that your harvest can be significant. For this reason, you must follow whatever laws are set by the lawmaker just as the commercial fisherpeople do.

What do the Recreational Fisherpeople do?

1. Because there are actually many more recreational fisherpeople than commercial fishers, you will represent 25 fisherpeople.
2. This means that if you take a scoop of beans that has 25 beans in it, each recreational fisherperson has caught one beanfish. Not bad.
3. However, if you only catch 10 beans, then only 10 out of 25, 2/5, or 40% of the recreational fisherpeople have caught a beanfish. Not so good!
4. When your harvests get below one beanfish per fisherperson, recreational fisherpeople begin to get worried.
5. At the end of each round, you will try to influence the lawmaker through a verbal recommendation telling her/him how well fishing is going and what you think should be done.
    - Should fisherpeople be allowed to catch more each round or use bigger and better fishing gear?
    - Are you worried that too much is being taken?
6. Keep track of the number of fish that you are catching with the chart on the other side of this page.

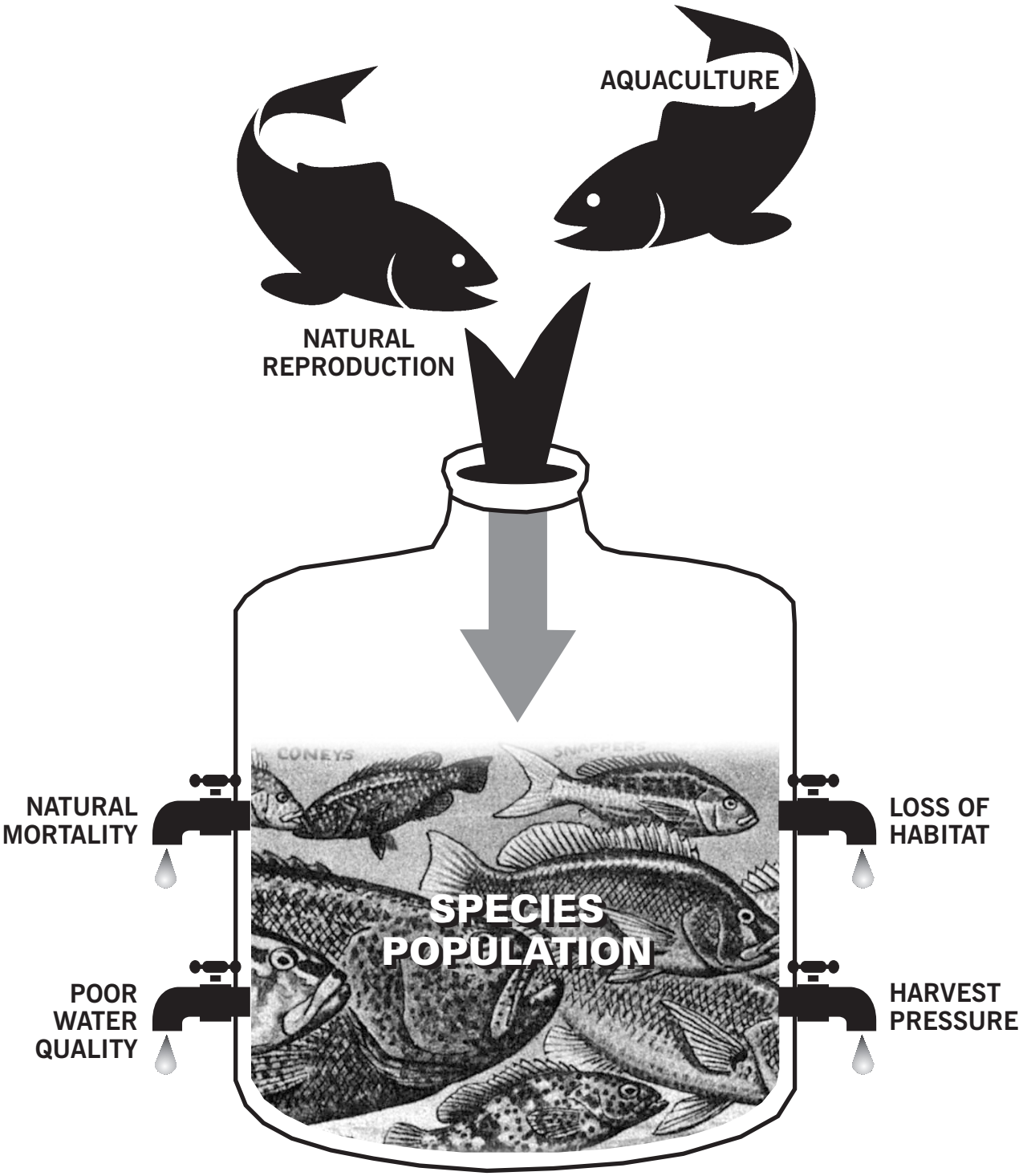
Remember:

Just because fishing is a recreation to you doesn't mean that you don't care what regulations are set by the lawmaker. You want the freedom to continue your way of life.

RECREATIONAL FISHERPERSON'S CHART

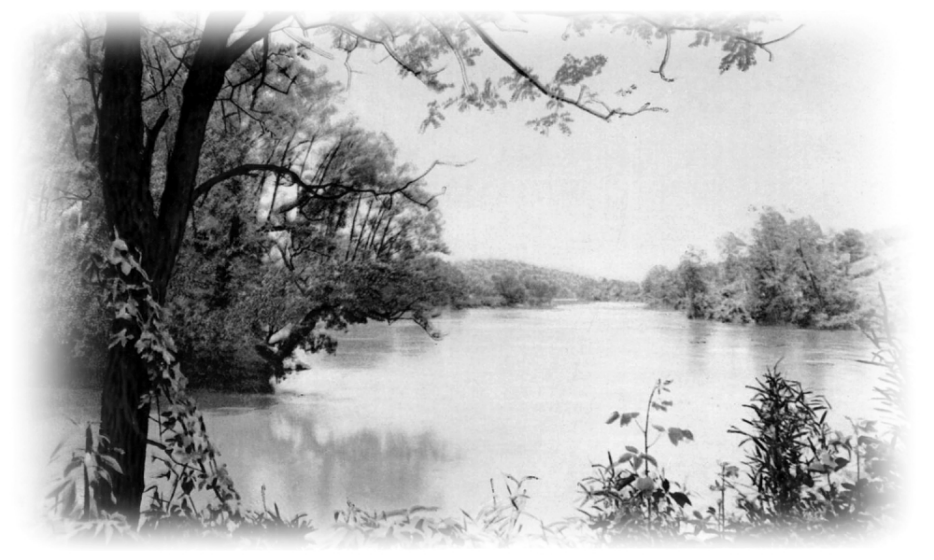
ROUND #	# of Beanfish Caught Total	Percentage of the 25 fishers who caught one beanfish (# beanfish caught/25 x 100) = %	Percentage of fishers who caught more than one beanfish (# beanfish caught - 25) x 4 = %	How content are your 25 fishers with their catch?
Example	50	50/25 x 100 = 200%	50-25 x 4 = 100%	
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

BOTTLE MODEL



Sediment: Clouding our Rivers and Sounds

T E A C H E R P A G E S



OVERVIEW

In this activity, your students will construct a model sound or river and use it to study the effects of sediment on aquatic life.

ESTIMATED TIME: 1 hour

LEARNING OBJECTIVES

- **Science:** *Nature of Science; Science as Inquiry*
- **English Language Arts:** *Critical Analysis and Evaluation*
- **Social Studies:** *Group Participation Skills*

VOCABULARY

adverse, buffers, dissipate, erosion, estuary, habitat, impervious surfaces, land use, sediment, smother, spawning, submerge, submerged aquatic vegetation

MATERIALS

For each group of five or fewer students:

- 2 clear jars of the same size filled with water (peanut butter or canning jars work well)
- 2 plastic aquarium plants or pieces of real plants
- Small container filled with dirt (soil from your yard or potting soil works best)
- Dried beans (lima or kidney beans or a combination)
- Macaroni or spaghetti noodles

Optional Materials:

- Styrofoam
- scissors
- string
- paper clips
- resource materials on sedimentation

BACKGROUND

Sediment, or dirt, is one of the worst pollution problems in the sounds of North Carolina. It is a source of pollution that is familiar and visible to many of us because we see it eroding from construction sites, farms, schoolyards, and lawns. Erosion is a natural process that has been greatly accelerated by our land use practices. By increasing the area covered by impervious surfaces, we have decreased the natural buffers and removed the roots of trees and plants that hold the soil.

Sediment has many adverse effects on aquatic life. Excess sediment clouds the water, making it impossible for submerged aquatic vegetation (SAV) rooted on the sound's bottom to receive enough sunlight to grow. SAV is critical habitat for many aquatic animals including crabs, young fish, and oyster larvae. Sediment also smothers fish eggs and bottom-dwelling oysters, and covers the gravel bottoms where fish spawn and aquatic insects live. In addition, sediment does not break down or dissolve like some pollutants. Instead with each storm or heavy rain it is stirred up again. Sediment makes an excellent pollution problem for students to investigate, because its effects are evident in waterways and streams. Furthermore, there are simple action projects students can participate in, which can help to reduce sediment erosion into North Carolina sounds and rivers.

TEACHER PROCEDURE

In this activity, your students will use the materials from the list above to make a representation of a North Carolina sound or river. They will then add dirt to one of the jars to simulate erosion and observe the effects that sediment can have on aquatic life.

1. Depending on your students' prior knowledge, you may want to conduct a class discussion or brainstorming session before beginning this activity. Discussion topics might include: the sources of sediment or the impact of sediment on the sound (see background information).
2. It may also be helpful to develop a list of animals and plants that live in the sounds and rivers that can be referred to when students construct their models.
3. In question 2, small groups of students will use the water-filled jars and items from the materials list (except for the dirt which will be used in question 4) to create a model sound or river.* The plastic aquarium plants can be used to depict submerged aquatic vegetation; beans

It may be helpful to assign student groups particular rivers or sounds and then have them compare the impacts of excess sediment.

can represent oysters; noodles can illustrate worms or eels. Depending on the amount of time you are willing to devote to this project, students can cut out fish, crabs or other organisms from Styrofoam meat trays. By punching a hole in the Styrofoam and connecting several paper clips, the animals can be suspended in the water. (This also makes for a great lesson in density!) The amount of direction that students are given in this activity is up to you.

4. When reading the paragraph, you may have to assist students in defining vocabulary words before the activity. Words which may be difficult for students include the following:
    - Sediment: *soil or dirt*
    - Smother: *to suffocate; prevent from getting air*
    - Spawning: *the process of laying eggs to reproduce*
    - Submerge: *to sink beneath the surface of water*
5. To wrap up the activity have students share their model with the rest of the class. Encourage them to share their thoughts on the impact of sediment in the model.

JOURNAL ENTRY

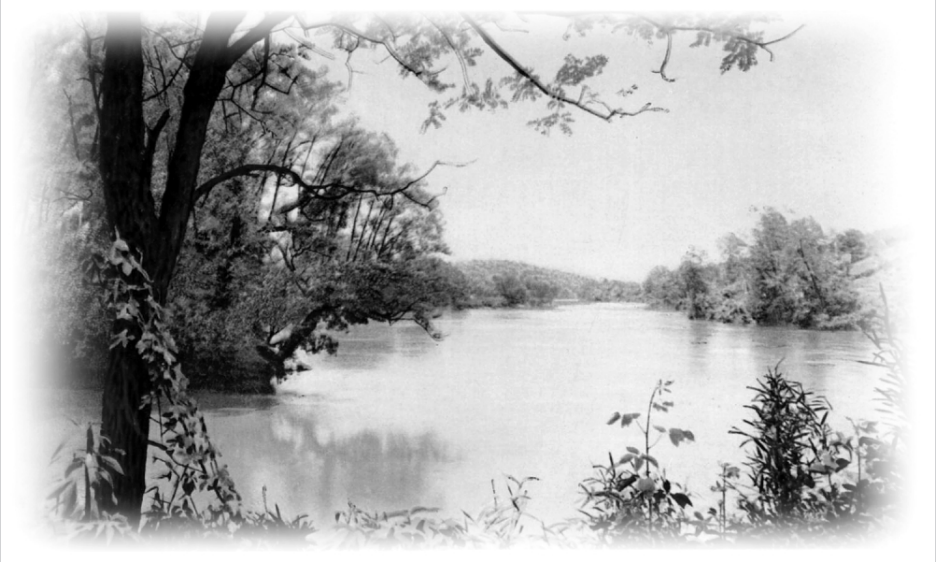
- Ask students to write a paragraph or story describing how sediment would affect an aquatic animal. How might sediment interrupt the food chain of which that animal is a part?
- Ask students to draw a picture of an animal in the jar with and without sediment and to write a caption for what the animal might be thinking.

EDUCATIONAL RESOURCES

Division of Soil and Water Conservation
PO Box 27687
Raleigh, NC 27611
919-733-2302

Sediment: Clouding our Rivers and Sounds

STUDENT PAGES



INTRODUCTION

Have you ever noticed dirt being washed down a hillside during a rainstorm? Have you seen a river that is so cloudy you can't see the bottom, even if it is only a couple of feet deep? If you said yes, then you have already observed erosion, which is when soil gets worn away by moving water, wind, or waves. In this activity, you will construct a model sound or river to study how sediment, one of the worst pollution problems in the sounds and rivers of North Carolina, affects aquatic life. Just to keep things straight, soil is the dirt on the ground and sediment is dirt that has been washed into the water.

MATERIALS:

- 2 clear jars of the same size filled with water
- 2 plastic aquarium plants
- 1 small container filled with dirt
- Dried beans
- Macaroni or spaghetti noodles

PROCEDURE

1. In the space below, describe three ways you think sediment affects the plants and animals living in North Carolina's sounds and rivers.

2. Using the materials listed above, except dirt, construct two identical sounds or rivers that you will use to observe the effects of sediment on aquatic life. The jars will be filled with water to represent the sound or river. You can be creative and use beans, noodles, and Styrofoam to represent a diversity of sound animals and plants. You may need to do some research to find out what animals live in the sound or river.
3. In the space below, draw a diagram of each of your model sounds or rivers. Label the organisms you will represent in each of your jars.
4. Add a handful of dirt to one of the jars. Cap the jar tightly and shake it.
5. Compare the two jars. What differences do you notice between the two jars? List at least four differences in the space below.

6. Through which jar could sunlight pass most easily?

7. To which organism(s) in your jar would sunlight be most important and why?

8. Wait for five minutes. While you wait, read the following paragraph on how sediment pollutes water from the book Turning the Tide and answer the question below.

   Sediment pollutes by smothering fish eggs, by tearing at fragile gills of just-born fish, and by covering gravel bottoms that are prime habitats for fish spawning and for aquatic insects. Further down river it may cover oyster beds. Sediment also clouds the water cutting off sunlight needed to grow the submerged grass that is critical habitat in streams and the bay. (Horton & Eichbaum, 1990)

   Describe at least two ways that you think the submerged grasses mentioned in the paragraph are important to animals living in the sounds and rivers.

9. After the five minutes are up, observe the two jars again. In the space below, draw and label the two jars, noting any changes that occurred in the jars.

10. Based on your observations and the reading in the table below, summarize how sediment affects each type of aquatic life represented in your jar. How does sediment affect the organism differently when the sediment is suspended in the water versus when it settles? How does sediment interrupt the organism's food chain?

Organism	**Effect of Sediment**