FISH FOR OUR FUTURE!

is a product of
the Partners with the Meduxnekeag Project
and School District No. 12

Printed in Canada – 1998
Design by GraphXperts Design Service

CONTENTS

JUST FOR TEACHERS

UNIT ONE

A L E V I N

for Elementary Students

An ALEVIN, such as a newly hatched salmon or trout, (pronounced 'ALE VIN) remains buried in the streambed gravel until the attached yolk sac is absorbed. When the young fish emerges from the gravel and begins to feed, it is called a "fry."

UNIT TWO

S M O L T

for Middle School Students

A young salmon (or sea-going trout) is called a "SMOLT" when it is ready to leave fresh water for the sea. Smolts have lost the dark "parr" markings on their sides and turned silvery

UNIT THREE

S A L M O N

for High School Students

EXTRA RESOURCE SHEETS

FISH FOR OUR FUTURE!

SMOLT

TEACHER: STREAM ORDER

Overview:

Students will use a map to discover and trace the length of the nearest river system and its watershed. In addition, students will become knowledgeable about natural stream changes from the headwaters to the mouth, as well as be able to identify human impacts.

Objectives:

Students will be able to:

- isolate and order any stream or river system in New Brunswick
- predict the characteristics along various parts of a stream, including expected life-forms
- list at least two human impacts affecting river systems

Subject Links:

- geography
- social studies

Time:

a minimum of one to one and one-half hours

Materials:

- New Brunswick road maps
- topographical maps *(if possible)*
- tracing paper
- pencil crayons

Background:

For information on stream orders, see Teacher's Resource Unit.

Process:

1. Generate a list of the similarities and differences between streams, creeks, brooks and rivers. *(i.e. velocity, size, temperature, volume, etc.)*
2. Explain that for scientific purposes a numerical system has been devised to standardize the various components of a moving water system. This numerical system may allow scientists to roughly determine the types of fishes that may inhabit that environment. Features such as water temperature, volume, fish species, etc. may change as the stream order increases from the headwaters to the mouth of the river. Most of the trout streams are first- or second-order streams.
3. Discuss the system of stream-ordering by building a sample river system on chart paper or the chalk-board. Link two streams to form a second-order stream and label each. Draw another similar structure and link the two to form a third-order stream, and so on until a fourth- or fifth-order stream is formed. Ensure that students understand that the land drained by the river system slopes downhill from a divide. Draw a line around the river system and label it as a ***watershed.***
4. Divide the class into small groups and give each group a provincial road map. Assign each group a community and locate the nearest river system to that community. Using the road map and/or the topographical maps, have students outline the watershed of their assigned community.

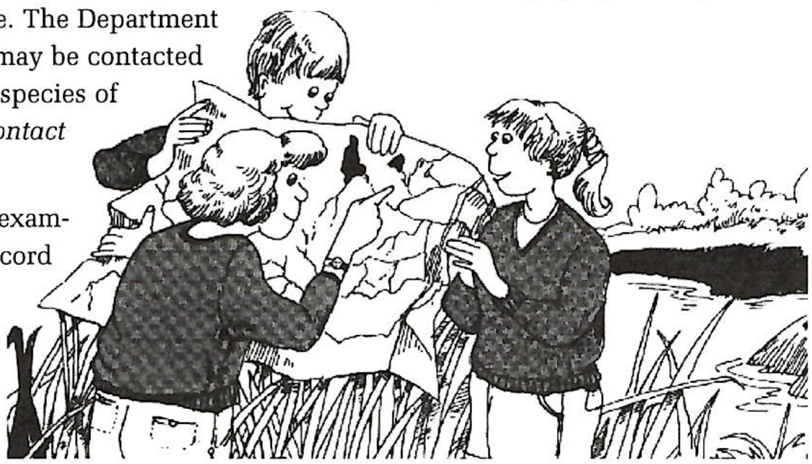
5. Using pencil crayons, have students colour each stream according to its order, and establish a key or legend to show which colour goes with which stream order.
6. Discuss what they now know about river systems and stream ordering. Are their maps consistent with how streams are ordered?
7. From the maps, as well as other sources of information, determine what the major sources of human impact are *(i.e. industry, settlements, forestry and farming operations, etc.)*. Discuss the following questions with the class:
   - As stream order increases, would human impact on the river system tend to increase or decrease?
   - What effect could this have on local fish populations? How might this affect other animal species?
   - Are there evidences of these effects near your local community?

Evaluation:

Provide students with a map of a simple watershed. Have them identify the order of the streams and give a brief description for each one.

Possible Extensions:

1. To provide a more accurate stream-order for a given area, students may use topographic maps or larger scale road maps, if available. The Department of Natural Resources and Energy may be contacted regarding information on the fish species of local streams. *(See appendix for contact information.)*



2. Organize a field trip to visit local examples of different stream orders. Record and compare stream bank conditions, rate of flow, water temperature, etc.
3. Allow students to use the G.I.S. (Geographic Information Services) computer program included with this manual to create their own watershed, showing the various stream-orders. ***NOTE: This program has minimal system requirements, and must be "unzipped" to work. If you're not familiar with computers, don't worry, it's easy to install the program and get it running. COMPLETE INSTRUCTIONS ARE PROVIDED WITH THE PROGRAM DISC.***

TEACHER: STREAM SURVEY

Overview:

Just like a doctor must examine his patient before a diagnosis and prescription can be written, so rivers and streams must be examined before problems can be fixed. An important part of this examination is the completion of a ***stream survey**. A class or several classes may adopt a stream or river, and assess its condition using the following survey form. The information may then be compiled and sent to the Department of Fisheries and Oceans for examination. If the students are interested, Fisheries and Oceans personnel will then examine the stream or river and make recommendations on what habitat improvements may be made.

Objectives:

Students will be able to:

- assess a stream or small river for physical and biological characteristics related to fish habitat
- identify the habitat requirements and one local habitat for a common New Brunswick fish species

Time:

advanced in-class preparation one to one and one-half hours: field trip one half-day

Materials:

For each group of students:

- stream survey form
- clipboard
- stop-watch
- thermometer
- pH paper
- insect identification wheel *(in **Fish Friends** manual)*

Advance Preparation:

1. **SELECT A SITE:** When selecting a site, it's important to choose a stream or river that is of manageable size. Generally, this is a stream with a maximum average width of 25 feet or less. Larger streams and rivers are more difficult to assess, and harder still to make habitat improvements on.
2. **LAND-OWNER'S PERMISSION:** It is vital to secure the permission of the land-owner before doing any habitat work, including stream surveys. Doing so greatly increases the chances that the land-owner will be cooperative later, if in-stream habitat reconstruction projects will be undertaken.
3. **GET ACQUAINTED:** Habitat concerns may be foreign ideas to many students. Several videos are available from the Department of Fisheries and Oceans *(see appendix)*. The Department of Natural Resources, or the Department of Fisheries and Oceans, with sufficient notice, will provide guest presenters on the issue of habitat management, etc. Oh! Don't forget to go through the worksheet with students to make sure that they have a working knowledge of the terms and concepts.

* *It's best to conduct a stream survey during low-flow conditions. The advantages are: the water is not as deep or fast, and the information gathered is more indicative of the true conditions of the stream, rather than the conditions that are present only after significant rainfalls or high water conditions.*

Process:

1. Assign groups of students a specific length of stream to survey. Generally, 25 metres is a well-managed section. It would be a good idea to make the sections adjacent to each other, to make it easier to monitor the groups. The data collected will provide a more accurate view of stream conditions.
2. Stress the importance of accuracy to students. Their information may be used to help determine what work needs to be done on that section of stream.
3. Ask students to minimize bottom disturbance, as they may seriously harm organisms living there. They should also be very careful because the stones, rocks and logs on the bottom may be covered with algae, which can be very slippery. Silty and muddy areas may be much deeper than they look from above the water surface.
4. After the field trip, develop a master data sheet and have each group transfer its observations.
5. Have each group research the habitat requirements of a local fish species, then compare their findings to their field trip results. What fish may be present in the stream that was surveyed?

Evaluation:

Have students write and submit an article to the school and/or local newspaper on what to look for in a good fishing spot for a particular fish species. If neither a newspaper or school paper is an option, another possibility might be to compile the information into a short book, and make it available to other students or classes.

Possible Extension:

Have students assess other local aquatic habitats by using the survey form to identify good fishing spots and either test them out or confirm their assessment through other anglers.

STREAM SURVEY FORM

Recorder's Name: ______________________ Stream Name: ______________________

Group: ______________________ County: ______________________

Date and Time: ______________________

Briefly describe weather conditions (rainy, snow, sleet, sunny, cloudy, windy). Be sure to include air temperature.

____

____

____

____

____

Average Stream Depth: __________ Maximum Stream Width: __________ Minimum Stream Width: __________

Average Stream Width: __________ Water Temperature: __________ pH: __________

What is the nearest waterway? ______________________

Who owns the land at this site? ______________________

By looking at the stream bottom in your survey area, estimate the percentage of each of the following.
Remember, your numbers must have a sum of 100.

PER CENT	STREAM BOTTOM TYPE
	BOULDER: the size of a dinner plate or larger *(approximately 25 cm or more)*
	COBBLE: the diameter is the length of an index finger to a dinner plate *(6.4-25 cm)*
	GRAVEL: the length of a thumbnail up to the size of an index finger *(2-6.4 cm)*
	PEBBLE: the size of a baby fingernail up to a thumbnail *(0.6-2 cm)*
	SAND: less than 6 mm
	SILT: less than 1 mm

Pick up a rock and look ***closely***: are there insects on it? __________ Are the insects moving? __________

Can you find any caddisfly casings? ______________________

Using your insect wheel-chart, identify other insects you have found: ______________________

____

Pick up a rock, is it muddy? ______________________ Was the rock set in sand or silt? __________

Approximately how much sand or silt was covering the rock? ______________________

What other important physical features are worth noting? ______________________

What species of wildlife do you see? ______________________

What animal tracks can you find within your study area? ______________________

Are there any fish? ______________________

What types of aquatic vegetation are there?

- ☐ brown algae
- ☐ green algae
- ☐ grass-like plants
- ☐ leafy plants

IS THERE/ARE THERE	YES	NO
stream-side vegetation		
hardwood trees (deciduous)		
alders		
grasses		
clear cuts		
farmland		
softwood trees (coniferous)		
shrubs		
field(s)		
swamp		
evidence of bank erosion		
stream braiding		
human development		

Which best describes the movement of the water?

- ❑ shallow and slow
- ❑ shallow and fast
- ❑ deep and slow
- ❑ deep and fast

Are there any objects in the stream that would stop fish from migrating upstream? *(Log jams, beaver dams, falls, etc.)* ______________________

____

____

____

____

DRAW a sketch of your survey area as if you were looking at it from the air. Be sure to include all important physical features such as pools, erosion sites, etc. Using a metre stick, find the maximum depth of each pool and include it in your drawing. Make sure your drawing is well-labeled.

SKETCH OF SURVEY AREA

Are there roads or land-fill sites nearby? ______________________

Other Comments: ______________________

____

____

____

____

____

____

TYPE OF GARBAGE	NONE	SOME	LOTS
paper/cardboard			
plastic			
tires			
glass			
metal			
other:			

STUDENT WORKSHEET: CHANNEL CHARACTERISTICS

Background:

Four features commonly called **riffles, pools, runs** and **flats** occur in streams and rivers. Their characteristics are described below.

Riffle:

A riffle is a swift, shallow portion of a stream or river where the flow of water is broken; rocks often protrude through the water surface. The substrate (stream bottom) is usually gravel, rubble or rock. Riffles add oxygen to the water through turbulent mixing, and provide the best habitat for the aquatic invertebrates that trout, salmon and minnows feed on. Salmon and trout spawn in riffle areas, and fingerlings *(trout and salmon when they are still the size of a finger)* live along the margins of riffles where rocks, logs and plants offer shelter.

Pool:

A pool is a deep, slow-moving portion of a river or stream. Pools can be various depths, but are usually the deepest areas of a stream. The bottom can be gravel, rock, boulder, silt or logs. Pools provide both a winter refuge and the depth needed to give protection from predation to larger trout and salmon. The deeper parts of runs are also used by these bigger fish.

Run:

A run is a swift, deep portion of a stream or river. Although the flow of water may be as swift as in a riffle, the water is deeper. Runs usually range in depth from 20 cm to 2 m depending on the stream size. The substrate is usually rock, rubble or boulder. Month-old trout and salmon move into the shallower runs, resting in eddies behind rocks and logs, darting out to grab floating invertebrates brought down from the riffle areas by the current.

Flat:

A flat is a shallow, slow-moving portion of a stream or river, usually located at a point where it widens. Flats can be as shallow as riffles, but do not have the current speed.

A healthy stream or river usually has a combination of the above four physical features.

The width of a stream or river can determine the distance between pools. A healthy stream will have several of these features along a length equal to **6 times its normal stream width**. This width can usually be determined by measuring the width at many places from vegetation to vegetation, then finding the average width.

Procedure:

Walk the length of your study area, walking downstream. Observe the channel of the stream and note the stream features that you see.

STUDENT WORKSHEET: STREAM BOTTOM

Background:

Trout and salmon prefer a stream bottom that is a mixture of gravel, rubble, rock and boulder with a generous sprinkling of sunken logs and stumps. The rocks and gravel, especially in riffles and runs, offer the best habitat for aquatic invertebrates on which trout and salmon populations feed.

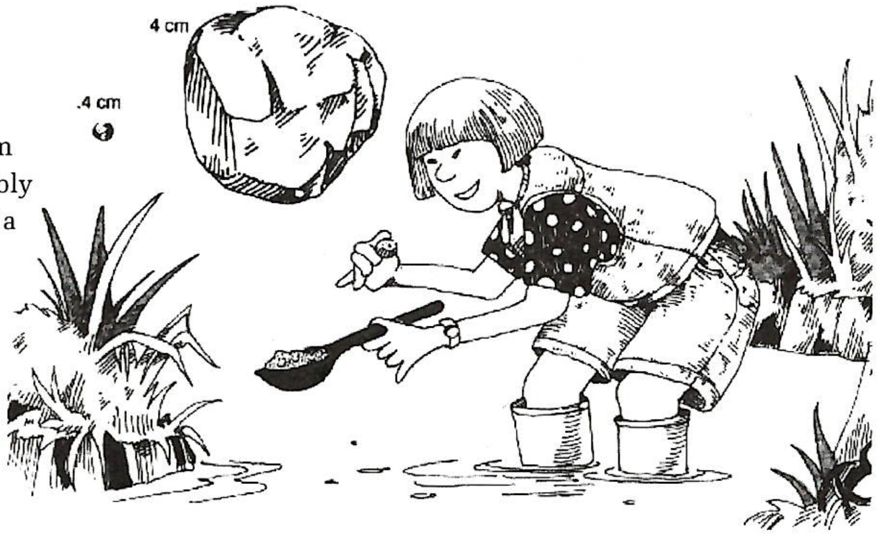
Salmon spawn at the heads of riffles or at the tails of pools. Spawning rubble varies between 1 and 8 cm in size although a medium size - about 2.5 cm - is preferred.

Brown trout begin to spawn as temperatures decrease in the fall. Females search out riffles at the tail of a pool or run that has suitable depth and gravel size (1 to 4 cm).

Because of their smaller size, brook trout prefer "pea-sized" gravel (0.4 to 2 cm), a smaller spawning gravel than brown or rainbow trout. In most streams wider than 1 m, this gravel is found in the inside bend of curves or inside channels of the main river. In slow-flowing streams that are not prone to flooding, this fine gravel may be found throughout the stream.

Procedure:

Using a scoop or a small shovel, remove a small quantity of bottom material from the stream, preferably from the head of a riffle or tail of a pool. Look for pebbles that range in size from 0.4 to 4.0 cm.



STUDENT WORKSHEET: BANK VEGETATION

Background:

In the past, little thought was given to the removal of vegetation from stream banks. Extensive areas were cleared to allow for agriculture and housing. This created problems in the form of higher water temperatures and poorer water quality.

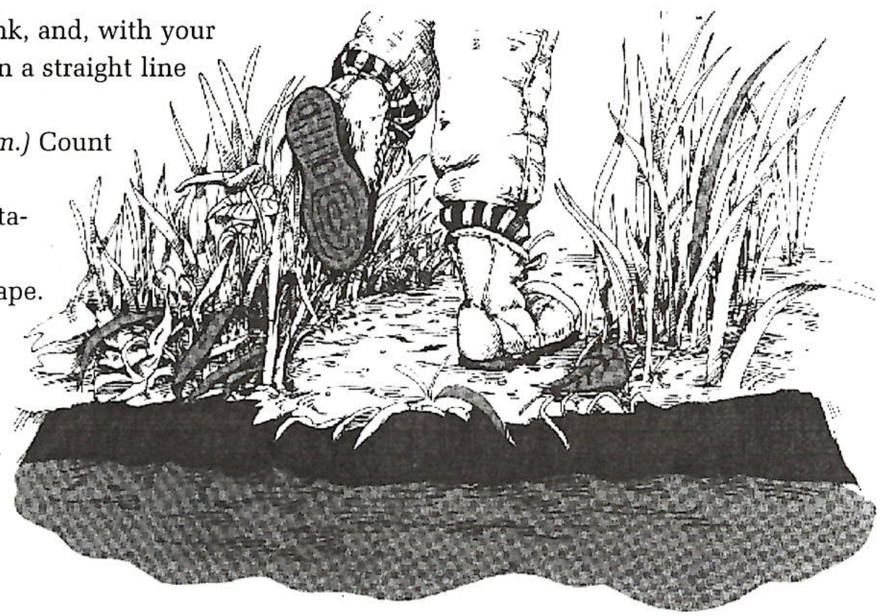
Removal of bank vegetation, poor ploughing practices and poor drainage patterns can release material from the land into the water during spring run-offs or rainstorms. These materials include fine silt, fertilizers, manure and pesticides.

Proper bank vegetation near spawning sites is important to ensure that soils are held in place leaving spawning gravels on stream bottoms free of silt and soil. A minimum of six metres of healthy plant/tree growth on either bank reduces overland runoff and decreases the likelihood of sediment entering the stream.

Procedure:

Start at the stream bank, and, with your back to the stream, walk in a straight line away from the water. *(Go perpendicular to the stream.)* Count your paces as you walk through undisturbed vegetation, or measure the distance using a measuring tape.

Repeat this on both sides of the stream at several points within your study area, and average your results.



STUDENT WORKSHEET: BANK VEGETATION

Background:

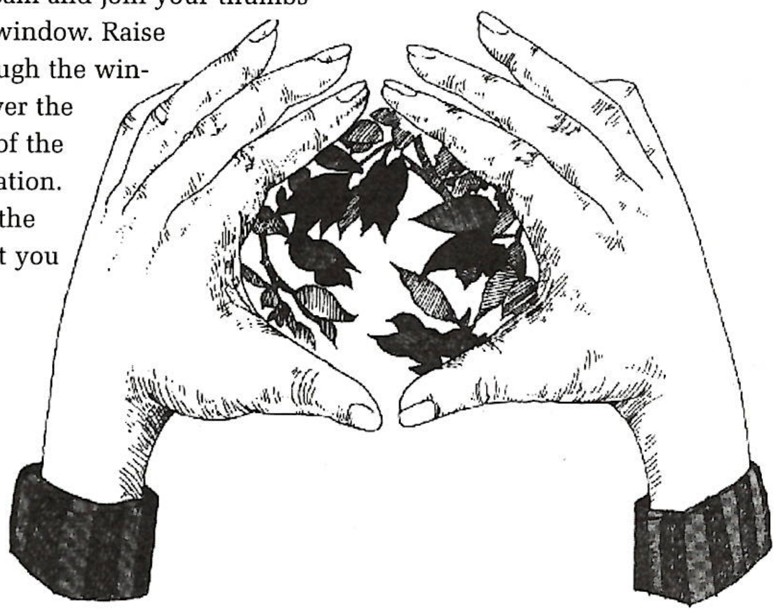
Plant growth along the bank not only stabilizes the bank, but also provides shade to the water surface, thereby regulating temperatures. This shading can be critically important in the mid-summer when air and water temperatures rise and water flows are reduced.

Too much shading, however, will reduce the production of aquatic invertebrates and result in less food for trout, salmon and other fish species. Too little shading encourages solar heating of the water, causing higher temperatures.

The percentage of shading suitable for fish varies from stream to stream and depends on factors like how much spring water enters the stream, the width and depth of the stream, and the development within the valley. Most times it is best to maximize shading along a trout stream.

Procedure:

Stand on the bank of the stream and join your thumbs and forefingers to form a round window. Raise your arms and look straight through the window at the vegetation hanging over the stream. Estimate the percentage of the window that is covered by vegetation. Repeat this at least five times in the section of the river or stream that you are surveying and average your results.

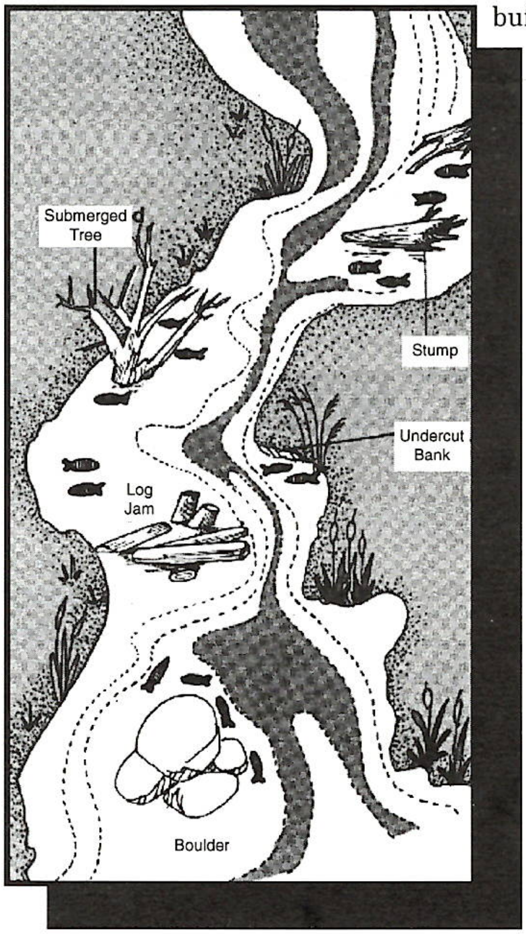


STUDENT WORKSHEET: STREAM SHELTER

Background:

Shelter is vital to the survival of trout or salmon in a stream or river. Like space, shelter requirements vary with the size of the fish. Ideally, trout like to be sheltered on three sides, which usually means top, one side and bottom *(an undercut bank is ideal)*. They also require a shelter that is a fairly close fit for their size. A shelter should break the flow of the water creating a "dead space" in or around the shelter.

Even the roughest of rapids have dead spaces as long as there is a structure that acts as a buffer to the current. In the shallows, woody debris such as branches, twigs and fallen tree limbs can provide many hiding places for small fish. When this material is absent, large sticks and small boulders can also provide good shelter areas. Larger, older fish look for shelter that is more substantial in the deeper areas of the stream. Undercut banks, log jams, stumps and boulders all offer hiding places for larger fish.



Procedure:

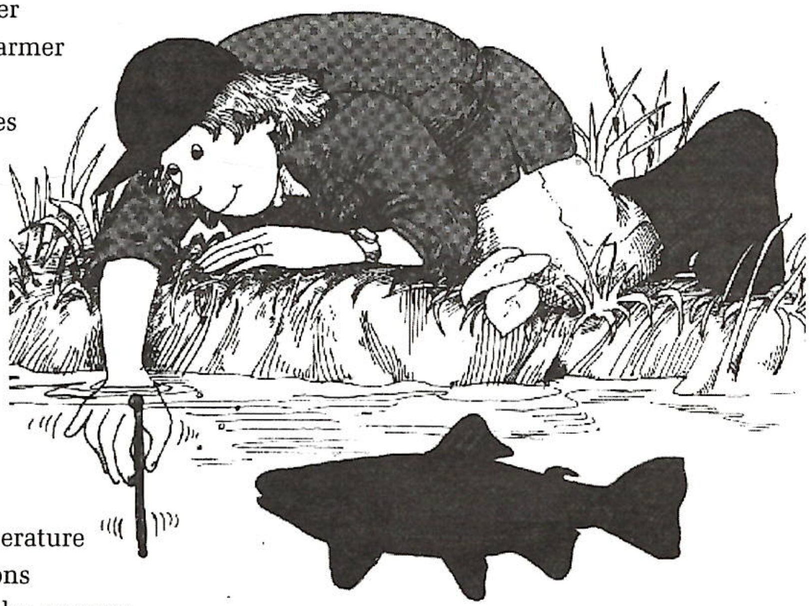
Walk the length of your study area. Observe the channel of the stream and record the shelters that you see *(particularly undercut banks, deadfalls, etc.)*.

STUDENT WORKSHEET: STREAM TEMPERATURE

Background:

Temperature often limits trout and salmon habitat more than any other factor. Stream temperatures are regulated by springs, shading and channel width. Most streams begin as springs bubbling out of the ground. Spring water comes from the melting snow and rainwater that have percolated into the soils of the surrounding hillsides.

Springs help maintain cool water temperatures in the summer and warmer temperatures in the winter. Many salmonoids die if water temperatures exceed 22 degrees Celsius for more than several consecutive days. Some fish such as rainbow and brown trout can tolerate warmer temperatures *(to a maximum of 24 degrees Celsius)*. It is best if a stream that produces salmonoids never reach such temperatures.



Procedure:

Using a thermometer, take the temperature of the water at three or more locations within your survey area. Calculate the average.

STUDENT WORKSHEET: POPULATION ESTIMATION

Overview:

In this activity, students will estimate and then count the populations of various life forms within a predetermined area. An aquatic area will then be studied, information compiled and the two study areas compared and contrasted.

Objectives:

Students will be able to:

- make a reasonable prediction of the population of life-forms within a given area
- compare and contrast their terrestrial study area with their aquatic study area
- make a hypothesis on past and future population numbers
- demonstrate mathematical skills of estimating, counting and graphing

Time:

two forty-minute periods *(excluding travel time)*

Materials:

- magnifying glasses
- string or twine
- small pails
- wooden stakes
- notebooks
- microscope *(if available)*

Advanced Preparation:

1. PREPARE SITES: Using four stakes, block an area several square metres for each group. To help define the areas, twine may be strung from stake to stake, enclosing each study area. *(This may make it easier to ensure that groups stay together too!)*

2. STREAM STUDY: If you choose to allow your students to do a comparative study of a stream, it is best to select the sites well in advance. *(See guidelines in "Just for Teachers.")* Remember, even slight rainfalls may cause a brook or river to rise significantly within a short period of time.

Process:

1. Assign groups of students a specific grid area to survey. Students should take note of both plant and animal life-forms that they encounter (including insects). *NOTE: It is not necessary for students to identify all they find.*
2. Once estimates are complete, and actual counts have been made, results may be graphed in two or more categories. *(i.e. plant, animal, insect)*
3. The above process may be repeated, using a stream or stream-side area as context.

Follow-up Questions:

1. What obvious signs of human impact do you see? Are they helpful or harmful impacts?
2. What could be done to improve the sites? Would the improvements benefit the animals and plants that live there? Why or why not?

Evaluation:

Evaluation may be based on the information compiled, and their answers to the follow-up questions. Attention should also be given to how the group members worked together.

Possible Extensions:

1. Students may perform a similar study using water samples from various locations (pond, swamp, stream, etc.) and a microscope. What similarities are there in the results? What differences?
2. Arrange for a guest speaker on a related theme: fishing, landscaping, outdoor recreation, etc.
3. Explorations in Science, level six "In the Field-Transect Study" Fish Fate (C-11) human impact, changes in habitat.

TEACHER: WHATA' LOTTA' WATER!

Overview:

As streams and rivers flow, they naturally pass through deep and shallow areas. Both are important to the life-cycle of organisms within the water. Deep areas, for example, often have springs, which add cold water to the river or stream. This provides habitat for fish such as salmon, that require cooler temperatures when overall water temperatures have increased.

When considering oxygen content and water temperature, shallow areas in the stream or river are particularly important. As water passes over rough shallow areas, the water aerates, increasing oxygen content and at the same time lowering water temperatures. As water velocity decreases due to lack of precipitation, etc., the oxygen content drops and water temperatures rise. This leads to habitat conditions that may not support certain aquatic life-forms such as salmon or trout.

An important part of overall stream assessment is measuring a stream's velocity. This, coupled with dissolved oxygen level, help to indicate the habitat condition of a body of water. Such information is useful in making fish-management decisions.

Objectives:

Students will be able to:

- make accurate measurements and record data
- calculate stream velocity and stream area
- understand the concepts of stream velocity and volume

Subject Links:

- math
- science

Time:

20-30 minutes of field work

Materials:

- 100' measuring tapes
- objects that barely float *(orange, apple, etc)*
- timer or stop-watch to record seconds
- worksheet

Advanced Preparation:

Arrange for a field trip to a local stream. You may wish to have students complete their stream survey at the same time. Be sure to check out the area beforehand, to ensure the safety of all students.

Process:

1. Explain the concept of water velocity to students. It may be helpful to work through a couple of examples with them.
2. Divide students into small groups. Distribute worksheets to each group. Have each group complete the worksheet.

STUDENT WORKSHEET 1
WHATA' LOTTA' WATER!

Velocity:

To find the water velocity of the stream, measure and mark a 30 metre distance along a straight section. If you can't find a 30 metre section, use 10 or 15 metres. Throw a stick or an orange, apple, or some other object that barely floats *(so it won't be affected by the wind)* into the water far enough above the upstream marker for it to reach the speed of the water before it reaches the first marker. Measure the number of seconds it takes to float downstream between the markers. Record below. Now divide the 30 metre distance by the total seconds it took the object to float between the stakes. ***Do this three times, then find the average.*** An example is provided for you.

$$\frac{\textbf{Number of Metres}}{\textbf{Number of Seconds}} = \_\_\_\_ \textbf{ metres per second}$$

$$\frac{\textbf{30 Metres}}{\textbf{10 Seconds}} = \underline{\ \ 3\ \ } \textbf{ metres per second}$$

1st Measurement: $\frac{\_\_\_\_ \text{ Metres}}{\_\_\_\_ \text{ Seconds}} = \_\_\_\_$ metres per second

2nd Measurement: $\frac{\_\_\_\_ \text{ Metres}}{\_\_\_\_ \text{ Seconds}} = \_\_\_\_$ metres per second

3rd Measurement: $\frac{\_\_\_\_ \text{ Metres}}{\_\_\_\_ \text{ Seconds}} = \_\_\_\_$ metres per second

Average velocity = ____ metres per second

Stream Width:

1. To find the average width of the stream, measure the width three times within your work area. Find the sum, and divide by three.

1st Measurement: _____metres

2nd Measurement:_____ metres

3rd Measurement: _____ metres

$$\frac{\text{total metres}}{3} = \frac{\_\_\_\_ \text{ metres}}{3} = \_\_\_\_\_\_\_\_ \text{ metres (average width)}$$

STUDENT WORKSHEET 2
WHATA' LOTTA' WATER!

2. The average depth of your section of the stream may be found by measuring the depth of the stream in 3 places across the stream in a straight line. Measure the depth in the middle, and halfway between the middle and stream bank *(on both sides of the centre mark).* Divide the total by 4 to get the average depth of the stream.

1st measurement: ________metres

2nd measurement:________metres

3rd measurement: ________metres

$$\frac{\text{total metres}}{4} = \frac{\_\_\_\_\_\_\_\_\text{ metres}}{4} = \_\_\_\_\_\_\text{ metres (average depth)}$$

NOTE: The reason you take 3 depth measurements then divide by 4 is to take into account the shallow areas of the stream. If the depth in three places is 2 m, 3 m, and 2 m, then the average depth is 1.75 m.

Discharge Volume:

Discharge volume is how much water is flowing in the stream at this time. This is calculated by finding the number of cubic metres of water per second. To do this, multiply the average number of metres the object floated per second, the width and the average depth.

metres/second x width x average depth = cubic metres of water per second

________m/second **x** ________m **x** ________m = ________*(Cubic metres of water per second)*

NOTE: A cubic metre of water is what may be contained in a volume 1 metre wide, 1 metre high and 1 metre long. It contains 1000 litres.

To determine the stream's discharge in litres:

multiply the cubic metres/second x 1000 ***(litres in 1 cubic metre water)*** **= ______ ℓ**

To determine the number of litres of water per minute:

multiply the number of litres/second x 60 ***(seconds per minute)*** **=______ ℓ/minute**

TEACHER: A BREATH OF FRESH WATER

Overview:

Water quality and levels of dissolved oxygen are vitally important to the survival of fish. Through the following **three** activities, students will role-play fish, examine either live or preserved fish and experiment with water in an attempt to explore the role and distribution of dissolved oxygen within a fish's habitat.

Objectives:

Students will be able to:

- recognize the gills of a fish and explain their function
- explain the role of oxygen as a potential limiting factor in aquatic environments and be able to identify at least two causes of an increase or decrease in dissolved oxygen.

Time:

one and one-half hours to two hours (preferably over several periods)

Materials:

- brightly coloured adhesive dots
- glass jars or bottles
- fresh frozen or preserved fish
- baggies or surgical gloves
- petri dishes *(or similar substitute)*
- water chemistry kit for testing dissolved oxygen levels
- aquatic plants
- tweezers
- microscopes or hand lenses
- teacher resource sheet

OPTIONAL:

- classroom aquarium with live fish
- small fish net
- fish bowls or glass jars
- non-toxic food colouring

Background:

Fish are different from most other vertebrates because they are able to take their oxygen directly from water. Oxygen, a colourless gas found in air and water, is essential to all plants and animals. Most land animals have lungs, which absorb the oxygen from the air and transfer it to the blood. The blood circulates to all of the animal's cells where the oxygen is used. The blood then carries carbon dioxide and impurities from the cells back to the lungs where they are exhaled.

Most aquatic animals, including fish, extract oxygen directly from the water using their gills. Gills are, in fact, far more efficient than lungs, extracting about 80 percent of the oxygen from the water that flows over them, while lungs extract about 25 percent of the oxygen from inhaled air. There is, however, approximately 26 times as much oxygen in the air than in reasonably well-oxygenated water.

Dissolved oxygen levels in natural water bodies can vary greatly, depending on many factors. Oxygen levels increase when: temperatures decrease, water flows and bubbles over rocks, and plants release oxygen into the water through photosynthesis. Oxygen levels decrease when: temperatures increase, animals and plants respire, and waters calm. Pollutants such as ferrous iron (found in municipal and industrial waste-treatment processes), sulphates (found in wood pulp processes), and the decay of organic materials also serve to lower oxygen levels.

The levels of dissolved oxygen in a body of water can be a limiting factor to what may live there. It is difficult to determine the minimum level of dissolved oxygen required to support fish life, since different species have various requirements. The level below which a fish exhibits behavioural or physiological change is referred to as its response threshold - the level below which a fish dies is its lethal limit. Both may vary with the size of the fish, age and the temperature of the water.

Water is taken through the fish's mouth and passes over the gill rakers, then over several rows of gill filaments (found under the gill cover). This is where the oxygen and carbon dioxide exchange occurs in tiny blood vessels. The hard, bone-like arches are the gill arches, which support the gill filaments and rakers, and contain the blood vessels. These are the three components of the gills.

Process:

PART ONE: FISH OBSERVATION

1. Divide the class into groups of three or four students. *Allow students to wash their hands before and after handling fish. If live fish are to be handled, students should take particular care to rinse their hands well, as detergent is extremely harmful to fish.*
2. Let each group take a turn at netting a fish from the aquarium and putting it in a jar or fish bowl.
3. Ask students to observe the fish, paying particular attention to the operation of the mouth and gill cover. The following questions might serve as a useful study guide:
   - Where are the gills?
   - How are the movements of the mouth and gill cover related?
   - Does the gill cover open after the mouth closes, or the other way around?
   - Does there seem to be a difference in mouth/gill cover motions and their timing and sequence when the fish swims or when stationary?
   - Does the size of the mouth opening during respiration vary with swimming speed?
   - Does the opening and closing of the gill cover change with swimming speed?
4. Have students add a drop of food colouring in the water near the fish's mouth and observe the movement of the water as the fish breathes. Have them record their observations.
5. Share the diagrams on the teacher resource sheet to help them confirm their observations.

PART TWO: SIMULATION

1. This activity will allow students to compare their respiration to that of fish. Have students hold their breath. As they hold it, ask them to think about whether they have ever been in a situation where oxygen (air) was difficult to come by, where they couldn't "catch their breath." Have them imagine needing to run over to the other side of the school before being able to breathe again.
2. Inform students that fish are not always so lucky; we can usually get fresh air when we need it. To demonstrate, have the students take on the role of a fish. Scatter coloured dots around the room to represent dissolved oxygen. Each fish must touch one in order to take a breath. (They don't have to remain touching as they take the breath.) Students can only take one breath per dot, and must move to a new dot in order to take another breath.
3. Have students assume the role of fish. Once they have had opportunity to experience the difficulty with finding "oxygen," stop the simulation and have students note the distribution of fish. Explore what might create more oxygen in one place, less in another. *POSSIBLE ANSWERS FOR MORE: turbulence, plants giving off oxygen, low temperatures. POSSIBLE ANSWERS FOR LESS: Lack of turbulence/mixing, decay of organic materials, animal respiration, pollutants, etc.*

PART THREE: EXPERIMENTATION

1. Have students fill some large bottles (large mason jars work good) with tap water and design their own experiments about oxygen content in water. You will need a dissolved oxygen test from a water chemistry kit, or a dissolved oxygen metre that you might be able to borrow from a high school or science department of a university or the Department of Natural Resources and Energy. *(See resource list in the Appendix.)*

   The following suggestions may help guide the students:

   - Alter water temperatures in one or more jars over time and test the oxygen content for changes.
   - Test and compare the oxygen contents of water that has been agitated to varying degrees: leave one jar stagnant, shake the second jar every three days, and shake the third jar every day. Measure the oxygen content over time.
   - Test the effect of plant life on the oxygen content in the jars by putting no plants in one jar, one plant in the second jar, and several plants in the third jar. Note the differences between the jars if they are completely covered for one day.
   - Experiment with various amounts and types of decaying plants and common household materials that often find their way into streams. How does their deterioration affect oxygen levels?

Evaluation:

Given a fish's dissolved oxygen limit, students must decide what conditions may be required to produce adequate levels for that species. How can the habitat be improved to provide those conditions?

Possible Extensions:

1. Replay the simulation exercise with some students as more efficient oxygen users (3 breaths for every dot touched). Could these fish be more likely to range into low oxygen areas than other fish? Why or why not?

2. Visit a local stream and test for oxygen levels in the water. Be sure to test above and below riffles or falls, in pools, above and below discharge pipes, etc. Have students develop a list of factors that would help put more oxygen in the water. *(POSSIBLE ANSWERS: plant life, air mixed into the water by turbulence in waterfalls and riffles, etc.)*

3. Gill Dissection:

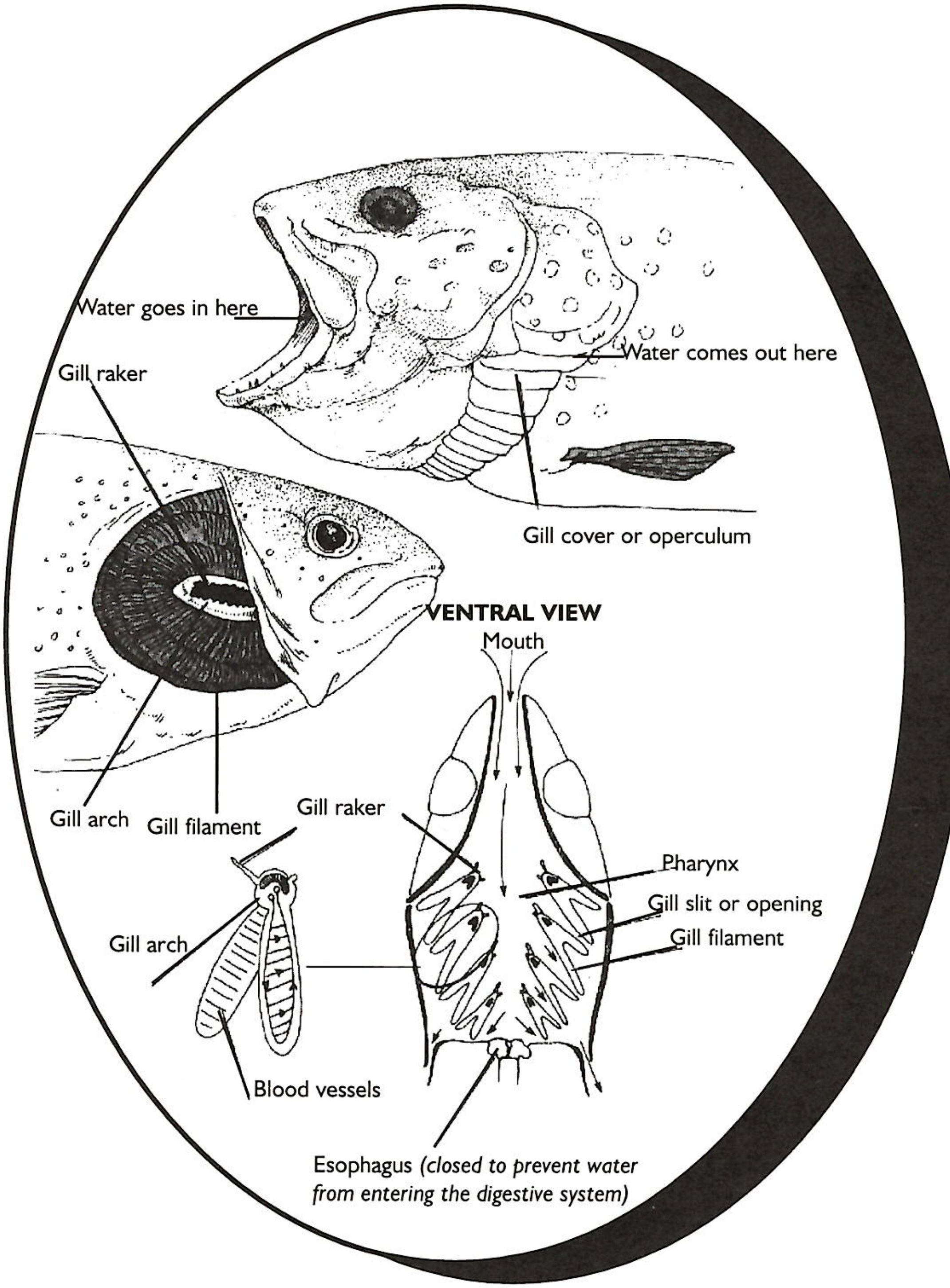
   a) Allow students to do this simple gill dissection. Have students lift the gill cover with tweezers, exposing the gills. Encourage them to feel the soft gill filaments and sharp gill rakers then describe their position and how they feel.

   b) Have students remove one gill arch with the tweezers and place it in a petri dish. Add a few drops of water to keep it moist. Point out the three parts of the gills. Have students examine each part carefully. Ask them to note the position of the gill filaments on the gill arch and to imagine the direction in which water would pass by.

   c) Help students take a sample of each part and examine it under a microscope.

   d) Have students draw a diagram of the gills and describe the gill parts. They might then compare their drawings with the Teacher Resource Sheet for accuracy.

TEACHER RESOURCE SHEET: A BREATH OF FRESH WATER



TEACHER: SUPER STURGEON

Overview:

The Saint John River has a world distinction for suitable sturgeon habitat. At one time endangered, the species is now somewhat stable. A record-sized sturgeon was caught in a fish net on the Saint John River in 1924. The fish was 4.27 m (14 feet) long with a mass of 324.4 kg (811 lbs). Through this activity, students will "recreate" that sturgeon.

Objectives:

Students will be able to:

- collect and compare data, organize information into charts, graphs and models
- develop measuring skills
- describe the external characteristics of a sturgeon

Time:

one and one-half hours to two and one-half hours

Materials:

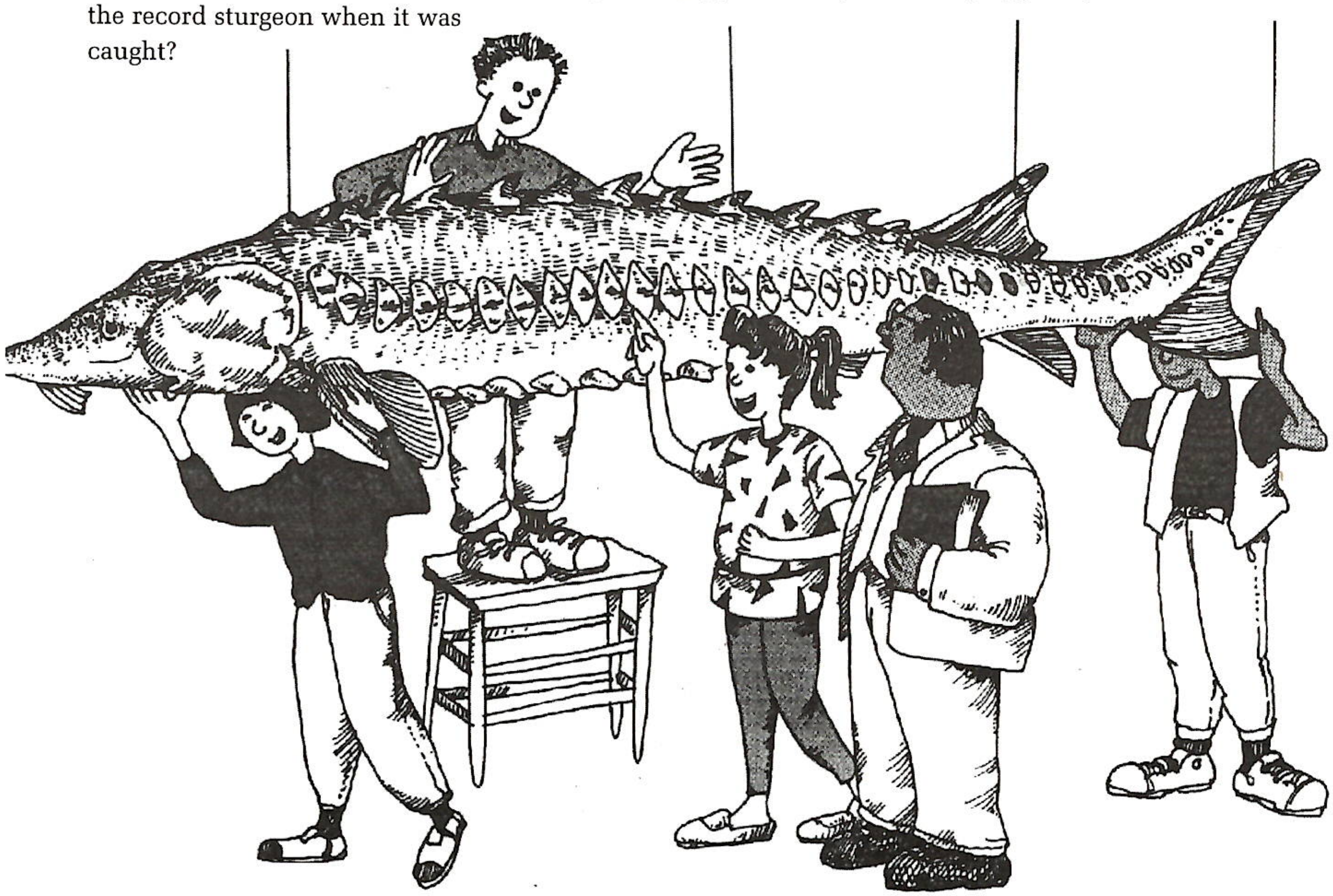
- Student Worksheet
- paper or newsprint in metre lengths
- metre sticks (one per group)
- thick pencils or crayons
- newspaper
- glue or stapler

Process:

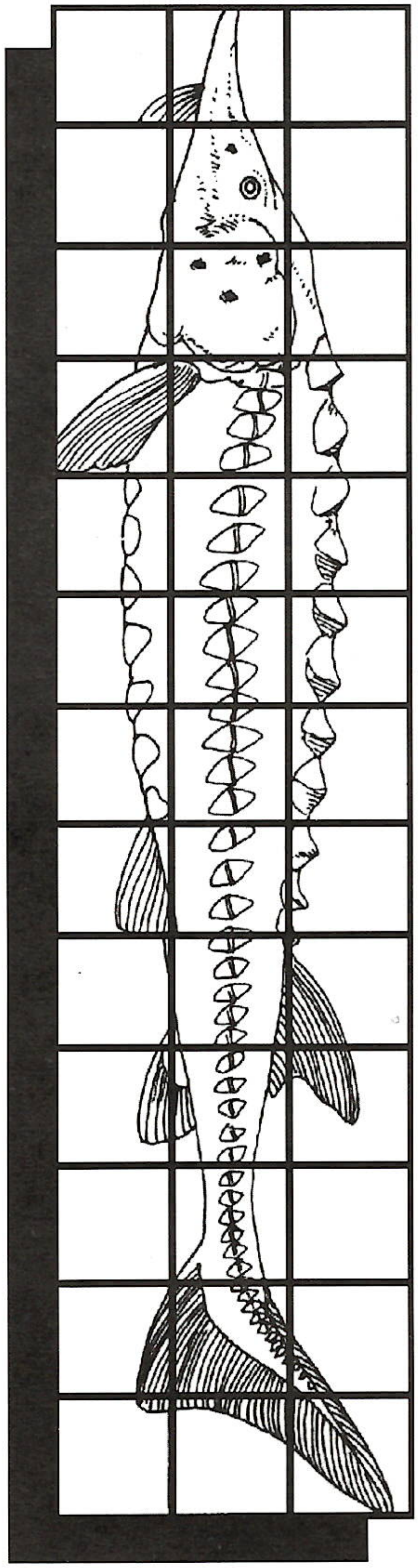
1. Ask any students who ever caught a large fish to stand and indicate the length of the fish with their hands.
2. Have the student with the largest fish come forward with hands still marking the length of the fish. Ask the rest of the class to estimate the fish's length in centimetres. Have a student measure the indicated length and poll the class to find out how accurate their estimates were.
3. Have students guess the length and mass of the largest fish caught in the St. John River. Introduce the Atlantic sturgeon to students using the fact sheet in "Understanding Fish."
4. Distribute a copy of the Student Worksheet to each student and explain that this is a scale drawing of one of the largest fish caught in our province. The scale is 1:32.7 (each square represents 32.7 cm of fish.) Discuss with students how scale can be used to reproduce the full scale outline of the fish.
5. Divide the class into groups of three or four. Have them use a metre stick to draw on the paper or newsprint a grid 3 by 13 squares, with each square 32.7 cm per side.
6. Once their grids are drawn, have students duplicate each square from the student worksheet to their larger grid to make a full-size outline of the record Atlantic sturgeon. *NOTE: Students may find it helpful to number the squares on both grids before starting the full-scale drawing.*
7. Discuss with students their impressions of the giant sturgeon.

Possible Extensions:

1. Depending on student time and interest, students may research the colouration of the Atlantic sturgeon and paint or colour their replicas appropriately. The drawings can be put together with staples or glue, stuffed with newspaper and hung from the ceilings to create a dynamic underwater world in the classroom.
2. Have students construct a time line of historical events that occurred during the life of this fish.
3. Have students find out the average number of eggs a female sturgeon produces per kg of body mass. How does this compare to other Maritime species? Approximately how many eggs may have been in the record sturgeon when it was caught?



STUDENT WORKSHEET



TEACHER: GRAY LADY DOWN

Overview:

Many of the external features of a submarine serve much the same purposes as the external features of a fish.

Objectives:

Students will be able to:

- develop an appreciation for the external features of a fish that enable it to live in its environment
- demonstrate skills in making inferences and predictions based on observations
- develop an awareness of design in natural and artificial objects

Subject Links:

- science

Time:

forty-five minutes to one hour

Materials:

For each student:

- student resource sheet
- student worksheet

Background:

Three "frontiers" have long fascinated humans: the atmosphere, oceans and space. What a thrill it would be to soar the skies like a bird, glide through the underwaters with the freedom of a fish or experience the weightlessness of outer space. Human travel beneath the water was extremely limited prior to the development of scuba gear (self-contained underwater breathing apparatus) and submarines. Many of the external features of a submarine mirror the structures and functions of external fish features.

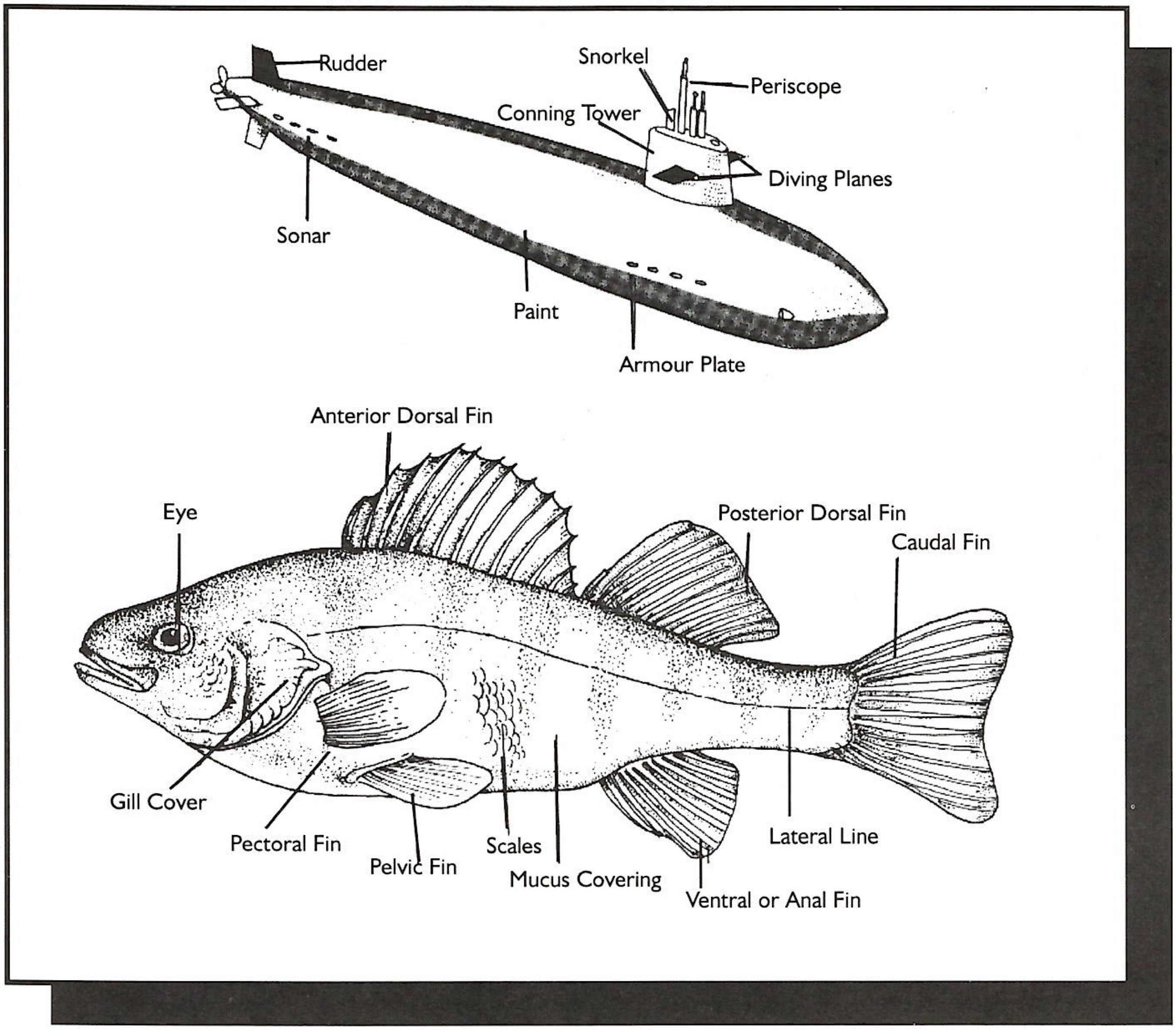
The **armour plate** on a submarine resembles the **scales** of fish and serves to provide cover and protection. Unlike a fish, however, a submarine's plate must be rigid to prevent implosion under extreme pressures. Implosion is not a concern with fish since they have little or no internal "air space." In addition many fish can adjust the amount of gas in their swim bladder s to compensate for changes in pressure as the fish rises or sinks.

Anti-fouling paint protects the submarine's plate from damage by algae and barnacles much the same way the **mucus layer** covering a fish's scales protect them from harmful fungi and bacteria.

The **hydroplanes** of a submarine act much like the **pelvic fins** of a fish. They can be moved to help maintain position, dive or brake. The **conning tower** of a submarine (sometimes called the sail), and the **dorsal** and **anal** fins of a perch have the same function: to help maintain an upright orientation. The pitch and roll of the submarine are thus controlled by the hydroplanes and the sail in much the same way that a fish's motion is controlled by its fins.

The submarine's **rudder** is used to change direction by swinging it toward the direction of the turn. (The resistance of the water directs the movement.) The flexible **caudal fin** of a fish works much the same way. When slow forward speed is required, or turns in a confined area, submarines often use **steering engines** similar to a fish using its **pectoral fins.**

A **periscope** allows those in the submarine to have a 360 degree view range. Similarly, a fish's **eye** allows it a viewing range of close to 360 degrees, to better escape predators and locate food.



The **sonar** receivers of a submarine allow the operator to send and receive low-frequency signals. Fish do not have ears; rather they have a **lateral line** which runs along each side from gill to tail. This line receives low-frequency vibrations, thus providing the fish with a means of sensing disturbances in the water around them.

The **snorkel** of a submarine allows oxygen to enter the hull of the ship when the submarine is close to the surface of the water. When the submarine is submerged, the air inside must be continually refreshed with stored oxygen. Fish obtain their oxygen in a different manner. Water is forced to flow over the **gills** beneath the gill cover, which absorb dissolved oxygen from the water into the body.

Process:

1. Discuss with students the difficulties humans encounter when attempting to spend long periods of time in an underwater environment. (Air supply, nitrogen concentration, maneuvering, navigating, etc.)
2. Discuss the technologies that have been developed (scuba, submarines, etc.) to overcome these problems and what inspired those technologies (fish).
3. Have students observe and compare the external structure of fish with that of the submarine outlined on the student resource sheet. Using similarities in form and structure as an aid, have them complete the right-hand column of the student worksheet.
4. Have students compare their conclusions with those of their classmates.

Evaluation:

Have students brainstorm possible future improvements or adaptations to submarine technology or scuba based on fish structures.

Possible Extensions:

1. Have students make models of submarines and fish by starting with the same cylinder shape and adding parts. Test them in water tables, tanks, pools or a stream.
2. Have students compare the design of other inanimate objects to animate objects, especially considering external features. (For example, birds and airplanes.)

STUDENT WORKSHEET: GRAY LADY DOWN

USING the diagram on your Student Resource Sheet, compare the structures of a submarine to those of a fish. List an adaption of the fish that performs a function similar to that of each part of the submarine listed below.

SUBMARINE	FISH
Armour plate - protects the submarine's inner hull	
Anti-fouling paint - protects the submarine from rust and growth of small aquatic organisms	
Forward hydroplanes - assist the submarine in stabilizing and diving	
Conning tower - helps keep the submarine in an upright position	
Periscope - allows for a 360 degree field-of-vision; some can also look up and down	
Rudder - uses the water's resistance to change direction	
Sonar detectors - records low-frequency vibrations from moving objects nearby	
Snorkel - allows oxygen to enter the hull	

TEACHER: BUILT FOR SPEED!

Overview:

Students will compete to design the most efficient fish for moving in flowing water. This will be simulated by testing their models in a stream of air. In so doing, students will investigate how the shape of a fish and the size and placement of its fins are related to drag and stability.

Objectives:

Students will be able to:

- identify the relative efficiency of various fish shapes in moving through water
- determine the most stable arrangement and function of fish fins

Subject Links:

- science
- art

Time:

a minimum of two hours

Materials:

- plasticine (pieces of about 100 g)
- rulers
- vacuum cleaners or hair dryers
- scissors
- clamps
- string
- blocks of wood (2" x 4" or 2" x 6")
- thin cardboard
- retort stands

Background:

FRICTION is the force that resists the motion of one surface relative to another with which it is in contact. When two surfaces move against each other, friction is created. Regardless of how smooth a surface may appear, it has irregularities, sometimes so small they can only be seen with the help of a microscope. These humps and irregularities create **restrictions**, forcing any fluid or air flowing over the surface into irregular paths. This irregular flow is known as turbulence. **Drag** is the combined effect of friction and turbulence acting on an object. The greater the drag, the slower the shape will be able to move through a fluid or air, hence design is vitally important for airplanes, ships and species of animals.

Some fish are designed to live in non-flowing situations; their shape is most efficient for hovering or feeding along the lake bottom. The focus of this lesson will be fish that are designed for life in flowing streams, where body shape is important for feeding or travel.

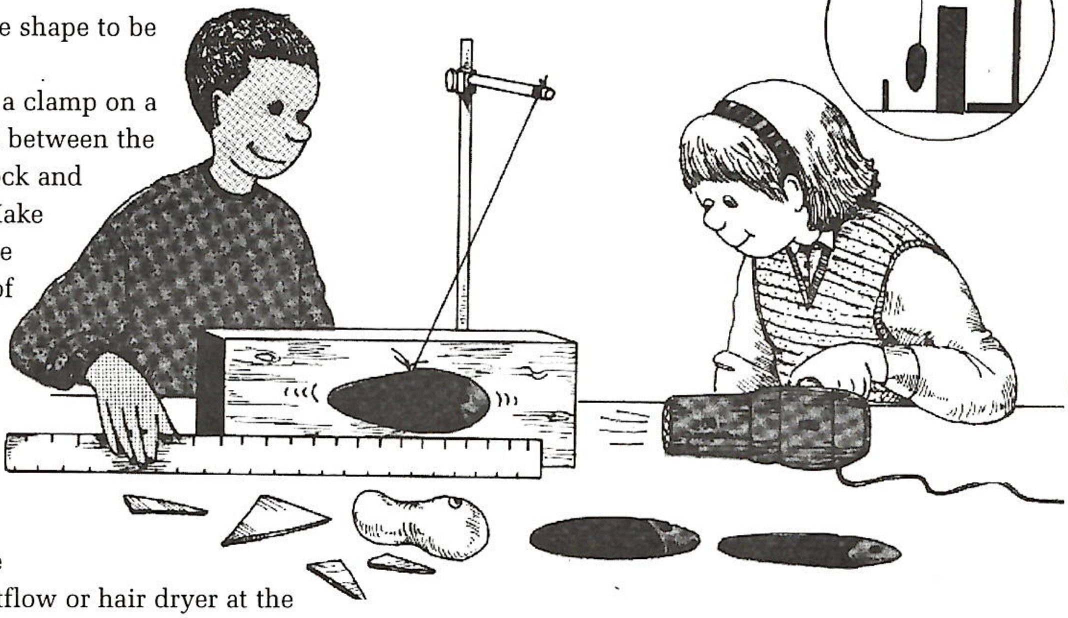
For the purposes of this lesson, the most efficient shape will be the one that can be pushed along a ruler the least distance by a stream of air. From this, students should be able to infer that the fish that moves most efficiently in the water is the one that is most streamlined.

Students will find it helpful if you demonstrate this activity at least one or two times. Plenty of time should be allotted for students to experiment with various body shapes and designs to determine their most efficient model.

Process:

1. Help students understand the relationship between body shape and adaptation of a species by discussing the following questions:
   - What body shape would a fish living in shallow, vegetated habitat have?
   - What body shape would a fish living at the bottom of a large, deep lake habitat have?
   - What body shape would be most beneficial to a fish if it lives in a large, deep lake where it is a predator of smaller fishes and prey to larger fishes?
   - What body shape would allow a fish to move easily through the strong current of a swiftly-flowing stream?
2. Divide the class into groups of three or four. Have each group make three or more plasticine shapes, with the least amount of drag possible.
3. Have students test their shapes in the stream of air generated by the vacuum cleaner or the hair dryer as follows:

   - Suspend the shape to be tested on a string from a clamp on a retort stand between the wooden block and the ruler. Make sure that the front edge of the shape is just alongside the 0 mm mark on the ruler.



   - Position the vacuum outflow or hair dryer at the predetermined distance from the edge of the ruler.
   - Turn on the vacuum and measure the maximum distance travelled by the anterior (front) tip of the plasticine shape along the ruler; record this distance.
   - Note the stability of the shape in the stream of air and record it. You might use a scale from 0 to 5, where 0 represents a shape that spins uncontrollably and 5 represents a shape that is completely steady and unwavering.
4. Have students cut out cardboard fins of various sizes and shapes and insert up to five of these into the plasticine shapes they found to have the least drag.
5. Have students repeat the vacuum hose test with various types and placements of fins and record the results.
6. When all the students or groups have found arrangements that they consider to be as stable as possible, have all the fishes in the class compete in the vacuum test to see which is the most efficient model.

Evaluation:

Have students compare their fishes to those on the fish poster. How are they the same? How are they different? Which fishes are suited for fast or slow moving water?

Possible Extensions:

1. An interesting extension would be to follow the classroom test using a real stream setting. Have students suspend their fishes from a metre stick placed above the water and observe the behaviour of the various models.
2. Have students examine fishing lures and note how the design features of the lure affect its movement through the water. Different kinds of lures such as plugs and spoons could be compared. Students may also compare the lures' movement to that of the fishes. Many lures are designed to resemble an injured fish by moving in an erratic or unstable fashion. Some students may find it interesting to make lures from old spoons or wood.

TEACHER: HABITAT RESTORATION BASEBALL

Overview:

The following game is a great way to learn general material and review.

Objectives:

Students will be able to:

- articulate questions they want to have answered
- gain research knowledge
- review material for a test/quiz, etc.

Time:

forty-five minutes to one hour

Materials:

- index cards

Process:

1. Brainstorm different subject areas as they relate to habitat restoration. (Basic information found in teacher's manual.)
2. Divide students into small groups or pairs to research chosen areas.
3. Use research to formulate questions of four levels of difficulty, with 1 being the easiest and 4 the hardest. Provide answers as well. Each group will develop at least five questions at each level of difficulty. (This will provide you with at least two hundred questions to form your data base.)
4. Using your questions and answers, as well as related information, put together a short presentation to share information with the rest of the class. Put questions and answers on index cards; 1 question and answer per card.

Game Rules:

- Collect index cards and classify
  1. Single (easy)
  2. Double
  3. Triple
  4. Home run (difficult)
- Shuffle cards within each level, set up 4 bases within the classroom and divide the class into 2 teams and establish "batting order."
- The first player from team 1 requests what level of question he/she desires, for example: triple. If the player answers the question correctly, he/she moves to the third base. If the player answers incorrectly, he/she is out. After three outs, the other team plays. Play as many innings as time permits.

This lesson was prepared by Phyllis, Mike, Shawna, John and Pam at a curriculum development workshop April 4/96.

TEACHER: HOW LONG?

Overview:

The following lesson teaches how to find the length of a river or stream.

Objectives:

Students will be able to:

- identify and locate a specific local habitat on a map
- use map symbols
- use the map's scale to determine the length of a waterway

Time:

one forty-minute period

Materials:

- provincial map
- hi-lighters
- string to measure
- metre stick

Process:

1. Pass out maps. Help students locate a specific watershed. Use hi-lighters to trace the river or stream from its origin to its mouth.
2. Explain and review map scale. Ask students how to determine the length of the waterway. Determine several methods to calculate its length. Which seems to be the most accurate?
3. Review the name of the waterway, the actual length of the waterway, and the method by which its length was determined.

Possible Extension:

Assign students to write a journal entry about what happened today. Explain that they used skills of taking initiative, cooperating and problem solving. They could complete the following thoughts: "Today was great because . . ." "What did you learn today?" or "What will happen next?"

This lesson was prepared by Phyllis, Mike, Shawna, John and Pam at a curriculum development workshop April 4/96.