TROUT IN THE CLASSROOM

“Lesson Plans”

50 YEARS

TROUT UNLIMITED

Bluegrass Chapter

2010 / 2011

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Salato Wildlife Education Center
Salato has an outdoor classroom. This area is a great meeting place to gather your students for activities or for a break after hiking the trail. Special features of the classroom include critter trap doors, brush piles, ample bench seating, a teaching bench, a view of multiple habitats, and easy access to Salato's trail system. Outdoor Classroom is not wheelchair or stroller accessible at this time.

Many thanks especially to Joan and Arthur Stoliar whose tireless efforts and devotion have made TIC the wonderful, inspiring program it is today.

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Editor and Writer:
Christine Economos
Don Thompson, KY Regional TIC Coordinator

Art:
Eric Hamilton,
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Design: Armistead Booker, Don Thompson KY Regional TIC Coordinator

Reviewers:
Phil Dickler, John Bowne High School

Matt Rota, Trout Unlimited
Rob Roberts, Trout Unlimited
Arthur Stoliar, Theodore Gordon Flyfishers
Barbara Taragan, NYC Department of Education
Kim Estes-Fradis, NYC DEP
Marilyn Steneken, Sparta Middle School
Sandy Broughman, KY TIC, KY TU Councilman
Gary S. Rose, KY TIC, KY TU Councilman

The following resources were consulted in preparation of this guide:
River Watch Network: River Monitoring Study Design Workbook
California's Salmon and Steelhead: Our Valuable Natural Heritage
(Published by Trout Unlimited, California Council)
Trout Unlimited Coldwater Conservation Guide
Fish Eggs to Fry: Hatching Salmon and Trout in the Classroom
(Oregon Department of Fish and Wildlife)
An Educator's Resource Guide for Hatching Salmon and Trout in the Classroom
(Oregon Department of Fish and Wildlife)
New Jersey version of Trout in the Classroom Activity Guide edited by Miriam Dunne,
NJ Department of Environmental Protection, Division of Fish & Wildlife. February 2006
USDA Natural Resources Conservation Service (NRCS), May 2000, Number 13
Water Research in Kentucky: http://www.water.ky.gov/
Tutorial on Water-quality: http://nwis.waterdata.usgs.gov/tutorial/finding_qwdata.html
USGS Water Watch for KY: http://waterwatch.usgs.gov/?m=real&w=gmap&regions=ky
Emerging Contaminants: http://ky.water.usgs.gov/prog_highlights/
Fish Consumption Advisory: http://www.water.ky.gov/sw/advisories/fish.htm
Karst Topography Movie: http://www.watersheds.org/earth/karstmovie.htm
Trout in the Classroom website: http://www.troutintheclassroom.org/
Kentucky Department of Fish and Wildlife Resources
Macroinvertebrate Identification Sheet (University of Kentucky Tracy Farmer Center for the Environment)
Macroinvertebrates and Chemical Water Testing (University of Kentucky TFCE)
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Introduction to Lesson Plans

Lesson plans may be rearranged in any order that follows the progression of activities pertaining to raising trout in the classroom and the eventual release of trout at streamside. The lessons presented in this document are basically for the 6^{th} to 8^{th} Grade level. The teacher may plan and adapt lessons adjusting them down to grade level 1 and up to grade level 12 with changes as deemed appropriate with the Kentucky Program of Studies – Science and Big Ideas guidelines. Please refer to KY POS for Science via the link below.

Depending upon the grade level of the students in the classroom, the teacher may decide to add lessons plans from other state's "Trout in the Classroom" programs or instead of adapting the lesson plans to fit the students' grade level, she/he may decide to skip a particular lesson plan in this set because students may not be able to comprehend the data presented.

Reference Kentucky Program of Studies KY POS - Science

Reference ISTE National Educational Technology Standards

Reference 21^{st} Century Skills

In addition to lesson plans, this course involves checking water quality, temperature, pH and ammonia in the aquarium along with keeping a journal and logs with activities performed each day. Live fish and an aquarium with chiller, airstone, filter and pump machinery, natural clean water, bacteria and chemistry that can be adjusted to produce a comfortable environment for the fish helps students develop critical skills in observation, problem solving and developing solutions with group consultation and communication. That the students keep a scientific journal of their observations, problems and resolutions is evidence of their progress as they raise trout from eggs to fry and release them into a cold water stream. The Kentucky Department of Fish and Wildlife requires a permit for raising trout and a permit for releasing trout into approved streams in Kentucky. Your TU mentor can help you make application for these permits.

In particular, the following introduction from the Kentucky Program of Studies (KY POS) document should give the students a full hands-on involvement with live creatures as they perform activities and learn from lessons during their involvement with "Trout in the Classroom".

> *"The science program at the primary level should provide opportunities for students to think and work like scientists. Students must be provided multiple opportunities to observe and experience the world around them in order to develop scientific conceptions and abilities necessary to do scientific inquiry.*
>
> *These abilities include:*
>
> *Asking a question about objects, organisms and events in the environment,*
> *planning and conducting a simple investigation/fair test,*
> *using simple equipment and tools to gather data and extend the senses,*
> *using data to construct a reasonable explanation and*
> *communicating investigations and explanations.*
>
> *Students should have opportunities to work individually and in groups of varying size and composition in order to conduct investigations, process information and discuss/debate important scientific concepts. Students must have regular opportunities to share their ideas with others and to test questions they generate as a result of their learning experiences.*
>
> *In our technologically advanced society, information gathering must extend beyond the classroom walls and must involve a variety of credible sources. Scientists also place a high value on*

accurate record keeping and open communication of findings. The science classroom should mirror this by emphasizing multiple, varied and consistent methods of documenting and communicating learning.

The scientific content standards at the primary level are directly aligned with Kentucky's Academic Expectations. Science standards are organized around seven "Big Ideas" that are important to the discipline of science. These Big Ideas are: Structure and Transformation of Matter, Motion and Forces, The Earth and the Universe, Unity and Diversity, Biological Change, Energy Transformations and Interdependence.

The Big Ideas are conceptual organizers for science and are the same at each grade level. This ensures students have multiple opportunities throughout their school careers to develop skills and concepts linked to the Big Ideas."

Core Classroom Activities

It is suggested that students of “Trout in the Classroom” become dedicated to the list of activities that must be done so that the trout will survive. Help students realize they have a responsible part to play in the survival of the trout as they study them and learn to make critical observations of the trout and their environment.

Journaling

Each student should keep a **Trout Journal**. It becomes their personal record of what they have discovered through observation, the conditions and problems encountered and their solutions to adjust or correct the conditions or problems they found.

A Team of three students will monitor the equipment and perform the following Daily, Weekly and Bi-Weekly Check Lists. After they have checked each item on the list, they will record their observations and resolutions in their Trout Journal and they will list them on the **Weekly Inspection Chart** on the clip board by the tank. Each week a new student will be assigned to the team and the one that has served the longest will retire. This rotation system will allow each student to have experience monitoring everything about the trout’s environment for up to three weeks at a time. This way the monitoring is done by experienced students while only one is being trained.

Daily Check List:

1. Keep an eye on tank temperatures; an increase in temperature might indicate a chiller problem.
2. Feed trout per the chart in Section VIII of “Trout in the Classroom” document.
3. Check and remove any dead fish or debris from the tank.
4. Test the water parameters (Ammonia, pH, Nitrites, and Nitrides) and record the readings in a log.
5. Ensure that water is flowing from the chiller and the filter and that the bubbler is still working.

Weekly Check List:

1. Clean the gravel (you will be performing water change at the same time) on both halves and wipe down all sides of the tank – usually Tuesday and Fridays are good days.
2. Remove and clean the pre-filters by squeezing them out in a bucket containing aged or well water.
3. Check all hose connections and tighten if any are loose.

Bi-Weekly Check List:

1. Rinse out the filter components using aged or well water once the fry are free swimming and eating.
2. Remove dust and lint from the fins of the coolant tubing (those black thin metal slats on the side of the chiller). This can be accomplished using a small vacuum cleaner, dusting cloth or soft bristle plastic dust brush.

Water Testing: (Use Kit provided with set-up)
The test kit provided has solutions for testing for ammonia, nitrate, nitrite, and pH. While testing for all four is a good practice, the two key tests are for pH and Ammonia. All test results should be kept in a log on a daily basis for review as well as providing “real” data for the students to graph.

Temperature: Use a standard aquarium thermometer to measure the temperature of the water. The optimal temperature for rainbow trout in nature is between 53° F. and 64° F. or 12° C. and 18° C. Eggs require colder temperatures of 50° F. to 52° F. As they hatch into alevin, the temperature may be raised by about 3 degrees to 55° F which supports faster growth. Temperature affects ammonia and oxygen concentration and fish metabolism in an aquarium. A sudden increase or decrease of 3 to 5 degrees within a 15-minute period (even within the acceptable temperature range) can create major problems for eggs and alevins. Make small changes in temperature by adjusting the chiller or adding a plastic bottle of ice and waiting 15-minutes before measuring for the next adjustment. If the water is too cold, you can exchange a gallon of warmer water at a time and waiting 15 minutes before measuring for the next adjustment. The average temperature of the tank should be between 55° F. and 60° F. for the fry stage.

pH: *“pH is defined as the cologarithm of the activity of dissolved hydrogen ions (H+).” Wikipedia*
You should strive for a neutral pH reading of about 7.0. If the water is too acidic (below 6.5), usually adding a total of ½ cup of rinsed coral chips in a 55 gallon tank will raise and maintain a pH of about 7.0 depending on the existing water chemistry. Aquarium hobbyists have used coral chips for many years in lieu of chemicals that are on the market. The coral chips support more bacteria that removes ammonia and acid from the water. As with anything that alters the chemistry of aquarium water, it must be done in slow steps in order not to adversely affect the fish. Divide the ½ cup of chips into 3 equal portions, spreading a portion every 3 or 4 days across the bottom of the tank over a 2 to 3 week period. If at the end of the 3^{rd} week, if the pH is still lower than required, add another 1/2 cup of rinsed coral chips over another 2 to 3 week period. Coral chips can be found in most pet stores.

Using coral chips exclusively instead of gravel will result in a pH off the measurement scale and will be harmful to the development of the fish.

If the water is too basic (above 7.5) add very small amount of baking soda, pre-dissolved in a cup of tank water. Recheck after 10 minutes.

DO NOT ATTEMPT TO MOVE THE pH level more than .1 or .2 IN A DAY.

Ammonia: Major water changes will be needed if the ammonia loads become consistently too high for the biological filtration to handle. This usually occurs when the fish are over fed or there are too many fish in the tank. If the problem is frequent, some fish may need to be removed to reduce the daily levels or the number of weekly water changes increased to 3 or 4 a week. Re-dose the tank with BioZyme to add additional bacteria to convert ammonia into harmless compounds.

Always have buckets waiting with tank-ready water (dechlorinated by sitting 48+ hours or well water). If you come in and all fish are lethargic – **do a 25% WATER CHANGE**.

If you come in and all fish are unmoving at the bottom of the tank – **do a 25% WATER CHANGE**.

If you come in and your fish don’t respond to food – **do a 25% WATER CHANGE**.

During the first few weeks, initial ammonia spikes from overfeeding are likely. Water changes (removal of ammonia) are the only solution.

It is also good to “boost” your tank with BioZyme as often as once a week.

If you change your filter media, only change one section at a time. This allows the bacteria from the remaining section to colonize the new media.

Other Helpful Notes

All water in tank must remain extremely clean. Everyone **must** rinse hands of all contaminates including lotions, soap, etc, before working with the tank.

Foam board around the tank on the back and sides will keep it insulated better and prolong the life of the chiller. Foam board can be cut to fit sides and back and attached with duct tape. A front piece can be cut and placed on the front glass of the tank at night, then removed each day for viewing.

If chiller runs continuously, contact your TIC coordinator, as it may need more refrigerant.

It is better to have slightly hungry fish than to over-feed the tank and have too much waste.

Have about 6 – 8 frozen jugs of water on hand. In the event of a power outage float one or two of these at a time in the tank to keep the temperature down. All labels and glue should be removed from jugs before use.

Weekly Inspection Chart

Week: ___________________________

Inspectors: _______________________ ____________________________

Date	Temp.	pH	Water: clear? Correct level?	Powerhead or air pump plugged in?	Number of live trout	Mortality (dead picked and recorded)	Initials of inspectors
MON							
TUE							
WED							
THU							
FRI							

Weekly Tot: ____ ______ ____________ _______________

Weekly Avg: ____ ______ ____________ _______________ **x/5**

Water change for this week: [ ] 1/4 tank [ ] 1/3 tank [ ] 1/2 tank

Observations: ____

____

____

____

____

Hatch and Release Program

Raising trout in your classroom is a hands-on activity that engages students and helps to connect them to real-life water quality, fish and wildlife issues and problems, and inspires them to seek solutions. Hatching eggs in the classroom and watching fish develop from eggs to fry generates enthusiasm among students and helps them develop caring attitudes about fish species and their habitats. This is the first step in fostering in students a sense of stewardship for the planet.

The long-term goal for Trout in the Classroom is for students to learn that water quality matters to fish and other creatures including humans and that urban populations are connected to and dependent upon their watershed. The short-term goal is to help the students discover what makes water quality good and bad and how environmental awareness can help them understand the importance of conservation of resources including watersheds, wetlands, headwaters, streams and rivers. Field trips are designed to engage the students with macroinvertebrate study as a biological measure of water quality for trout since that is their diet preference. Stream conservation trips with stream clean-up and restoration projects with their parents and Trout Unlimited leadership gives students a hands-on environmental lesson of what they can do to make a better future for Kentucky streams.

We want to encourage students to begin thinking like scientists. What is the difference between students and scientists? Students usually answer questions others ask; however, scientists ask questions no one else is asking. This helps them to develop their observation and imagination skills to determine the problems, gather data, draw up hypotheses, propose solutions and test them to determine the truth nature of the problems and solutions. The aquarium acts as a hand-on laboratory for chemical, physical and biological analysis to determine the source of problems before they become critical.

The program encompasses not only science, but many other curriculum areas including language arts, mathematics, social studies, ecology, and art. The program is easily adapted to the needs and abilities of students, whether they are 2nd graders or high school students.

One feature of the program is that it is hands-on and flexible. Teachers can implement it as a complete yearlong unit of study or it can be an extension of the regular science curriculum.

Teachers are encouraged to adapt the lesson plans to the needs of the students and the school. Teachers are free to use the lesson plans in a different order, add to them and skip others. The TIC web site has lesson plans from several states that could be referenced.

TIC lessons have many applications in other courses.

Science:
Animal studies, animal behavior, anatomy
Measure water quality
Chemistry, the properties of matter
Weather and climate
Genetics and reproduction
Habitat and the environment, including human impact
Ecosystems, including food chains and food webs
Earth structure, Earth’s features
Technology and innovation
Measuring and scientific inquiry
Stream study

Social Studies:
Human impact
Maps and measurements
Municipal decision-making

Democracy: working with representatives
Resource management

Mathematics:
Measurements and geometry
Weighted Averages and Indexing
Percentages and algebra
Charting

Language Arts:
Journaling
Essay and poetry writing
Point of view

Fine Arts:
Poetry
Visual Art
Performing arts

Physical Education:
Fishing
Hiking
Water sports
Schoolyard games

Egg Stages: As the trout grow, how they have changed should be recorded by students in their journals. This can be accompanied by discovering the anatomy of a trout, coloring the trout and naming their egg stages and fry stages.

Fry Stages: Activities will involve the various fry stages as well as how to feed trout using the Feeding Chart according to how many fry have hatched and left the hatching basket. The Feeding Formula is included in the lesson plans for those with mathematical skills.

Macroinvertebrate Stages: Lesson Plans should anticipate what the small trout will eat in the stream once they are released. This should be followed with a lesson on the young trout's primary food source of macroinvertebrates. The life cycle of invertebrates from nymphs to emergers, to duns drying their wings and flying in mating swarms as flys occurs where the female flys lay their eggs upstream from where they emerged. After the flys have laid their eggs, they die and many fall to the stream as spinners with spent wings laying flat on the water. How these insects are used as indicators of water quality can become a game called “Catch the Critter” found in the lesson plans below in preparation for releasing the young trout at streamside. Indeed, the most exciting lesson at streamside before the trout are released is when the students take a field trip to net the insects from under rocks in the stream. They keep track of how many of each type of insect are collected. Your mentor can schedule a University of Kentucky entomologist or a Kentucky Fish and Wildlife biologist for this lesson when the trout are released. The stream quality index obtained by a formula of weighted averages becomes a very good math problem.

Trout Journals

Raising trout in your classroom will provide many opportunities for students to use their observation skills. It will also generate opportunities for recording, measuring, formulating and answering questions, writing, illustrating, hypothesizing, and drawing conclusions. Journaling is a natural way for students to record their findings about trout. Suggest students purchase a loose-leaf notebook to use as their trout journals.

Encourage the students to write in the journals daily, focusing on notable events—from setting up the aquarium to the release day. Descriptions of changes as the trout grow, drawings of them at various stages, observations about trout behavior, and completed hand-outs should be included in journals.

Below are some questions you might pose to students as they observe the trout during different stages of development. Questions open their minds to critical observation and aid them in forming their thoughts before they write them down.

Eggs

- Why are some eggs lighter in color than others?
- How to you remove them from the egg basket?
- When the little head comes out, what do they look like?
- How much food do they need before they hatch?

Alevin

- What color are they?
- Do they have fins?
- What do alevin eat?
- What is most interesting about them?
- How well do alevin swim?
- What do alevin do when light shines on them?
- How might this reaction help them to survive in the wild?

Fry

- Observe how the fry move.
- How many fins are there?
- Draw the fish and label the fins.
- Describe the motion of each fish.
- What is the direction and range of movement?
- Do paired fins move together in the same way?
- Are some fins used more than others?
- What happens to the fish’s fins when it is still?
- How do parr markings help the small trout hide?

Color

- What colors can you identify on the fish?
- Are the back and stomach the same color?
- Why do you think the fish are colored this way?
- Which is easier to see, a fish swimming near the top of the tank or near the gravel?

Senses

- Do you think fish have good eyesight? Why?
- Can fish hear? How do you know?
- Can you see the lateral line?
- What purpose does it serve?

Behavior

- What do fish do when they are startled? Why?
- Do the fish move as a group? What is this called?
- Are all the fish the same size?
- How do the fish interact with each other?
- Do individual fish have established areas of the aquarium that they stay in?
- What do fish do at feeding time?
- Do they all get the same amount of food?

Please print the following for the students below this line

Notes on Keeping a Trout Journal

To the student:

A field journal is essential to a scientist's fieldwork. As you observe the trout you will make sketches and record all your observations, thoughts and questions in your field journal. Your field journal will be unique to you, reflecting your personal style. There is no “right” way to keep a field journal. Some scientists will sketch simple pencil drawings, and others will paint colorful, detailed images. You can use whatever tools work best for you. Try working with pens, pencils or watercolors to capture an image. Some people record their observations in charts, list and labels, while others will write long, detailed descriptions.

Here are some questions that may help you get started:

- What do I see?
- What is the condition of the water in the tank?
- Temperature?
- Do I see anything that surprises me?
- How have the trout changed since the last time I observed them?
- The answers to these questions, along with all your observations, interpretations, and data will be a valuable source of information as you complete your trout study. Did you know that scientists share their field journals? Their journals are a permanent record of their work and are kept in libraries for scientists to study in the future.

Lesson 1: Introducing Students to the Aquarium

Preparation:
The aquarium should be set up and running for a month before doing this activity.

Materials:
Weekly Inspection Chart (one per student),
Water testing kit

Standard Correlations:
KY POS–Science Grades 4-10

Procedure:
1. Tell the students that during the next 6-8 months, they will participate in raising trout in the classroom. At the end of that time they will go to a stream to release the trout into their natural habitat. Point out that the purpose of the program is not to stock a stream, but to learn about fish development, water quality and the problems wildlife, like trout, face in the wild. This is biological science as well as environmental study.
2. Display the aquarium set up to students. Have them gather around as you describe the equipment and the purpose of each item. Tell students that one important aspect of raising trout will be monitoring the trout, the water, and the equipment. Display and distribute the daily inspection charts to students. Tell students the charts will provide the class with valuable data that can be used to evaluate the project and improve it.
3. Discuss with students what their roles will be during the project. Explain that every student will keep a journal in which they will record their observations of the trout both in words and in drawings. In addition, they will each be responsible for monitoring the aquarium. Explain that each week three students will do daily monitoring of the aquarium. At the end of the week, one student will leave the team and a new student will join the team. Using this rotating basis there will always be experienced students monitoring the aquarium. At the end of the program they will all participate in the release.
4. Do a “run-through” of how students will monitor the aquarium. Ask students to fill out the Weekly Inspection Chart for this day as they complete the inspection with you. Conduct the water quality testing using the instructions in your test kit. Point out that the water quality will change when eggs are introduced to the tank and that it is critical to trout survival to maintain a healthy water quality.
5. Provide time for students to draw and label a diagram of the aquarium and equipment in their journals.

Lesson 2: Trout 101

Timeline: This lesson can be taught even before eggs arrive.

Objective: To teach students about trout that are part of the salmonid family and why cold water conservation is necessary for their survival and even if they die, they become part of the food-chain.

Materials: The article from Trout Unlimited below called Trout 101 and the multiple choice questionnaire covering the material in the article.

Standard Correlations:
KY POS–Science Grades 4-10

Students will learn the following: Students will learn about trout and salmon and come to understand that they are both species from the same family of salmonids and share many traits. They will be able to distinguish which species that are called "trout" are actually "char". They will learn that some rainbow trout exhibit the same sea-going traits of salmon because they are anadromous (sea-going) and return to their spawning grounds in fresh water after about 3 years at sea. These are called steelhead trout. They will learn that trout are an indicator of good water quality and that their habitat is very important for their survival. Students are introduced to the part trout play in the food-chain, ecosystem and other subjects that will become parts of future lesson plans.

Procedure:

1. Allow students to read the lesson Trout 101 so they can answer the questions in the handout. Tell them to learn how to spell anadromous as they find out what it means.
2. Explain to the students that salmonid is the name of a family of cold water fishes in North America that includes trout, char and salmon. A taxonomy family contains many species.

Trout 101

What is a trout?

Many species of salmonids are known commonly as “trout.” Often we think of fish swimming in mountain streams or alpine lakes when we think of trout. Those environs historically provide the type of ecosystem salmonids require–namely, cold, clean, oxygenated water. We think of cutthroat trout, the rainbows, the goldens, and the browns as being true trout. We even call some salmonids “trout” that aren’t trout at all: The bull, brook and lake trout, for example, are really another type of salmonid known as “char.” And to confuse matters more, some fish that really are trout we call by other names: For example, fish we call “steelhead” are actually ocean-going rainbow trout.

Anglers tend to lump species together that share similar physical characteristics and habitat, and in doing so sometimes blur the lines of specific taxonomic distinctions. And while a biologist or taxonomist might quibble, that’s what we’ve done with many of the fish we call “trout.” In many waters, for example, brook trout (char) and rainbows share the same habitat, and more than one angler has mistaken a bull trout (char) for a brown. But for conservation purposes, what is important when we think of trout and the various fish that share this name is their common need for clean, cold water and healthy ecosystems. In other words, “salmonid conservation” is conservation of the environmental qualities we associate with clean, free-flowing waters, and healthy forests and rangelands.

What is a salmon?

Like trout, there are several different types of salmon, notably the chinook, coho, sockeye, and chum of the West and the Atlantic salmon of the East. And like trout and char, all are members of the salmonid family. Salmon are known for their migration out of fresh water into saltwater and back, and are generally thought of as being much larger than their trout relatives. Their ocean migration gives most salmon the label “anadromous.”

An-ad`-rom-ous: Rooted in the Greek word for “running up,” any fish born in fresh water, migrating to live a life stage in salt water, then returning to fresh water to spawn (reproduce).

Yet to further illustrate the similarities within the salmonid family, not all salmon migrate to saltwater, and conversely some trout species do. Landlocked sockeye salmon called kokanee, for example, live in fresh water lakes and migrate into fresh water tributaries to spawn. And steelhead--genetic duplicates of fresh water rainbow trout--make the ocean migration, returning to spawn in fresh water streams. So do some species of cutthroat. Unlike trout, which can spawn a number of times, most salmon species die once they spawn; however the Atlantic salmon is one exception.

Why is trout and salmon conservation important?

Trout and salmon species are often viewed as indicators of overall environmental health. Where trout or salmon are present, that generally indicates a healthy ecosystem and, in turn, the presence of other healthy populations of wildlife. Where trout and salmon have disappeared, that generally indicates a damaged ecosystem, and other wildlife that once shared it are likely suffering too. In this way, trout and salmon set the standard for the overall health of an ecosystem--a standard that benefits all living things that share it, including humans.

Additionally, trout and salmon represent a critical cog in the wheel of any food chain in which they live. Consider, for example, the life cycle of a chinook salmon. Born in freshwater streams, usually the tributary of a large river like the Snake or Columbia in the Pacific Northwest, they emerge from the gravel as tiny fingerlings. They are born in huge numbers and immediately provide food for predators, such as other fish and aquatic birds.

Within about a year, the young salmon begin their migration seaward, feeding aquatic predators and birds for a journey that can be hundreds of miles in length through a wide array of habitats. Those that reach the ocean remain there and grow to adulthood, supporting oceanic food chains--and that of humans--

during the length of their journey, which over the course of a few years can take them all the way to the Gulf of Alaska and back.

For instance, the chinook salmon then return to fresh water, where again they feed larger predators, including humans. The adult chinook that successfully reach their natal streams to spawn die soon thereafter. Even after death, they are a food source for bald eagles, deer, bear, and other wildlife and their carcasses contribute rich nutrients to the water and the nearby trees and plants. Indeed, without the salmon, many ecosystems and the wildlife that live there would suffer; some would not exist at all.

What does Trout Unlimited do?

TU focuses its trout and salmon conservation efforts on several fronts. From local on-the-ground habitat protection to lobbying at the highest levels of government, TU uses science as its key weapon in the fight to conserve, protect and restore North America's trout and salmon fisheries and their watersheds. These efforts generally target one or more of the so-called "Four Hs" of fisheries conservation - habitat, hydropower, harvest and hatcheries.

Trout 101 Questions

1. To what family do rainbow trout belong?
    a. Cold water fishes
    b. Char
    c. Salmonid
    d. Chum
2. To what family do salmon belong?
    a. Cold water fishes
    b. Char
    c. Salmonid
    d. Chum
3. Which of the trout below is actually a char and not a true trout?
    a. Steelhead trout
    b. Brook trout
    c. Cutthroat trout
    d. Brown trout
4. Write in the name of fish that are sea-going?
    a. ______________________________
5. What is the main difference between trout and salmon?
    a. Trout live only in rivers and streams
    b. Salmon return to fresh water where they hatched
    c. Most salmon die after they have spawned
    d. Rainbow trout live after they die
6. What habitat is the worst for the family of salmonids?
    a. Clean water
    b. Salt water
    c. Warm water
    d. Fresh water

7. Which one is not part of the food-chain?
    a. Grasshopper
    b. Chum
    c. Algae
    d. Cog
    e. Worm
    f. Bacteria
8. Who benefits from a healthy ecosystem?
    a. Salmon
    b. Trout
    c. Bears
    d. Humans
    e. All living things
9. Write in the name of the rainbow trout that goes to sea?
    a. ______________________________
10. What is the name of the organization that tries to conserve, protect and restore North American trout and salmon fisheries and watersheds?
    a. ______________________________

Lesson 3: Trout Markings

Timeline: This lesson can be accomplished even before eggs arrive. The students will become familiar with adult trout and what their young fry will eventually look like in a wild environment.

Objective: To teach students that trout coloration and markings are indicative of specific habitats and therefore a form of camouflage that varies between species.

Materials: Images of various trout species, cups, paint brushes, water, watercolor palettes, and copies of the trout outline (below). Pass out the Kentucky Department of Fish and Wildlife Resources Stocking Program.

Standard Correlations:
KY POS–Science Grades 4-8

Students will learn the following: How trout adapt to their surroundings using coloration as a form of camouflage.

Procedure:
1. As students look at the pictures, tell them to identify and notice the colorings of the trout body, the eight fins, the gill cover, any spots, the parr marks, and the lateral line.
2. Explain to students that trout often match their habitats in coloration and ask why this might be a good idea (protection from predators, more successful predation).
3. Give each student water coloring supplies and a trout outline. Some students may like to have crayons to make small spots that resist the paint.
4. Ask students to paint their trout, keeping in mind or referring to the images they just saw. Their trout can be unique, but it must still have trout-like features.
5. Students who finish quickly can add habitat with paint or crayon.

Wrap-up: Ask students to share their trout paintings, explaining to the class which distinct features they gave their trout. Students might also explain in which kind of habitat their trout lives.

In small groups or as a whole class, have students look at artistic images and photographs of different species and subspecies trout. (Older students can do this research themselves.)

Background: Rainbow trout are important residents of the cold Kentucky streams that feed our City's drinking water reservoirs. Trout are an indicator species, which means that they are pollution-sensitive; their presence indicates that water is very clean. Like the forests they live in, rainbow trout are largely dark-colored on top—olive green, brown and blue—with a red slash from their gills down the center of their side and lighter on the bottom. The small specks of dark blue and brown color help them to match their surroundings.

Trout species all over the world similarly match their native habitats. For example, sea-run trout are mostly silver and trout in the arid west feature golden hues.

Trout in the Classroom

Rainbow trout (Oncorhynchus mykiss) are the particular species of trout that are grown from eggs to fry in the Kentucky “Trout in the Classroom” program. The result of raising trout in the classroom will be a field trip to a clean, cold water stream approved by the Kentucky Department of Fish and Wildlife where students will test the stream to determine if it meets the quality standards of KDFWR. If so, these students will stock the stream with their trout. A history of Kentucky trout stocking program is quoted below.

Kentucky Department of Fish and Wildlife Resources Stocking Program:

Rainbow trout *have been utilized in the trout program since being stocked as catchable-size fish into both Lake Cumberland and Herrington Lake tailwaters in 1952.*

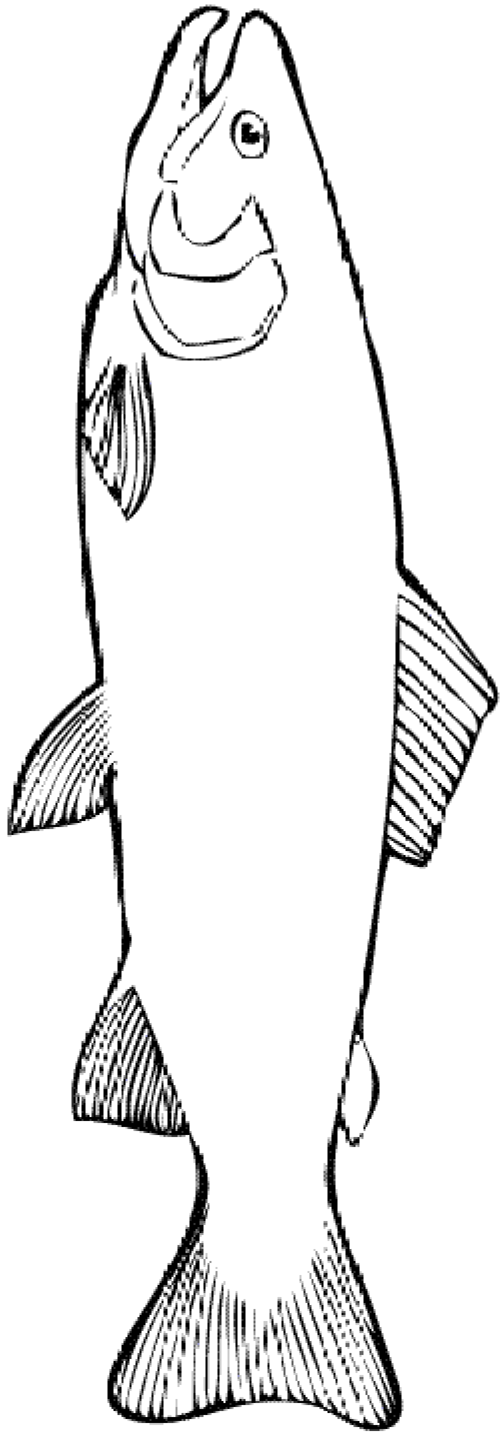
Brook trout*. The U.S. Fish and Wildlife Service established brook trout in two streams from stockings in 1968. The KDFWR has expanded trout fishing waters for wild brook trout to several streams with the Owhi strain, beginning with introductions of 3-4 inch brook trout in a headwater stream in 1980 and 1981. Headwater streams are considered for wild brook trout management if they have the following: (1) at least 1 mile of suitable coldwater habitat, including a maximum water temperature of <68°F; (2) an excellent rating for all trout stream rating parameters; (3) are within public land; (4) 100% of their watershed is in silviculture; (5) there is no road access within at least 0.5 mi; and (6) they are either located above 2,000 ft msl or have a natural fish barrier.*

Brown trout *(Plymouth Rock strain), 3-4 inches long, were first stocked by the KDFWR in Laurel Creek during 1981-1984, resulting in the creation of a high quality put-grow-take fishery for brown trout. This stream and eight others began to be annually stocked with fingerling brown trout in 1988. These streams were selected for put-grow-take stockings of brown trout due to being rated good or excellent, having good pool habitat for good brown trout growth and survival, and not fitting the criteria for wild brook trout management.*

Annual stockings of 8-inch brown trout began in the Lake Cumberland tailwater in March 1982. Herrington Lake tailwater has been annually stocked with 8-inch brown trout since 1988. Laurel River Lake tailwater has received brown trout since 1995.

There are a total of 12 streams that have designated sections for a seasonal catch-and-release season. Seasonal catch-and-release regulations became first effective in 1999 at Bark Camp Creek, Cane Creek, East Fork Indian Creek, Hawk Creek, and Rock Creek (Bell Farm Bridge to TN border). Hawk Creek was deleted from stocking in 2002. Otter Creek was added in 2002. Swift Camp Creek, Left Fork Beaver Creek, Lick Creek, and Casey Creek were added in 2003. Beaver Creek, Elk Spring Creek, Middle Fork Red River, and East Fork Clarks River were added in 2004. East Fork Clarks River was deleted from stocking in 2007. Big Bone Creek and Clear Creek became designated as a seasonal catch-and-release stream in 2006. No trout are allowed to be kept from October 1 - March 31, except at Swift Camp Creek where the seasonal catch-and-release season extends through May 31. Only artificial baits are permitted during these months. Rainbow trout are stocked at a rate of about 100-500 fish per mile, depending on number of stocking sites and stream size.

Color a Trout



Colorful Fish Images as Art

The following images are printed to show students what their trout will look like when fully grown.

Rainbow Trout

Trout Picture Resources

Behnke, Robert J. Trout and Salmon of North America. Illustrated by Joseph R. Tomelleri. New York: The Free Press, 2002.
Review Joseph R. Tomelleri's Colorful Fish of North America.

Prosek, James. Go Fish: A Fishing Journal. New York: Stewart, Tabori & Chang, 2000.
_____. Trout: An Illustrated History. New York: Alfred A. Knopf, 1997.
_____. Trout of the World. New York: Stewart, Tabori & Chang, 2003.
Review James Prosek's art for colorful American trout.

Locate the Rainbow, Brown and Brook Trout in Color named Trout_Markings.pdf.
These can be displayed on a screen from your computer or you can copy them in color for the students to paint. The students may use the black and white outline image above to paint or color the trout of their choice.

Lesson 4: Find the Trout in a Stream

Objective: To teach students that spotting trout from a point above the stream where sunlight is shining on the water is quite easy when they know the secret. The secret is that light casts a shadow on the bottom of the stream of the trout floating above. If they can look for two matching images, the trout and its shadow, they can easily spot trout or any fish in a stream. If a stick looks like a trout, it may also cast a shadow. It is best to find a moving pair of images about the size of a trout. The shadow will move as the trout moves.

Materials: Images of various trout in the diagram of a stream (below).

Standard Correlations:
KY POS–Science Grades 4-6

Students will learn the following:

- Trout hide under overhanging trees and under banks, too.
- Students learn to read a stream.
- Trout hide for safety.
- Trout find a feeding lane where food is easy to reach without much effort.
- They find a comfort zone of shade and cool, clean water.

Procedure:

1. Trout in the wild are both predator and prey. The famous fly fisherman, Lee Wulff, in "Trout on a Fly", The Lyons Press (c) 1986, wrote about how trout adapt to their environment and how they weigh their energy conservation between what they seek to consume in order to survive and how they protect themselves from their enemies who prey on them for food. Wulff's description of the trout's needs in order of priority has never been equaled.
2. Before passing out the stream picture (below), read the following quote from Lee Wulff and try to impart his excitement to the students.

Enthusiasm is contagious! Catch it from Lee Wulff!

> *"We live in a world of predators and prey. Man has been the fiercest predator of all. When we fish for trout, a predatory act in which we seek to capture a living animal, we are allied with the hawks that prey on the pigeons; we are one with the wolves that take the caribou and the lion that stalks the gazelle. We take pride now in being non-preying predators and releasing our fish; but we cannot release a fish until we have captured it so we are still as much predators as ever whether we keep our fish or put them back. To be a good angler one must be a good predator.*
>
> *Now let us consider the trout. He is a mid-range predator. Half the time he is scaring minnows and insects to death and the other half he is scared to death by bigger fish, and by fish hawks, fierce eels, otters, mink and the like. . .*
>
> *A trout, to be catchable, must be relaxed and predatory, not scared. . . The trout's three primary needs: safety, food and comfort. His first concern is not to be killed. His second is to get enough food to stay alive and hopefully enough to be very happy. A trout also wants to be comfortable-- for discomfort is troubling and extreme discomfort, such as water too warm for him to function in, will kill him. . .*
>
> *A trout must get enough food to make up for the energy he expends in getting it. But a good predator will have an extra supply of energy for emergencies and to spend, sometimes, out of the*

pure joy of living or in practice to build strengths and skills against the competition for hard times to come.

The trout learns that the things that move, either through the water or within themselves (like the pulsating of a mayfly's gills or the swimming motion of a nymph's legs or body) are living and edible. Motion becomes his first and major criterion as to whether something he sees is edible and worth chasing or not. Motion, either of or within a fly, has caught more trout than anything else. . .

Picture the trout lying in his selected feeding spot. A few hunger pangs heighten his awareness of things around him. He's strong and feisty on this late spring day. Along comes something swimming or drifting across his vision. He's old enough and wise enough to have a little caution, having been hooked and escaped a time or two, but this thing is intriguing. It has colors in a combination never seen before. It swims in a way that's most unusual. He studies it and realizes that this is something truly different.

But what is it?
Is it good to eat?
What will is taste like?

It's moving out of range and it's now or never. If he lets it go by he'll never know what it would taste like and he decides to find out. They say curiosity kills cats; the same holds true for trout.

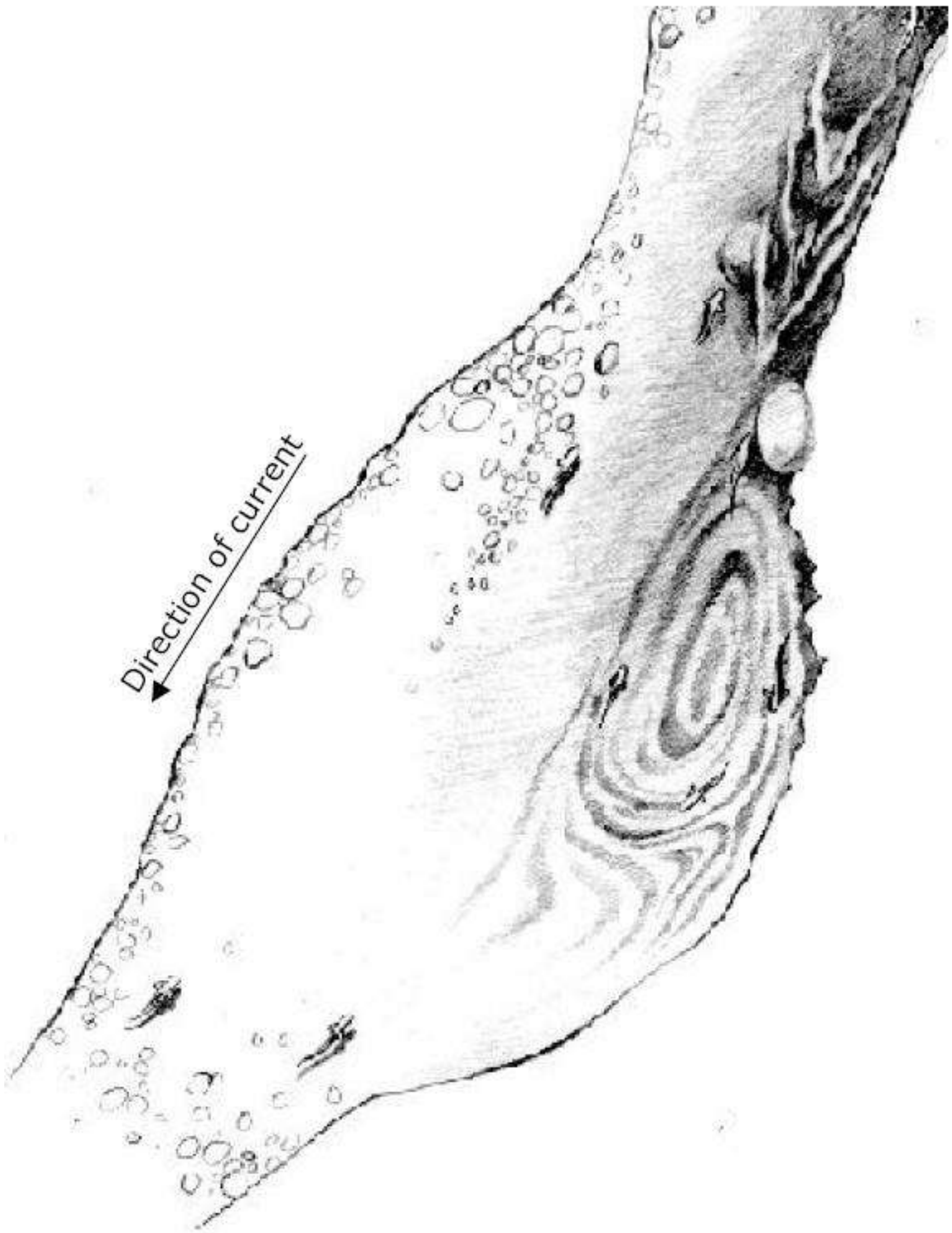
Trout will hide and when they have hidden you cannot catch them on a fly. I have waded across the Beaverkill and, stepping on a flat-topped stone, sent a good trout scurrying out from under it to safer water somewhere else. Trout will ease in under overhanging banks and nestle in hiding against the earth or roots or weed growth. . . I would walk along the edge of the stream until I saw a fish dart in under a bank. Then, quietly, I would slowly feel around with my hand until I found the trout. A gentle stroking on the flesh seems to soothe rather than to bother them. When the exact position of the fish is determined a quick closing of the hand can provide a grip that will hold them. "Tiggling" is an old poacher's method that requires no complex tackle, just understanding and skill.

It's easy to see that there is a great deal to learn about the trout and his ways. We have made a beginning. Studying the ways of trout can be a lifelong interest, with new and surprising insights possible for the wisest of old-time anglers."

Assignment: Ask the students to count the trout images they can spot and write down the number and their name in the top left hand corner of the sheet you gave them.

Wrap-up: Ask them what they think they learned from the Lee Wulff story you read.
Ask some of the students how many they found. Explain that this lesson about reading a stream is not easy and is learned over a lifetime while observing and fishing a clear river or stream.
Ask students to turn in their sheets.

Can you find the Trout in the stream?



How many are there?

Lesson 5: What occurs from eggs to fry?

Timeline*:* This lesson is a good one to teach after the eggs begin to hatch. It will be a review of what has already happened and what the students can expect to happen next. It represents the stages the eggs go through to produce small fry that will grow to a size that can be released into a cold water stream. The students will learn to recognize differences as the trout change shape while they go through the egg and fry stages. The students are encouraged to ask questions about what stage the eggs or fry are in if they don't know. Later, you may want them to observe and count how many are in each stage.

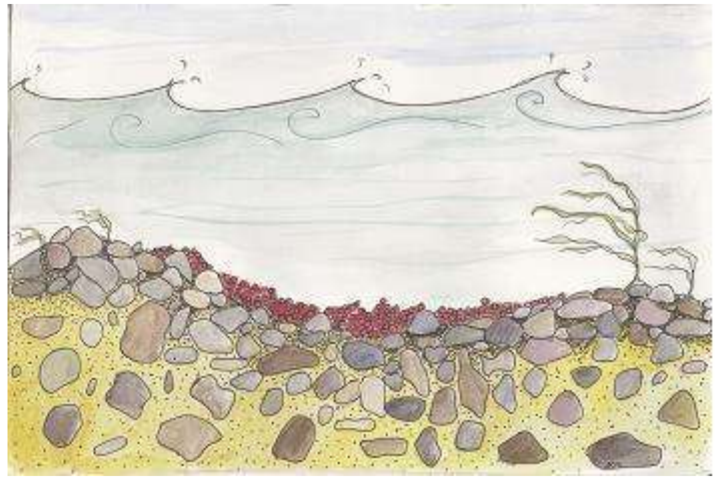
Standard Correlations:
KY POS–Science Grades 4-6

What the students will learn:

- Eggs die before they hatch and must be removed from the tank with a turkey baster.
- Eyed eggs hatch in about a week.
- They're little round balls with heads poking out.
- They swim out of the egg with big bellies on them.
- This stage is called Alevin because of their yolk sacs.
- Some are too heavy to swim out of the basket.
- Those that do swim out, end up on the bottom.
- They can't eat until they have absorbed the food in their yolk sac.
- The ones that don't have a yolk sac can be fed.
- Count those that can be fed so they can follow the feeding chart.
- The small fish are called fry.
- Parr marks are the vertical colors on their sides that can be used a camouflage.

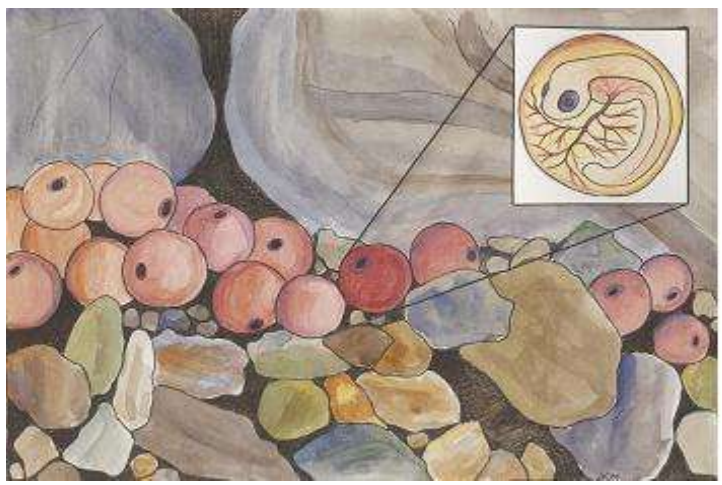
Note: Please print the following pages in color or show them on a screen so the whole class can see them while you comment on the various stages. A Classroom Slide Show that shows real trout is named Trout_ID.pptx.

ONCE I WAS A BABY TROUT



First I was a GREEN EGG sitting in my redd.

Then I was an EYED EGG, my eyes were on my head.

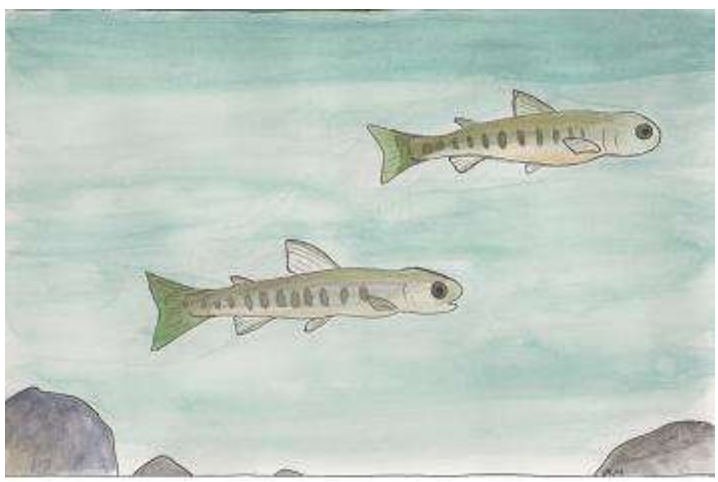


Then I started HATCHING; the egg shell left my back.

Then I was an ALEVIN with a big yolk sac.

Then I had to USE YOLK; I watched my belly shrink.

Then I was a LITTLE FRY— I wanted food, I think.



So I looked for BUGS TO EAT and I swam around.

Soon I had my PARR MARKS, so I couldn't be found.

Lesson 6: External Trout Anatomy

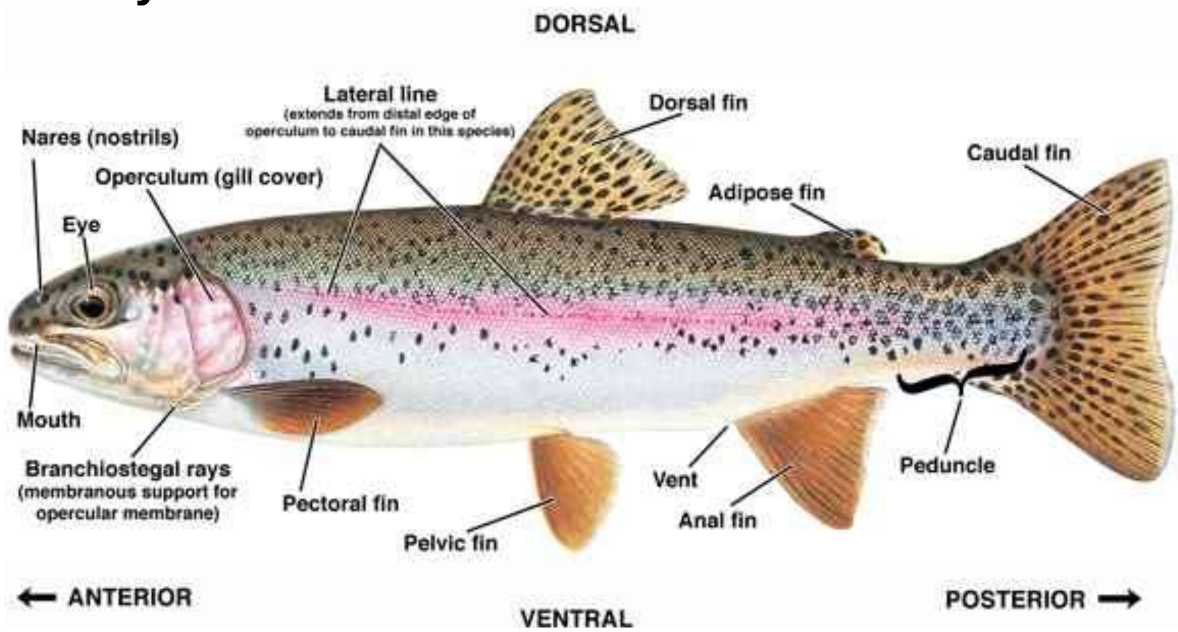
Preparation:
Duplicate Trout Body handout and Trout Body crossword.

Materials:
Trout Body handout (one per student), Painting by Joseph E. Tomelleri
Trout Body Crossword (one per student)
Index cards (one per student)

Standard Correlations:
KY POS–Science Grades 6-8

Procedure*:*
1. Briefly discuss with students how our senses and our physical features allow us to function in our environment. Point out that humans move through air; trout through water.
2. Ask students to think about how things might look, taste, smell, sound, and feel in a water environment. If necessary, use these questions to stimulate discussion.
3. Observation is the first step in the scientific method. Questions help us define what we observe.
4. What physical features would an animal, like a trout, need to function in a water environment?
5. What sort of body shape would a trout need to move quickly through the water?
6. What helps propel a trout through the water?
7. What sense organs help a trout find food?
8. Have students work in small groups. Explain that they are going to examine the features of a trout and how those features help the trout function in its environment. Distribute the Trout Body hand-out to students. Instruct them to read the information on the hand-out and to identify each body part and how it helps the trout to function. (Allow 15 minutes)
9. Distribute one index card to each student. Have students write a question about a trout feature on the front of the card and the answer on the back. For example, "What is the biggest fin?" (**answer:** caudal fin). Collect the cards and use them to play a quick question-answer game.
10. Have students draw and label a diagram of a trout in their journals.
11. Distribute Trout Body crossword to students to complete during their free time.

Trout Body



Eyes: Why are the trout's eyes on the side of their head? Are they prey or predator?
What is the trout's field of vision in degrees? 90, 180, 270, 360
Do they have a blind spot? Yes or No.
Why is their eye shaped to a point in the direction they are looking? Does it help them focus?
The pupil has a slight triangle shape which gives the trout a larger field of vision.

Nares: The nare is a closed sac and functions as a nostril, helping the trout to detect odors. Which has the best sense of smell? A blue-tic blood hound or a fish? A shark can smell a drop of blood 100 yards away. They can smell a bucket of blood a mile away. Trout return to their home stream yearly to spawn. How do they know they have found it? They can identify the smell of the water.

Mouth: Trout do not gulp their food; they suck it up using their mouths. Mouths are also used to feel things. The trout will take a lot of things into its mouth to see if it is worth eating. It closes its mouth to crush it. If it feels like food and the juices taste good, it will reposition it in its mouth and swallow it whole.

Kype: Why is the jaw hooked? The kype is the hooked part of the lower jaw. Males use the kype to fight over mates during spawning time.

Gills: How does the trout breath? Gills work much the same way our lungs do. Trout draw water in through their mouths. The water passes through the gills where a lot of very tiny blood vessels so that oxygen is exchanged for carbon dioxide.

Operculum: The delicate gills are protected by a hard plate called the operculum.

Pectoral fins: If the fish were an airplane gliding through the air, what would the pectoral fins do? The pectoral fins are paired fins which act as brakes and help with side to side and gliding movement in fast current. The flow of water acts like a flow of air. Where are the pectoral fins located? They are below the gills.

Pelvic fins: The pelvic or ventral fins are paired fins which are set back from the pectoral fins. They help with up and down movement.

Vent: The vent is an opening through which extra water is excreted. The vent is the opening through which eggs or sperm (milt) pass during spawning.

Anal fin: The anal fin is behind the vent and is used for swimming and stabilization.

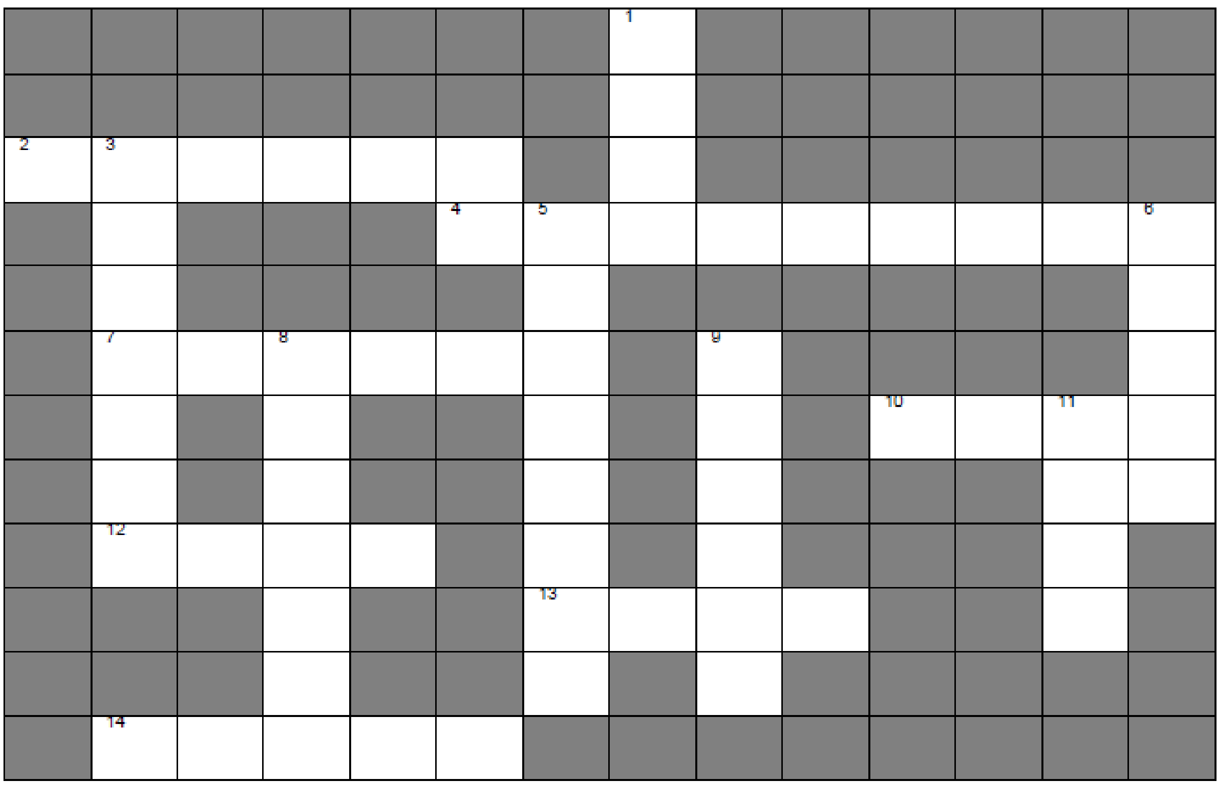
Caudal fin: What is the trout's biggest fin with the most power? The caudal fin or tail fin is the biggest fin. It provides the "push" for the trout to start moving and also acts as a rudder for steering through the water.
Dorsal fin: The dorsal fin is used for swimming and stabilization.

Adipose fin: Why do you suppose the adipose fin is on a trout and not on several other fish? It keeps the water running along the side of the fish rather than crossing over its back. The adipose fin is used for swimming and stabilization. (Adipose means that it is a "fatty" fin without rays.)

Lateral line: Do fish have ears? What is the lateral line. How can it hear? This sense organ runs from the operculum to the tail. This sensor detects pressure waves or vibrations. It helps the trout maintain position without bumping into other fish or objects in the water. The lateral line can detect when someone is stepping on the bank or a log on shore.

Trout Body Crossword

Across		Down	
2	The fin that gives the trout a ‘push’ and acts as a rudder	1	The hooked part of the lower jaw
4	A hard plate covering the gills	3	This ‘fatty’ fin does not have rays
7	This fin is used as a brake and helps with up and down movement	5	Fins below the gills
10	The opening through which eggs or sperm (milt) pass during spawning	6	The trout use this body part to suck up food
12	These organs have triangle-shaped pupils	8	This line is a sense organ running from the operculum to the tail
13	One of the fins used for swimming and stabilization	9	One of the fins used for swimming and stabilization
14	This organ works the same way our lungs do	11	This organ helps the trout detect odors



Lesson 7: Trout Dissection

Preparation:
Read the background information on trout anatomy and functions. Duplicate Fish Anatomy diagram (one for each student).

Materials:
A fresh, whole trout
Dissecting scissors
Tweezers or forceps
Newspapers
Probe
Paper towels
Magnifying glass
Fish Anatomy diagram

Standard Correlations:
KY POS–Science Grade 8-10

Procedure:
1. Choose a location where all students can view the dissection clearly. Cover the surface with newspaper. Refer to the reference sheet (if needed) to help explain the function of each organ or characteristic.
2. Have students feel the fish's skin and discuss what purpose the slime serves. (It protects against growth of fungus and it allows the fish to glide more easily through the water.)
3. Have students use the magnifying glass to carefully examine the scales and note how they are arranged.
4. Have students describe the color pattern of the fish and talk about the function of coloration (protection, camouflage).
5. Observe the lateral line. Discuss what it is used for and the way it works.
6. Have students describe the fish's overall shape and how this adaptation is beneficial to the fish. Look at the placement of the fins and ask students to imagine the fish swimming in the water. How does it move? How are the fins used? Note the range of movement of each fin.
7. Allow students to feel the bony rays that support the fins. Have a volunteer count the number of rays on the anal fin. Point out that this is one of the most distinguishing characteristics of salmonids.
8. Note the size of the eye. Its relatively large size, and the large pupil tells us how important vision is for this animal. Have students note that there is no eyelid. Have them observe the tough, clear membrane that covers the eye. Rotate the eye in the socket.
9. Locate the nostrils. Describe the large olfactory lobes that are located in the brain. Ask students to speculate why a salmonid's smell receptors are so highly developed.
10. Open the mouth and have students note the color of the gums. Have volunteers feel the teeth along the gum margins and on the roof of the mouth. Ask students what function these teeth perform. Are they used for chewing? (The teeth are used for grasping and holding onto prey.) Make note how wide the mouth can open and have them comment on why this is so. Point out that the mouth is also used for breathing. In low oxygen conditions, fish can actively pump water over gills by opening and closing the mouth. Demonstrate this action with the fish's mouth.
11. Point out the gills arches by having students look down the fish's mouth. Use a probe to separate the arches and explore how they are arranged.
12. Place the fish on its side and look at the operculum—the bony plates which protect the gills. Lift the operculum and look at the gills. Cut the operculum away from its base, exposing the gills.

13. Remove the gills by cutting the upper and lower attachments of the arch. Look at the gill rakers, the bony projections along the inside curve of the arches. Observe the large surface area provided by the gill filaments, and the thin tissue which allows blood vessels to come into contact with the oxygen in the water. Compare and contrast gills and lungs.
14. Carefully cut the fish open using the scissors or scalpel. Before moving any organs, let students observe how all the internal organs fit together. Look for the thin transparent membrane that encloses the organs. Cut away the flap of skin and look for fat deposits, which are found around the stomach.
15. Look for the swim bladder. It is made of very thin tissue and is located in the upper body cavity, below the kidneys. It will be less developed in small fish and since it will not be inflated, it may be hard to find. If you can't find it, point to its location and discuss its function.
16. The male reproductive organs will be a flaccid white or orange tissue near the intestines. Eggs may or may not be noticeable in females. They will vary in size depending on the maturity of the fish.
17. Put the fish on its back and find the kidneys, located just under the backbone. They are thin, dark in color and run the whole length of the body cavity. Call on a volunteer to discuss the function of the kidneys.
18. Investigate the digestive track by starting in the mouth and following the route that food would take. Put the probe through the mouth and into the esophagus to show the beginning of the route. Then follow the course of the stomach using your finger or the probe. The first area of the stomach is called the cardiac stomach; this is where digestion begins. Have students notice the different kinds of tissue that make up the stomach.
19. The pyloric stomach is that portion from which the pyloric ceca project. It begins at the bend below the cardiac stomach, and is made of different tissue. Discuss how the stomach area is increased by the pyloric ceca and how this improves the function of the stomach.
20. The intestines extract nutrients from food. Notice the network of blood vessels which are used for nutrient exchange. Follow the intestines to the anal opening, where waste products are eliminated.
21. Lift the stomach to show the spleen. It is a reddish organ found at the end of the cardiac stomach. Ask a volunteer to discuss the spleen's function.
22. The liver is in front of the stomach. Discuss the liver's role in the digestion of fats. Point out the gall bladder, a mass of darker tissue on the liver.
23. Move the liver to locate the heart—which can be found near the fish's mouth. You should be able to make out the different chambers. Point out that the fact that the gills, heart, and liver are so close together is no accident. Blood pressure is best near the heart (pump). Blood is filtered by the liver, and absorbs oxygen from the gills; both are vital functions.
24. Cut through the fish to expose the backbone and muscles and have students note the arrangement of muscle mass. Point out that this is the part of the fish that we eat.
25. Carefully cut away the skin by lifting it while running the scalpel along the skin-muscle interface. If you have a small fish, the skin may be thin enough to place under a microscope. If so, observe the pattern of the scales, the growth rings on the scales. If the skin is too thick, use a magnifying glass. Try to remove some of the scales so that you can look at the rings.
26. Discuss with students how the trout's body parts and functions compare to a mammal's.
27. Distribute the Fish Anatomy diagram to students. Have them label the organs and include the diagram in their Trout Journals.

Trout Anatomy

All animals are adapted to their environments. The streamlined shape of trout allows them to swim through the water with the minimum of resistance. They can maintain their position in a stream with little effort.

EXTERNAL FEATURES

Skin: The outer layer of skin, the epidermis, contains pigment cells and mucous glands. The dermis is the layer of skin that lies under the epidermis. It contains nerves, blood vessels, and connective tissue. The trout's scales grow from and are imbedded in the dermis.

Scales: Imbedded in the dermis, only a small portion of each scale is visible. The scales overlap with their margins pointing toward the tail. This helps to reduce friction in the water. Scales grow with the fish. The age of a trout can be determined by counting the concentric rings on a scale.

Teeth: Teeth can be found along the margins of the upper and lower jaws.

Fins: The fins (except for the adipose fin) are composed of a tough membrane that is supported by bony fin rays. The caudal fin, or tail fin, propels the trout through the water and helps it to stay upright. Females use the caudal fin as a fan when making a redd. The anal fin helps the trout propel forward, balance and steer. The dorsal fin helps the trout to stay upright and on course. The pelvic and pectoral fins, the paired fins, help the trout maneuver, turn, brake, and balance. The adipose fin is a fatty fin. It is used for swimming and stabilization.

SENSORY ORGANS

Eyes: Trout can see things both near and far away. The eyes have large pupils which allow available light to be admitted. This is probably why trout tend to stay away from sunny areas.

Nostrils: Trout have a well-developed sense of smell. The nostrils are covered with flaps that guide incoming water into the olfactory sac, which contains the smell receptors. Water passes through the sac and exits through another opening in the nostril.

Ears: Trout hear well, although there are no external openings to the inner ear mechanism. The inner ear is composed of chambers that contain pieces of bone, called otoliths. As the trout moves through the water, the bones move and hit against nerve endings, sending messages to the brain.

Lateral Line: This mucous-filled canal runs the length of the trout and is located in the skin. The lateral line acts as a sonar device, picking up vibrations by movement in the water or on nearby land.

INTERNAL SYSTEMS

Nervous System: As in most vertebrates, the nervous system is made up of the brain, spinal column, and nerves. The trout's brain is encased in a bony skull.

Olfactory and optic lobes: process information from the nostrils and eyes.
Semi-circular canals: help maintain balance
Cerebellum: controls muscle movement
Medula: controls vital processes, such as heart rate and respiration

Nerves: send impulses to the brain, which reacts to the stimuli.

Respiratory System: The gills take in oxygen and eliminate gaseous waste. Water is taken in through the mouth and passes through gill openings. The gill arches have filaments along their back edges. Blood flows through the very thin filament, which allows for waste to be exchanged for oxygen. Gill rakers on the edges of the arches strain particles out of the water to prevent injury or clogging to the gills.

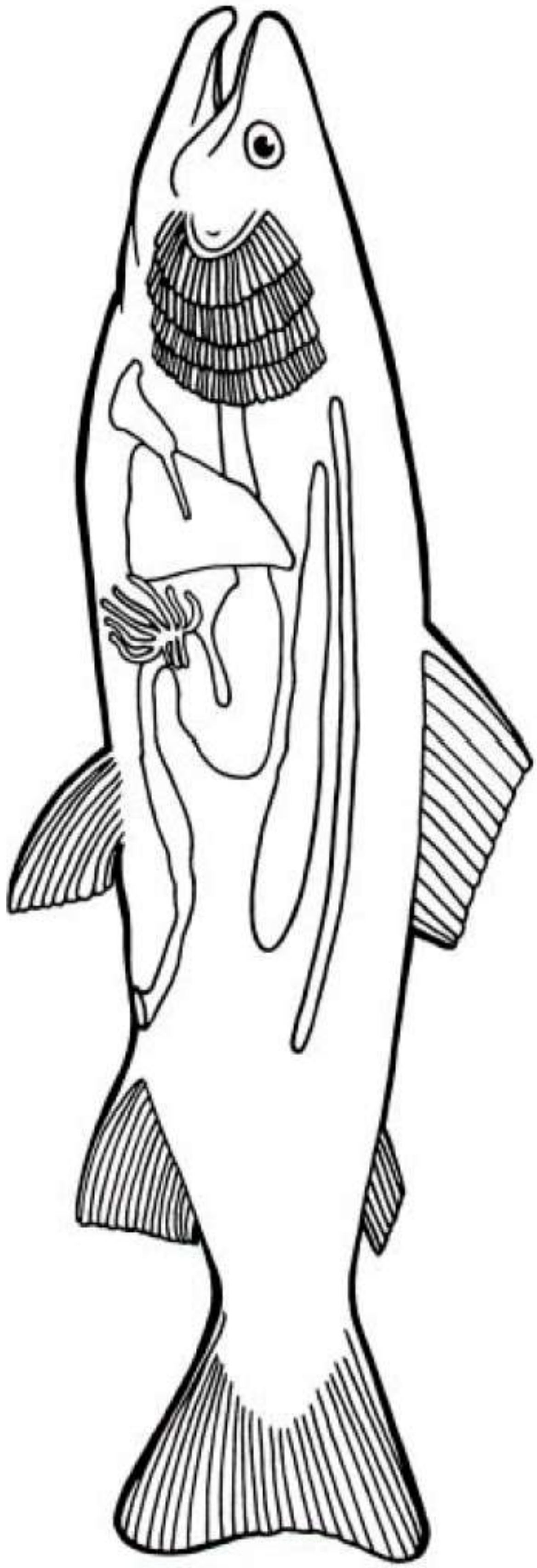
Skeletal and Muscular Systems: The trout's skeleton is comprised of bone and cartilage. Its muscles are laid down in segments and have thin sheets of connective tissue between each segment. Muscles are connected to the tissue. Dark muscle tissue has better blood circulation and is used for prolonged activity, such as swimming. Light muscle tissue has less of an oxygen supply and is used for short bursts of activity.

Circulatory System: The heart and blood vessels carry oxygen from the gills to the tissues and carry waste back to the gills and kidneys.

Digestive System: When a trout eats both food and water enter its mouth. Water is directed to the gills and food to the esophagus which leads to the stomach.
In the stomach food is mixed with hydrochloric acid and mucous and then passes to the intestines. Food is broken down in the intestines by enzymes. Nutrients are absorbed. Waste is eliminated through the anus.

Liver: The liver produces bile which is stored in the gall bladder. The bile breaks down fat.

Spleen: The spleen manufactures and stores blood.



Kidneys: The kidneys filter waste from the blood stream and also manufacture blood. Two canals, ureters, carry waste from the kidneys to the bladder. From the bladder, the waste passes to the outside.

Swim Bladder: The swim bladder allows the trout to remain suspended in the water at any depth. Air enters the swim bladder through a duct when the fish gulps air.

ReproductiveSystem
The gonads produce the sex cells. The females ovaries are generally an orange hue and appear granular.
The granules are developing eggs.
The male testes are limp white organs which produce sperm. Sperm and eggs pass through passageways from the gonads to the urogenital opening.

Trout Anatomy

Lesson 8: Trout Life Cycle

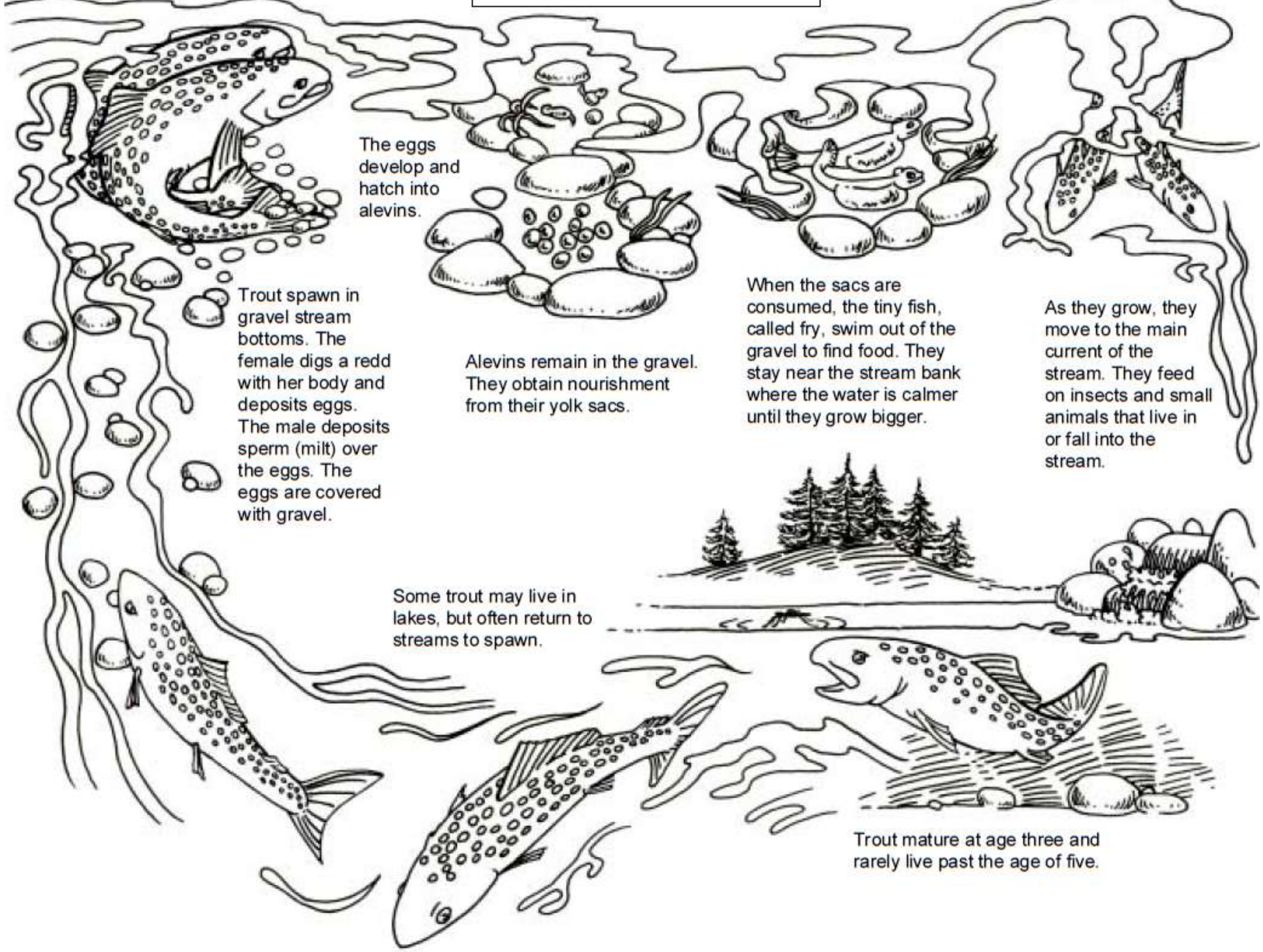
Preparation:
Duplicate the Trout Life Cycle handout.

Materials:
– Trout Life Cycle handout

Standard Correlations:
KY POS–Science Grades 4-6

Procedure:
1. Call on students to describe what a life cycle is. Tell students they are going to work in groups to learn about the life cycle of the trout. Then each group will use their creative talents to present the life cycle of the trout to the rest of the class.
2. Distribute Trout Life Cycle hand-out to students.
3. Brainstorm with students to discover some creative ways of presenting the trout life cycle. Encourage ideas such as: presenting the life cycle in a play, a short story, or poetry; present the life cycle in a series of artistic drawings or a poster; make up a song with lyrics that describe the life cycle and present it to the class. A "This just in" newscast could become a possibility. After brainstorming, have students work in small groups.
4. The groups should decide how they will present their life cycle. Each member should be responsible for some aspect of the presentation.
5. Groups can work on their presentations during class time or as homework activity. When groups are ready, set aside time for groups to make their presentations to the rest of the class. Afterwards, discuss which presentations were the most informative and the most engaging.

Trout life cycle



Lesson 9: What Trout Need

Preparation:
Review “Creating a Fish Habitat in Your Classroom.” Duplicate the Rainbow Trout information sheet for students.

Materials:
– Rainbow Trout information sheet

Standard Correlations:
KY POS Science–Grades 6-10

Procedure:
Discuss with students how the aquarium will simulate a trout’s environment in nature. Review the conditions for trout development. Copy this chart on the board:

Conditions for Trout Development

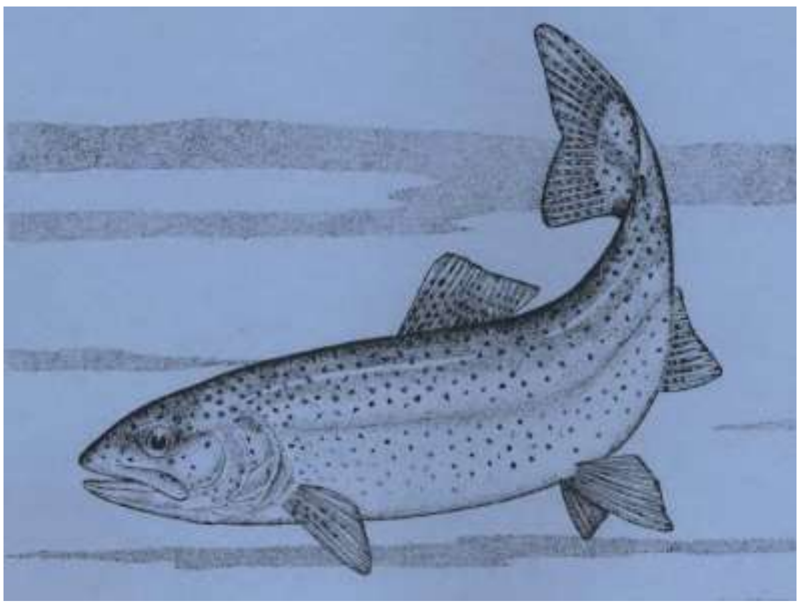
	In Nature	In the Aquarium
Limited Light		
Cold Water	(12° C. to 18° C.)	(53° F. to 58° F.)
Oxygen		
Clean Water		
pH (6.5 to 7.5)		
Predators		
Food		

1. Have students work in small groups. Distribute the Trout Information Sheet to each student. Give groups 20 minutes to read the sheets and to discuss how a trout’s natural habitat meets the conditions listed.
2. Students with computer access may research web documents by searching for rainbow trout habitats.
3. Math oriented students may convert temperatures in the sheet below from Celsius to Fahrenheit using the formula: Tf = (9/5)*Tc+32 where Tc = temperature in degrees Celsius, Tf = temperature in degrees Fahrenheit
4. Allow time for groups to share their findings in nature while recording responses on the board. For each item, call on the students to say how the aquarium will meet those same conditions.
5. Explain to the students that the aquarium temperatures are set to a smaller range of degrees than the optimal in nature because of the ammonia caused by their waste in the tank which reduces the oxygen content. The optimal temperature in the tank for eggs is 50° F. to 52° F. and for fry 53° F. to 58° F.
6. After the discussion, have students copy the chart in their journals.

Rainbow Trout (Oncorhynchus mykiss)

Rainbow trout are coldwater fish that have long been symbolic of clear, healthy mountain streams and lakes in North America. The historic range of rainbow trout extends from Alaska to Mexico and includes British Columbia, Washington, Oregon, California, Idaho and Nevada. Because of their ability to thrive in hatcheries, rainbow trout have been introduced into much of the United States and now inhabit many streams and lakes throughout the country. In fact, rainbow trout have been stocked into streams of every continent except Antarctica. Steelhead trout (sea-run, anadromous rainbow trout) are native to the pacific coast, but have been introduced into the Great Lakes. Steelhead trout leave their spawning grounds usually as adults and go to sea where they become very large predator fish before returning to their original native stream to spawn. Many rainbow trout live in lakes, but navigate to higher colder stream tributaries to spawn.

Rainbow trout have many needs including safety from predators, sources of food and clean, cold water. For safety, they seek undercut banks, overhanging trees and brushes for shade, roots, rocks, deep pools and downfall trees that cover midstream portions of rivers and streams where they can hide. Predators that seek to devour trout in the wild are birds, otters, mink and bears, other larger fish and humans.



For reproduction, trout need gravelly areas of streams with clean silt-free bottoms and good water-flows like riffles. Wild rainbow trout spawn in the spring, but hatchery-raised trout may spawn at any season of the year. The female rainbow trout uses her tail to prepare a redd in the gravel. The redd is about 4 to 6 inches deep. The female lays eggs and the male deposits sperm called milt over the eggs. After spawning, the female covers the eggs with gravel to hold them in place so the current won't wash them down stream. They may deposit several clusters of eggs further upstream from the first redd. Competition between males determines the more dominate allowed to fertilize the eggs in a redd. Clean, oxygenated water flowing through the redd keeps the eggs clean and helps them develop successfully.

As alevins hatch with their yolk sac attached, they remain in the gravel and grow using nourishment from the yolk sac. After the yolk sac is absorbed, the fry emerge from the gravel and begin to search for food. They feed on small aquatic insects. After they grow beyond 4 inches, they are called fingerlings and may prey on minnows and invertebrates. As adults, trout feed on aquatic insects in every stage from larval nymphs, emergers, duns and adult mayflys that mate and lay their eggs on the water upstream from where they emerged. Stone flys, caddis flys and dragon or damsel flys are also food sources in every stage of their life cycle. Other food sources for adult trout are scuds, snails, mollusks, leeches, crawfish, frogs, ants, beetles, mice, grasshoppers, salamanders and small fish.

Trout need a comfortable habitat of clean, cold, acid free water with optimal temperatures between 12° C. and 18° C. and a pH between 6.5 and 7.5 that is oxygenated by fast moving water called riffles. Better trout habitats in nature contain a 1:1 ratio between riffles and deep pools.

Lesson 10: Trout in the Ecosystem

Preparation:
Duplicate Trout in the Ecosystem handout (one for each student).

Materials:
– Trout in the Ecosystem handout
– Scissors
– Glue or tape
– Additional sheets of paper

Standard Correlations:
KY POS–Science Grade 6-10

Procedure:
1. Call on students to define **ecosystem**. (Answers should include all the living and nonliving things in an area. There is an interaction among living and nonliving things in an ecosystem.) Ask students to consider the ecosystem that trout inhabit and to name some of the living and nonliving things in this ecosystem. Write their responses on the board. (Answers can include: sun [energy], algae, water, plants, insect larvae, insects, small fish, frogs, turtles, snakes and trout.)
2. Ask students to define **food chain**. (Answers should include that a food chain moves the sun's energy through a community from producers to consumers.) Point out that in a food chain there are producers and consumers. Have students identify which of their responses are producers and which are consumers (Algae and water plants are producers; insect larvae, fish, frogs, turtles, and trout are consumers.)
3. Write minnow, dragonfly, algae, caddisfly larva, trout, and sun on the board. Call on a volunteer to use these examples to draw a diagram showing how the energy moves through this food chain. Ask for volunteers to help explain the flow of energy. (Answer: the sun provides energy for the algae to grow; algae is consumed by caddisfly larva; larva consumed by dragonfly; dragonfly consumed by minnow; minnow consumed by trout.)
4. Point out to students that there are other ways of showing energy flow through an ecosystem. In an **energy pyramid** the producers are at the base and the top consumer is at the tip of the pyramid. As you move from the base to the tip there is less and less food and energy available.
5. Ask students to define a food web and discuss how it is different from food chains and energy pyramids. (Answers should include that a food web shows the relationship between all of the species in an environment. It shows the competition for food and is basically a map of overlapping food chains.) Point out that every food chain and food web ends with decomposers-- worms, insects, bacteria, and fungi--organisms that break down dead organisms and waste into matter that is absorbed by the decomposers or returned to the environment and used by producers.
6. Have students work with a partner. Distribute **Trout in the Ecosystem** handout to each student. Explain that partners will use one two-page handout to create an **energy pyramid**. They will use the other two-page handout to create a **food web**. Instruct students to cut out the pictures and to arrange them on a separate piece of paper into an energy pyramid. With the other pictures, they will construct a food web and draw arrows to show the relationship among the members of that community. When students have finished, have them share and compare their energy pyramids and food webs.
7. Discuss with them what would happen if some of the members of community died. How would this change affect the trout?
8. Cutouts for the **energy pyramid food chain,** and **food web** are located in the Addendum and can be printed on heavier stock for each group of students.

Lesson 11: Threats to Trout Habitat and Survival

Preparation:
Duplicate Threats to Trout Habitat and Threats to Trout Survival handouts (one for each student).

Materials:
– Threats to Trout Habitat and Threats to Trout Survival handouts
– Poster material
– Colored markers

Standard Correlations:
KY POS—Science Grade 6-8

Procedure:
1. Discuss with students the factors in their own environment that make it habitable. Their responses may include clean water, air, food, housing, etc.
2. Discuss with them how their environment would be impacted if, for example, there was significantly less oxygen in the air.
3. Discuss with students the types of disease pathogens in humans – bacteria, viruses, parasites.
4. Call on students to describe factors in a trout's environment that make it habitable. Write students' responses on the chalkboard. If students have trouble coming up with ideas, suggest categories such as habitat (lake or stream), water quality, availability of food, oxygen, etc.
5. Tell students they are going to examine the trout habitat and factors that threaten it, as well as disease pathogens that affect trout in hatcheries, aquaria, and in the wild. Have students work in small groups. Distribute *Threats to Trout Habitat / Threats to Trout Surviva*l to each student. Have groups read and discuss the information in the hand-outs.
6. Have each group choose one threat to further research. Suggest the groups use the information in the hand-out along with internet resources. Have each group make a poster that highlights the threat and its effect on trout and on the trout habitat.
7. When groups are ready, have them present their posters to the rest of the class. Display the posters in the classroom or in the school corridor.

Threats to Trout Habitat

Trout need cold, clear water to survive and grow. Snow melt, underground springs, and rainfall feed streams and lakes where trout live. Trees and vegetation that line the banks make the banks stable and provide shade. The shade helps to keep the water cool and offers a hiding place for fish. Leaves that drop into the stream or lake decay and become food for insects, which in turn are eaten by fish. There are several habitats within a stream. Each habitat has different features and contains a different community of inhabitants. Young trout live in the calm, shallow waters near the banks. As they grow they move into the deep pools. Pools are the slower moving stream sections with smooth surface water. Many kinds of aquatic insect larvae make the pool their home. Dragonfly larvae hide in the silt at the bottom. There they can ambush unsuspecting prey. Caddisflies in the larval stage consume dead leaves.

Riffles are the area of streams where the water is shallow and runs swiftly over rocks. More organisms live in riffles than in pools. Many of the riffle inhabitants live in the cracks between rocks or under rocks. The swift current of the riffle oxygenates the water and quickly moves out waste. Organisms in riffles are adapted to this habitat. The swimming mayfly is streamlined so it can move in the fast current without being swept away. The black fly larvae attach themselves to the bottom of the riffle. The stonefly has a flat body and sprawling legs, which allow it to stay close to the surface of the rocks where there is a slower current. The riffle is a favorite place for trout. In the riffle they cannot be spotted by predators, there is plenty of oxygen, and the current brings them a fresh and constant food supply. The Kentucky Department of Fish and Wildlife Resources prefers to have a 1:1 ratio between riffles and pools for trout streams.

The natural balance in a stream is often threatened by pollution. Pollution isn't necessarily poison or waste being introduced into the stream. In fact many pollutants are, in small doses, harmless substances, but in large doses prove deadly to streams. Organisms in streams can tolerate substances at a range of levels. Outside the range, the organism will die. The optimum temperature for trout is between 53.6° F. and 64.4° F. Trout can survive temperatures as low as freezing and as high as 77° F. Outside this range, however, they will die. The insects that trout eat are more vulnerable to pollution than the trout themselves. Without insects, the trout starve.
Throughout the higher elevations in the Eastern United States, brook trout are facing threats to their habitat. For more detail see "Conserving the Eastern Brook Trout: An Overview of Status, Trends and Threats." It is not known if Kentucky has a history of Brook Trout that arrived during the ice age; however, some streams like the Laurel river tributaries have been stocked with Brook Trout.

Dams An on-stream dam impounds water that becomes susceptible to warming during the summer. This warm water may cause stressful or lethal water temperatures for trout both in the impounded area and downstream. Silt and sediment that collect behind the dam can impact in-stream habitat by smothering spawning sites and macroinvertebrate species that are important prey items for trout. Dams are also barriers to fish migration – a particular concern for streams that have spawning populations of trout. Manmade dams are responsible for damaging trout habitat in more streams than would first seem apparent. Many dams built long ago on Kentucky rivers and streams are no longer used for their original purpose (logging, milldams and diversion dams), but have stood the test of time.

The Laurel River is a prime example of trout habitat that has been significantly degraded by dams. On other streams, dams have been built to provide drinking water, electric power and flood control and these situations are causing increasing problems for trout streams not only in terms of high water temperatures but also with regard to maintenance of in-stream flows.

In the Cumberland River system below Wolf Creek Dam, the dual purpose of flood control and power generation has caused mortality of wild brown trout downstream due to the release of excessively warm water or output too low for constant cool flows. The failure to maintain sufficient flow downstream during the summer has also been problematic for trout. However, the result of too much water released at one time for electric power generation has caused macroinvertebrate dissemination because these bottom dwelling insects are left on the banks to die when the water is shut off. The release of anoxic bottom waters below the thermocline is also a concern with dams that have controlled releases. This could be solved with a small but calculated amount of water released regardless of flood control or power generation all the time and/or with an increased number of smaller generation cycles.

Loss of nearstream vegetation
The removal or loss of nearstream vegetation, particularly on the headwaters of trout streams, can result in undesirable thermal warming patterns. Construction activities in stream corridors such as road widening, bridge and culvert construction, etc. have resulted in short term or permanent losses of nearstream vegetation. Livestock grazing that destroys nearstream vegetation, causing unstable banks, has been observed along trout production streams and could be prevented or minimized through fencing. Roadway culverts improperly designed or installed culverts can prevent or impede fish passage and can be particularly problematic during low and high flow situations. In-stream fish habitat can also be lost if native substrate is not re-established in the culvert.

Nonpoint source pollution
Land disturbances within the watershed can increase pollutants. Urban development contributes to the stream pollution. During dry weather, gasoline, oil, dust, pesticides and other chemicals collect on roadways, sidewalks, and parking lots. When it rains, these chemical substances are washed into streams and lakes.

Runoff from roadways and a variety of sources may not pass through quality basins or other filtering devices prior to entering the stream. Silt is frequently a primary constituent of nonpoint source pollution and is a major threat to the state's trout resources. Runoff from poor farming practices and land disturbances are major contributors of silt.

Point source pollution
Discharges emanating from a point source, such as wastewater from treatment plants, can cause summer thermal alterations and increased pollutant loads that can stress or kill trout.

Channelization, channel relocation and stream cleaning
The first of these two activities are occasionally performed as part of stream crossing and road widening projects. Municipalities, county Mosquito Commissions, and farmers are probably most active in stream cleaning activities intended to improve runoff patterns. These small scale projects can cause localized damage by leaving a uniform stream bottom devoid of cover and structure for fish. Beneficial woody debris, that should be left in the stream channel unless causing a significant blockage, may often be removed under the guise of stream cleaning.

Global warming
Climatic changes associated with global warming may pose a problem for those trout streams in Kentucky where summer water temperatures approach critical levels for trout survival.

Acid rain
Acid rain is also a big problem for trout. Factories and power plants in the Midwest burn fossil fuels, (coal, oil, gas) that release sulfur dioxide and nitrous oxide into the atmosphere. When these chemicals are combined with rainwater or snow, they form acids. Soil in Kentucky cannot neutralize the acid effectively. The optimum pH reading is 7, which means that water is neutral. It is neither too acidic (low pH), nor too alkaline (high pH). Some lakes and streams polluted by mine runoff in Kentucky have a pH reading of 5, which is highly toxic to organisms. In addition, the acidity leaches aluminum from the substrate, which is deadly to fish and other organisms.

Threats to Trout Survival

Trout in hatcheries or in the wild face biological threats that can weaken or kill them. These threats come in the form of bacteria, viruses, fungi, parasites and other diseases. As a hatchery “manager”, it is important to recognize and minimize the threat from disease in your own aquarium.

Trout in hatcheries or aquaria are crowded more closely together than they would be in a stream, and diseases are spread more quickly because of crowding. Keeping the water cool and changing it frequently are two good methods of controlling disease. Pathogens that can harm trout are carried by other fish, so it is extremely important that you not introduce any other fish besides trout to your aquarium – even as food.

Streams naturally contain lots of bacteria that are not specific to fish disease. These microorganisms break down plant and animal life so that the nutrients can be recycled. Under stressful conditions for fish (low oxygen levels), common soil and water bacteria can harm fish. They can produce lesions or skin ulcers, and cause damage to internal organs.

There are many types of diseases caused by bacteria and viruses that are specific to fish. Crowding the fish and not changing the water frequently enough are the main culprits of infectious outbreaks. Gill disease, skin lesions, and kidney disease are some of the main bacterial infections caused by fish-specific bacteria. Skin lesions resulting from the bacterial disease Furunculosis may result when fish are stressed. Fish are also susceptible to viral infections. At the fingerling stage, Infectious Pancreatic Necrosis (IPN) is especially tough on hatchery fish. Infected fish will swim in a spiral and large numbers of fish die at once.

The disease is transmitted from the broodstock, so controlling infection there is the only solution. Parasites are always present in streams and a healthy fish can usually survive a light parasite load. A common parasite of trout is an external protozoan called *Ichthyophthirius* (ICK-thee-oph-thir-ee-us), also known as Ich. This organism gets under the lining of the skin, fins and gills. It can be seen without magnification, and looks like grains of salt and pepper under the skin. The lumps have a horseshoe-shaped macronucleus visible under a low-power microscope. Fish will behave wildly with an Ich infection – thrashing around and jumping out of the water. Formalin can be used to treat infected fish.

An internal parasite that is especially troublesome for trout causes whirling disease. The disease organism is *Myxobolus cerebralis*, an internal protozoan. This organism attacks cartilage in the head and spinal column causing deformities, and a mad tail-chasing behavior; hence the name whirling disease. The disease cycle includes an aquatic worm host. Once the worms are burrowed into the sediment, the disease is impossible to eradicate. Getting rid of the pond material is the only way to eradicate the disease.

The invasive algae known as Didymo (Didymosphenia geminate) recently appeared in the Cumberland River (Lake Cumberland tailwater). This algae is also in Arkansas, Tennessee, West Virginia and several western states. Didymo, native to northern Europe and Canada, is a white, gray, light brown or beige mass on the stream bottom that resembles shag carpet. It can choke the stream bottom with mats that cover up native plants and crowd out native insects that trout need for food. Prevention of Didymo requires inspection and cleaning of all wading gear and boat hulls, livewells, lower units and trailers for any vegetation after leaving the water to remove all algae or vegetation, soak in 2% solution of chlorine or undiluted vinegar and allow to dry for at least 2 days. Felt wading shoes should be soaked in a 5% solution of chlorine (household bleach) before drying.

Lesson 12: Where Does Our Water Come From?

Preparation: Duplicate the Water Use and Watersheds excerpts from the Kentucky Division of Water for student handouts.

Materials: Map of Water Basins in Kentucky and surrounding states.

Standard Correlations:
KY POS—Science Grade 6-8

Procedure:
After all students have read the handouts printed below, ask the following questions:

1. What is the most prominent stream, river or lake in your watershed?
2. Can you name your water basin?
3. What type of rock underlies your water basin?
4. Where do we get our water?

5. Divide into 5 groups and have each group read the subject of the websites printed below from the Kentucky Division of Water, plus one of the following: USGS Water Quality, Water Watch, Emerging Contaminants and Fish Consumption Advisory for Kentucky, and the Karst Topography movie.
6. Using the research on watersheds websites below, have each group find 1. Water Research in Kentucky and assign one of the next 5 websites to each group to research and prepare a quick summary for one of their members to communicate to the class what they found at their specific website. This may take longer than one session. If so, have the group write down their website URL so they can look it up at home and the summary of each group could be communicated in your next meeting or class.

Water Research in Kentucky:	http://www.water.ky.gov/
Tutorial on Water-quality:	http://nwis.waterdata.usgs.gov/tutorial/finding_qwdata.html
USGS Water Watch for KY:	http://waterwatch.usgs.gov/?m=real&w=gmap&regions=ky
Emerging Contaminants:	http://ky.water.usgs.gov/prog_highlights/
Fish Consumption Advisory:	http://www.water.ky.gov/sw/advisories/fish.htm
Karst Topography Movie:	http://www.watersheds.org/earth/karstmovie.htm

Wrap up:
Have students contact their municipal water supply authority, county health department, or private water supply company to find out the source of their drinking water whether it be surface water or groundwater.

Have students brainstorm questions that they want to ask about where their water supply comes from, if there are threats to the supply (drought, floods, pollution, contaminants, diversion of water, etc.)

Water Use

In Kentucky, water is used for public, industrial, domestic and commercial supply, in addition to irrigation, mining, and thermoelectric-power generation. The source of your water depends on where you live, how populated the area is, and what the geology is like.

Groundwater from private wells, public wells and springs is one of Kentucky's vital resources and is the source of drinking water for more than a million Kentuckians. Central Kentucky is populated, and ground water is concentrated in rock fractures, bedding planes, and solution cavities in the limestone rocks. Because the ground water is not uniformly distributed, it is less accessible than the groundwater in western KY. In some areas, the quality of the ground water may be unsuitable for particular uses. The Groundwater Section monitors and assesses the quality of groundwater throughout Kentucky by collecting water samples from wells and springs. These samples are routinely analyzed for metals, nutrients, pesticides and other substances to characterize and understand this important resource. Reservoirs and rivers are heavily used and water transferring systems are used to transfer water from the more pristine rural areas to urban centers. Eastern Kentucky is less densely populated, and aquifers are able to store and produce large amounts of ground water. However their sloping hills cause fast runoff which can accumulate quickly causing floods. This document was prepared in cooperation with the Kentucky Department of Environmental Protection, the U.S. Department of the Interior and the U.S. Geological Service.

What is a dam?


Wolf Creek Dam - Lake Cumberland, KY

A dam is defined by KRS 151 as any structure that is 25 feet in height, measured from the downstream toe to the dam, or has a maximum impounding capacity of 50 acre-feet or more at the top of the structure.

Existing Dams KRS 151.293, Section 6, authorizes the Energy and Environment Cabinet to inspect existing structures that meet the definition of a dam. The Dam Safety and Floodplain Compliance Section of the Water Infrastructure Branch maintains a list of these structures in an inventory database. In determining the frequency of inspection of a particular dam, the cabinet takes into consideration the size and type, topography, geology, soil condition, hydrology, climate, use of the reservoir, the lands lying in the floodplain downstream and the hazard classification of the dam.

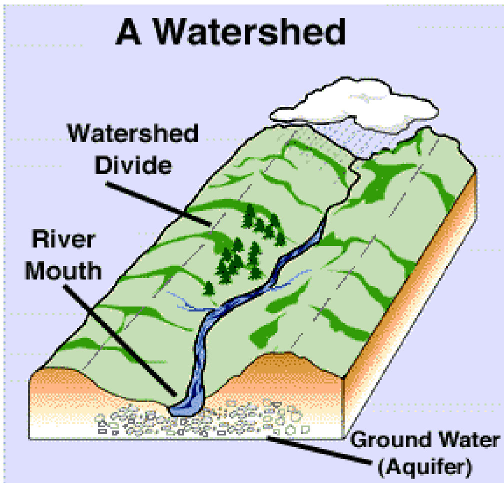
Dam Classifications

7. **High Hazard (C)** Structures located such that failure may cause loss of life or serious damage to houses, industrial or commercial buildings, important public utilities, main highways or major railroads.
8. **Moderate Hazard (B)** Structures located such that failure may cause significant damage to property and project operation, but loss of human life is not envisioned.
9. **Low Hazard (A)** Structures located such that failure would cause loss of the structure itself but little or no additional damage to other property.

What is a Watershed?

A **watershed** is a geographic area in which all water running off the land drains to a specific creek, river or stream. Each region draining into a river system, creek or body of water has a watershed defined by topographic and hydrologic features that separate it from the adjoining watershed.

What's the difference between a watershed and a basin?

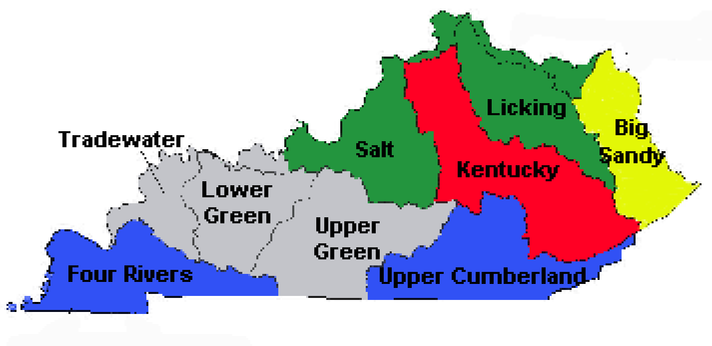


Basin - A basin is a large-scale watershed, such as the Kentucky, Salt, Licking and Green rivers. These are also referred to by a U.S. Geological Survey coding scheme called Hydrologic Unit Codes (HUCs). Each of these basins has a six-digit code called HUC6 watersheds. HUC6 watersheds cover an average of 2,525 square miles. Watersheds with more digits are smaller.

Subbasin - Subbasins are smaller scale basins, such as the North Fork Kentucky River, South Fork Licking River, Tygarts Creek, Lower Cumberland or Lower Tennessee. These watersheds have eight-digit codes and may be called HUC8 watersheds. They average 748 square miles.

Watershed - Technically speaking, this refers to all sizes of watersheds as defined above. However, it is common to use this term to refer to watersheds of a size smaller than a basin or subbasin. These watersheds have 10- or 11-digit codes and may be called HUC10 or HUC11 watersheds. HUC11 watersheds average 64 square miles.

Subwatershed - Subwatersheds are smaller watersheds, on the scale of a community. These watersheds have 12- or 14-digit codes and may be called HUC12 or HUC14 watersheds. HUC14 watersheds average 4.4 square miles.

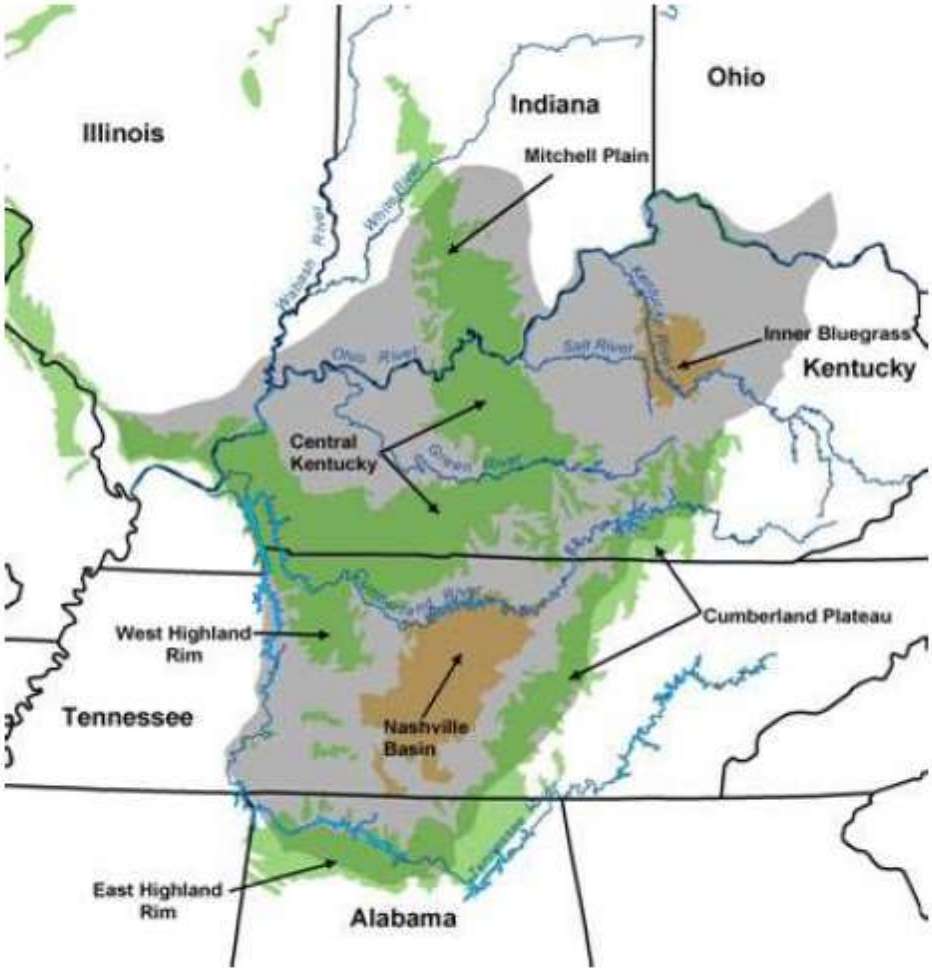


For administrative purposes, Kentucky has grouped the 12 basins into seven management units, each with a dedicated basin coordinator and river basin team, as follows:

Red: Kentucky River Basin
Green: Licking River Basin and minor Ohio River tributaries
Green: Salt River Basin and minor Ohio River tributaries
Green: Tradewater and Ohio tributaries
Blue: Upper Cumberland River Basin
Blue: Four Rivers (Cumberland, Tennessee, Ohio and Mississippi)
Yellow: Big/Little Sandy and Tygarts River basins

These Basin management units are each assigned to a five-year basin management cycle, as illustrated by the color-coded map. For example, all basin management units in the green-colored area follow a schedule of activities that includes scoping and data gathering, assessment, prioritization and targeting, plan development and implementation -- then the cycle begins again. Basin management units in the blue-colored area begin the same cycle of activities in the next year, and so on. The Licking and Salt river basins and minor Ohio River tributaries are grouped as are the Upper Cumberland and Four Rivers basins.

Water Basins



Geographic boundaries of the Interior Low Plateaus regional study area and major regional karst terranes (Explanation: tan areas underlain by Ordovician-age carbonates (carboniferous limestone); green areas underlain by Mississippian-age carbonates; and grey areas underlain by relatively less karstified Ordovician-Mississippian-age carbonates, or non-karstic sedimentary rocks).

Carboniferous limestone is a sedimentary rock made of calcium carbonate. It is generally light-grey in color, and is hard. It was formed in warm, shallow tropical seas teeming with life. The rock is made up of the shells and hard parts of millions of sea creatures, some up to 30 cm in length, encased in carbonate mud. Fossil corals, brachiopods and crinoids are very much in evidence as components of Carboniferous limestone; indeed the rock is full of fossils.

Carboniferous limestone has horizontal layers (beds) with bedding planes, and vertical joints. These joints are weaknesses in the rock, which are exploited by agents of both denudation and weathering. They also lead to the most important characteristic of Carboniferous limestone - its permeability. Water seeps through the joints in the limestone. This creates a landscape that lacks surface drainage but which has all manner of characteristic surface and subsurface features. The Carboniferous Limestone has been folded and faulted by massive Earth movements which can be seen by the fact that the rocks are now above sea-level and no longer horizontal.

Lesson 13: Find Your Watershed on EPA

Preparation:

Check out the website recommendations below to determine if they are active or not. If inactive, please find those that will work for this EPA Watershed lesson.

Materials:

Students will need a computer either at home or in computer lab at school.

Have the students follow the lesson listed below and bring back answers to the class for discussion.

Standard Correlations:

KY POS–Science Grades 6-10

Procedure:

Print out the lesson on the next few pages below for the students. Let them know they can type in the few URLs listed in this lesson into their browser.

Prepare for an orderly discussion of the topics the students will find on the EPA site and prepare questions that will help students remember what they have discovered. The main point to leave with the students is that we are neighbors to other families, farmers, businesses and industrial plants in our watershed whether upstream or downstream.

Learn the name of your watershed by opening EPA Watersheds
and entering a local zipcode at: http://cfpub.epa.gov/surf/locate/index.cfm

What can you do to make a difference in your watershed? Click on **Adopt Your Watershed** and print the resulting page for your classroom discussion.

Select the **Ten Things You Can Do to Make a Difference in Your Watershed** and print it out for discussion in class.

Open the EPA Waters Web site at: http://www.epa.gov/waters/ir/

Click **Kentucky** on the US Map.

From the drop down list, select the name of your watershed and press **GO**.

On the Blue and Pink chart below, locate a waterbody (river, creek, lake) and click on its name in the left column.

If the background id pink it is impaired, if the background is blue it is good.

Return to the previous page by clicking on the back arrow ← in the top left corner of your browser.

Pick a Pink background waterbody you think you know and click on its name in the left column. Pick several waterbodies to see a different **Causes of Impairment**.

Read the **Cause of Impairment** and note below:

What is the **Probable Source of the Impairment**?

What are the words that you don't know their meaning?

Please look up the meaning of words you don't know using Google search engine or Wikipedia to find the definition.

Write down or copy and paste the definitions below:

What is a Riparian Habitat?

What is Eutrophication?

What is Escherichia Coli or Coliform bacteria?

What is the difference between point and nonpoint pollution sources?

Who are your neighbor cities upstream in your watershed?

What can these neighbors do to keep pollution out of the water that comes downstream to your water treatment plant?

Who are your neighbor cities downstream in your watershed?

What can you and your family do to keep pollution out of the water that goes downstream to their water treatment plants.

What is the name of your water treatment plant where you get your drinking water?

Can you find your water treatment plant on the web?

Do they have online lessons for students about water quality?

Lesson 14: Trout Stocking by the Numbers

Preparation:
Duplicate the *Trout and Water Quality Stream Management* background and *Managing Trout Stocking by the Numbers* handouts.

Materials:
– none

Standard Correlations:
KY POS Science Grades 8-10

Procedure:
1. Have students read the ***Managing Trout Stocking by the Numbers*** background information, and then working in teams, answer the questions derived from hypothetical situations that follow.
2. As an alternative, students can pick a real body of water (either a lake or a stream), research its habitat suitability and capability of supporting trout, and then make recommendations on how many and what kind of trout it can support.
3. A trip to Wolf Creek Trout Hatchery or Salato Natural Resource Education Center can be part of this activity.
4. Help students think of questions they could ask a hatchery manager or fisheries biologist.

Questions: Some suggestions to get this going are:
1. How big will a 4" fish get between October and March delayed harvest?
2. What is the percentage of trout stocked that live-over into the following year on the Lake Cumberland tailwater?
3. Is Paint Creek below Paintsville Lake a live-over stream for rainbow trout?
4. How do you measure the trout census from year to year?
5. Where can I find out about upcoming trout stockings so we can plan a field trip at that time?
6. What is the difference between a creek and a river?

Managing Trout Stocking by the Numbers

Angler demand for trout means that fishery managers must develop programs and strategies aimed at providing this user-group with a satisfying angling experience. Trout raised in a hatchery provide resource managers with an effective management tool for creating and enhancing recreational coldwater fisheries. Trout are raised at the Wolf Creek National Trout Hatchery below Jamestown, KY at the dam.

Put-Grow-Take Trout Stocking

Trout fisheries in Kentucky's streams are represented by brown, rainbow, and brook trout. Before 1980, the Kentucky Department of Fish and Wildlife Resources (KDFWR) stocked primarily rainbow trout for put-and-take fisheries. As of 2008, the trout program includes six streams (17.2 miles) that have natural brook trout populations and three tailwaters (78.4 miles) and 11 streams (59.2 miles) for put-grow-take brown trout or rainbow trout fisheries. There are a total of 302.5 miles (88.4 miles in tailwaters) of trout fisheries in 67 streams (Paint Creek and Beaver Creek listed twice) that include 14 tailwaters. Forty-three percent (130.8 mi) of the total miles of trout stream fisheries is represented by brown trout. There are 8.7 miles in two streams that are managed for put-and-take and put-grow-take brown and rainbow trout fisheries at Fort Campbell Military Reservation that lies in both Kentucky and Tennessee.

Rainbow Trout

Rainbow trout have been utilized in the trout program since being stocked as catchable-size fish into both Lake Cumberland and Herrington Lake tailwaters in 1952. Rainbow trout are stocked at a rate of about 100-500 fish per mile, depending on number of stocking sites and stream size.

Brook Trout

The U.S. Fish and Wildlife Service established brook trout in two streams from stockings in 1968. The KDFWR has expanded trout fishing waters for wild brook trout to several streams with the Owhi strain, beginning with introductions of 3-4 inch brook trout in a headwater stream in 1980 and 1981. Headwater streams are considered for wild brook trout management if they have the following: (1) at least 1 mile of suitable coldwater habitat, including a maximum water temperature of <68^{o}F; (2) an excellent rating for all trout stream rating parameters; (3) are within public land; (4) 100% of their watershed is in silviculture; (5) there is no road access within at least 0.5 mi; and (6) they are either located above 2,000 ft msl or have a natural fish barrier.

Brown Trout

Brown trout (Plymouth Rock strain), 3-4 inches long, were first stocked by the KDFWR in Laurel Creek during 1981-1984, resulting in the creation of a high quality put-grow-take fishery for brown trout. This stream and eight others began to be annually stocked with fingerling brown trout in 1988. These streams were selected for put-grow-take stockings of brown trout due to being rated good or excellent, having good pool habitat for good brown trout growth and survival, and not fitting the criteria for wild brook trout management. Annual stockings of 8-inch brown trout began in the Lake Cumberland tailwater in March 1982. Herrington Lake tailwater has been annually stocked with 8-inch brown trout since 1988. Laurel River Lake tailwater has received brown trout since 1995. In 1986 and 198, fingerling brown trout were stocked into 10 streams to establish wild brown trout fisheries without success. Brown trout reproduction was documented in a few of these streams, but not at a level to sustain a fishable population.

Two of these streams are now being stocked annually with 4 or 8-inch brown trout for providing a put-grow-take fishery - Chimney Top Creek since 1990 with 4-inch fish and Bark Camp Creek since 1992 with 8-inch fish. Annual stockings of 8-inch brown trout began in 1997 at Slabcamp, Stonecoal, Minor, Laurel, and Big Caney creeks. Trammel Fork began to be annually stocked with 8-inch brown trout in 1991 instead of 4-inch fish to improve survival. Eight-inch brown trout have been stocked at East Fork Indian Creek (Menifee County) since 1993. Laurel River Lake tailwater was added in 1995. Brown trout stocking in Slabcamp Creek / Stonecoal Branch was discontinued in 2006.

A 15-inch size limit on brown trout was imposed in 1989 at Herrington Lake tailwater, but was changed back to statewide regulations in 2008. A 20-inch size limit was implemented on brown trout at Lake Cumberland tailwater in 1996.

Brown trout are stocked at a rate of about 200 4-inch or 100 8-inch trout per mile in headwater streams <20 ft wide; 200 8-inch trout per mile in streams 21-40 ft wide; 300 8-inch trout per mile in 41-60 ft wide streams; 400 8-inch trout per mile in 61-100 ft wide streams; and 500 8-inch trout per mile in >100 ft wide streams. At 50% survival through age 6 (or 5 lb fish), the biomass from these rates would result in about 30-60 lb of trout per acre. The mean standing stock of all fish in streams in Kentucky, based on fish sampling data using rotenone by KDFWR, is about 62 lb/acre, excluding the Ohio River and lower Cumberland River.

Tailwaters Stocked with Rainbow and Brown Trout

TAILWATERS	Total Rainbows	Total Browns	Months Stocked
Buckhorn	3,800	0	4,5,6,10,11
Carr Creek	8,400	0	4,5,6,7,8,9,10,11
Cave Run	8,500	0	4,5,6,10,11
Cumberland*	161,000	38,000	4,5,6,7,8,9,10,11
Dewey	3,200	0	4,5,10,11
Fishtrap	6,600	0	4,5,6,10,11
Grayson	8,000	0	4,5,6,10,11
Herrington	4,600	1,000	3,4,5,6,7,8,9,10,11
Laurel River	250	500	3
Martins Fork	4,800	0	4,5,6,7,10,11
Nolin River	16,600	0	4,5,6,7,8,9,10
Paintsville	16,600	0	4,5,6,7,8,9,10,11
Rough River	5,000	0	4,5,6
Yatesville	1,800	0	4,5,11

*Stocking dates for Cumberland River (Cumberland Lake tailwater) will not be announced.

Trout Stocked in Kentucky Streams

Statewide Streams	County	Total Rainbows	Total Browns	Months Stocked	Catch and Release (No Harvest) Season
Bark Camp Creek*	Whitley	3,600	500	3,4,5,6,10	Oct. 1 – Mar. 31; 3.9 miles
Beaver Creek	Wayne	2,900	0	4,5,6,9	Oct. 1 – Mar. 31; Hwy 90 bridge upstream to Hwy 200 bridge – 2.8 miles
Beaverdam Creek	Edmonson	2,400	0	4,5,6,9	
Big Bone Creek	Boone	3,000	0	4,5,10	Oct. 1 – Mar. 31; Inside the Big Bone Lick State Park
Big Double Creek*	Clay	2,000	0	3,4,5	
Big Caney Creek	Elliott	4,000	250	4,5,6,7	
Cane Creek*	Laurel	4,900	0	3,4,5,6,10	Oct. 1 – Mar. 31; 6.6 miles
Casey Creek	Trigg	8,000	0	4,5,6,7,8,9,10	Oct. 1 – Mar. 31; 3.6 miles

Statewide Streams	County	Total Rainbows	Total Browns	Months Stocked	Catch and Release (No Harvest) Season
Chimney Top Creek*	Wolfe	0	450	6	
Clear Creek	Bell	2,000	0	4,5,10	Oct. 1 – Mar. 31; Hwy 190 bridge 4.5m down stream
Craney Creek*	Rowan	1,400	0	10,11	
East Fork, Indian Creek*	Menifee	3,900	400	3,4,5,10	Oct. 1 – Mar. 31; 5.3 miles
East Fork, Little Sandy River	Boyd	2,000	0	4,5	
Elk Spring Creek	Wayne	2,000	0	4,5,6,10	Oct. 1 – Mar. 31; 2.8 miles
Goose Creek	Casey	4,500	0	4,5,6	
Greasy Creek	Leslie	1,500	0	4,5,6	
Hatchery Creek	Russell	24,000	0	Monthly	
Hood Creek	Johnson	1,000	0	4,5	
Jennings Creek	Warren	3,000	0	4,5,6,7,8,9	
Laurel Creek	Elliott	3,000	250	4,5,6	
Left Fork, Beaver Creek	Floyd	1,600	0	4,5,10	Oct. 1 – Mar. 31;Hwy 122 bridge upstream – 3.6 miles
Lick Creek	Simpson	3,600	0	4,5,6,7	
Line Fork	Letcher	4,000	0	4,5,6,9,10	
Little Whippoorwill Creek	Logan	750	0	4,5,6	
Lynn Camp Creek	Hart	4,000	0	4,5,6,7	
Middle Fork, Red River*	Powell/ Wolfe	5,000	0	3,4,5,10	Oct. 1 – Mar. 31; Inside of Natural Bridge State Park – 2.2 miles
Middle Fork, Rockcastle Creek	Martin	2,500	0	4,5,10	
North Fork, Triplett Creek*	Rowan	2,000	0	3,4,5,6	
Otter Creek	Meade	2,200	500	4,10	Oct. 1 – Mar. 31; Ft. Knox Military Res. & Otter Creek Park 9.7 miles
Paint Creek	Johnson	0	300	4	
Peter Creek	Barren	3,600	0	4,5,6,7,8,9	
Raven Creek	Harrison	1,000	0	4,5	
Right Fork, Buffalo Creek	Owsley	1,500	0	4,5,6	
Rock Creek*	McCreary	17,600	0	3,4,5,6,9,10,11,12	Oct. 1 – Mar. 31; Bell Farm bridge upstream TN border – 9.8 miles
Rough Creek	Hardin	3,000	0	4,5,6,7	
Rough River (Hwy 54 bridge)	Grayson/ Ohio	4,800	0	4,5,6,7,9	
Round Stone Creek	Hart	3,600	0	4,5,6,7	
Royal Springs	Scott	1,500	0	6,7,8	
Russell Fork	Pike	9,000	0	4,5,10	

Statewide Streams	County	Total Rainbows	Total Browns	Months Stocked	Catch and Release (No Harvest) Season
Sinking Creek	Breckinridge	6,000	0	4,5,6,7,8,9	
Station Camp Creek	Estill	2,000	0	4,5	
Sturgeon Creek	Lee	1,000	0	4,5	
Sulfur Spring Creek	Simpson	5,000	0	4,5,6,7,9	
Swift Camp Creek*	Wolfe	1,000	0	4,10	Oct. 1 – Mar. 31; within Clifty Wilderness Area – 8.0 miles
Trammel Fork	Allen	9,600	400	4,5,6,7,8,9	
Triplett Creek	Rowan	2,000	0	3,4,5,6	
War Fork*	Jackson	4,000	0	3,4,5,6,10	

*Daniel Boone National Forest stream; stockings are not announced.

Four brook trout streams have had catch and release regulations, single hook and no live bait restrictions on fishing tackle since 2000. Stocking numbers of brook trout and months are not available.

1. Dog Fork – Wolfe County
2. Parched Corn Creek – Wolfe County
3. Poor Fork – Letcher County, from the headwaters to Hwy 932
4. Shillalah Creek – Bell County, outside the Cumberland Gap National Historic Park

Trout and Water Quality Stream Management

Establishment

There are many options in streamside management. However, all of them include the maintenance or creation of adequate vegetation. Although any width of woody or grassy vegetation is better than none at all, providing at least 15 feet of permanent vegetation on a stream's sides should be a minimum goal for even the smallest streams (see Table 1). Ideally, streamside management zones of at least 150 feet on each side of a stream or river should be maintained. Where adequate tree or shrub cover is already present along a stream, it can simply be preserved or perhaps enhanced. For help with streams that have severe erosion problems you should consult your county Natural Resources Conservation Service office, the Kentucky Division of Water, or your regional Kentucky Department of Fish and Wildlife Resources Wildlife Division office.

Trees are the best type of vegetation to establish and/or maintain on the 15-100 feet of ground directly adjacent to each side of streams. If you are planting trees, use species that are suited to the soil type and water conditions present. Planted tree seedlings should be spaced 10-12 feet apart (or about 500 trees per acre). In flood-prone bottomland areas, use tree species such as swamp white oak, swamp chestnut oak, pin oak, Shumard oak, bald cypress, pecan, shellbark hickory, and green ash. For streamsides that are not normally flooded, select from species such as white ash, white oak, northern red oak, cherrybark oak, shagbark hickory, tulip poplar, persimmon, American sycamore, and American beech. Shrubs such as elderberry, viburnum, and dogwoods can be planted also, but they usually volunteer anyway.
Natural revegetation, or simply allowing a streamside to grow up in volunteer trees, is a viable option in many situations. However, you have less control over the species of trees that will grow up in the streamside management zone and it may take longer to get the desired results. Typically, light-seeded tree and shrub species such as elms, maples, sycamore and ash grow up in a naturally revegetated area during the first several years.

Establishing of a zone of grasses and forbs (desirable broadleaf plants) between the zone of woody vegetation and crop, hay, or pasture fields is highly beneficial. A field border of native warm-season grasses or beneficial cool-season grasses (see figure 1) would increase the nutrient and sediment filtration effectiveness of the zone, while also providing grassland cover to wildlife in the area. When planting grasses, do not use tall fescue. Fescue is poor wildlife cover, plus its invasiveness limits other plants that are more beneficial to wildlife.

Management

The most important thing a landowner can do for a streamside area is to protect it. Protecting stable streamside zones are much less expensive than correcting severe erosion problems and restoring degraded streams. Where a pasture field borders a streamside protection zone, cattle should be excluded from the streamside zone by fencing. Developing upland water sources such as ponds and stock tanks for cattle is recommended. When cattle have unrestricted access to streams they destroy beneficial streamside vegetation, causing banks to become unstable and erode. Livestock manure also reduces water quality (for example, high *E. coli* bacteria levels in the water supply) if access to streams is not limited. Unfortunately, on many farms, streams are the only water sources for cattle. In those cases fencing can be used to provide limited access points to stream water supplies.

Some landowners may wish to remove a few trees, or perform "timber stand improvement," on the wooded portion of their streamside protection zones. This may be beneficial in some situations, provided that a sufficient number of favored trees are left. Consult with a wildlife biologist or forester before thinning along a streamside.

Placement of nesting boxes would be a welcome addition to any streamside area with the right cover type. Some wildlife species that use properly constructed nesting boxes in this setting include wood ducks, prothonotary warblers, great-crested flycatchers, and eastern phoebes. Another enhancement for streamside zones would be the addition of brush piles for cover. Given the opportunity to thrive, the natural or planted permanent vegetation along a streamside will provide numerous benefits to wildlife, fish, water, and soil.

Table 1. Widths of streamside management zones (SMZ) and associated benefits

SMZ Width	Benefits
15 feet	Stabilizing streambanks, reducing algae
25 feet	Stabilizing streambanks, water quality, some wildlife habitat
50 feet	Stabilizing streambanks, water quality, wildlife & fish habitat
100-150 feet	Stabilizing streambanks, water quality, wildlife habitat, fish habitat, some timber production

Classification Methods:

Lakes
Lakes are classified as trout maintenance or non-trout according to their ability to support trout year round. Trout survival in lakes is dependent upon summer water quality conditions, which can reach critical levels during the summer months. Lakes are surveyed mid-August when water temperatures are highest and dissolved oxygen levels are typically at the lowest levels. To support trout, lakes must have a layer of water with favorable conditions of temperature (21° C or less) and dissolved oxygen (4 mg/l or greater) all year long.

Streams
Streams are classified based on the documented occurrence of natural reproduction, and the presence or absence of trout and/or trout associated species. Streams which lack naturally reproduced trout in their first year of life are classified as trout maintenance or non-trout based upon the streams total fish population.

Trout Production – Young-of-the-year trout must be documented within the sampled stream segment. Young-of-the-year (y-o-y) trout can be visually distinguished from older trout in the field, based upon their size (typically less than 100 mm in length).

Trout Maintenance – Incidence of Occurrence of trout and/or trout associated species > 20 %.

Non–Trout - Incidence of Occurrence of trout and/or trout associated species <20%.
The *Incidence of Occurrence* was developed based upon fisheries data. The number of times that the species was found to inhabit a stream with a naturally reproducing trout population was proportionally compared to the total number of stream segments in which the species was found. The result was an *Incidence of Occurrence*, expressed as a percentage, for that particular species with reproducing trout populations. The higher the *Incidence of Occurrence* the greater the species' "association" with trout.

Management of Habitat
To survive, fish need a healthy environment that satisfies their life requirements. Fish habitat is aquatic space, as determined by chemical, physical, and biological factors. Habitat characteristics play a key role in determining fish assemblages (fish species and their numbers, and sizes). Habitat also influences biotic interactions (competition, predation) that affect fish communities. Three habitat factors that affect the distribution and abundance of trout in streams and lakes are water quantity, water quality, and in-stream habitat.

Management Factors for Cultured Trout
Cultured trout in Kentucky are presently managed according to two general management strategies: Put-and-Take Catchable-size brook, brown, and rainbow trout are stocked for immediate harvest to provide a short-term, seasonal fishery. Survival of these trout through the summer period is not expected (or poor) because suitable summer trout habitat (temperature < 21°C and dissolved oxygen > 4 mg/L) is absent. The trout stocked waters managed under this stocking strategy include park ponds, shallow lakes, and warm water streams. These waters are stocked in the spring and may be stocked again under the fall or winter program.

Put-Grow-Take
Rainbow, brown and brook trout are stocked for immediate and/or delayed harvest to provide a long term, year-round fishery. Suitable habitat is consistently available to sustain trout throughout the year, and trout are expected to survive over more than one growing season. Trout-stocked waters managed under this stocking strategy include coldwater streams and deep lakes that are capable of supporting trout year round, where wild trout populations are limited or absent. These waters are stocked in the spring and may be stocked again in the fall or winter.

Timing of Stocking Programs for catchable trout
The timing of trout stocking can greatly influence the success of the program. The KYDFWR trout stocking program for catchable trout currently includes a spring, fall and winter component. The spring stocking program is by far the largest and most popular of the three, but fall and winter stockings programs are successful in providing additional opportunities for Kentucky anglers.

Trout Allocations
The number of trout that are distributed in any body of water is determined using a formula developed in 1990. The formula takes into consideration stream size, access, proximity to other trout stocked waters and population.

Species Selection Criteria
For each trout-stocked water the trout species that will have the least impact upon the resident fish population, and provide the highest survival and angler catch rates, is selected for stocking. For many waters, the species selection is not critical and brook, brown, and rainbow trout may be stocked in any combination. However, in these situations brook trout are typically stocked first because their willingness to bite usually results in high angler catch rates and satisfaction on opening day. By the 1st or 2nd week following opening day, when the hatchery supply of available brook trout has been exhausted, rainbow trout are then stocked. Towards the end of the spring stocking season (4th or 5th week), brown trout are stocked. Most waters stocked late in the season are generally capable of supporting trout year round and brown trout survival rates in these waters are generally better than the other two species.

Trout Production Streams
Streams having reproducing trout populations are stocked with a cultured species that minimizes unfavorable interactions (interbreeding, inter-specific competition, etc.). Rainbow trout raised by Trout in the Classroom schools can only be stocked into waters where rainbow trout are not currently reproducing on their own. Therefore, they are allowed by Kentucky Department of Fish and Wildlife to be stocked into streams where annual stocking by the KDFWR already stocks rainbow trout.

Reproducing trout species	Acceptable cultured trout species
brook	rainbow
brown	brook and/or rainbow
rainbow	brook
brook and brown	rainbow
rainbow and brown	brook
brook and rainbow	rainbow or brook (the opposite of the dominant wild species)

The frequency of the stockings is based upon the size of the stream, and flow. Although current stocking practices are designed to minimize the impacts of hatchery trout in streams already supporting natural populations, the consequences of these stockings on the natural populations has not been investigated.

Low pH Waters
Streams and lakes which have been identified as having poorly buffered, low pH (< 5.5) conditions are stocked with brook trout due to the species ability to tolerate low pH conditions.

Marginal Trout Lakes
Lakes having marginal summer trout habitat (i.e. holdover trout are occasionally, but not regularly caught) are stocked early in the season with brook and rainbow trout, and receive brown trout during their last in-season stocking. A number of these waters historically supported trout year round but over the years declining water quality has resulted in the reduction or elimination of summer trout habitat.

Non-trout Lakes and Streams
Lakes and streams that lack supportive capabilities for trout during the critical summer months are stocked with brook and rainbow trout. The proportion of each particular species stocking is dependent on hatchery production.

Size Selection Criteria
The size of catchable trout that will have the least impact upon on the resident fish population, is compatible with the available habitat, and will provide a high return to the creel is selected for stocking. Catchable-size trout stocked in the spring are categorized into two sizes – quality (10.5 inch average) and broodstock, sometimes referred to as breeders (15 inches and larger). All waters stocked with trout in the spring receive quality-size trout. Broodstock are mixed in with the quality trout early in the stocking season (2% per load until the supply is exhausted) unless the receiving water falls into one of the following four categories:

1. Trout Production Streams – These streams contain naturally reproduced trout that are seldom more than 12 inches long and do not compete well with the much larger broodstock trout.
2. Trophy Trout Lakes – Quality-size stocked trout put into these lakes are able to grow to trophy size in 1 – 2 years, negating the need to stock larger broodstock.
3. Holdover Trout Lakes – Quality-size stocked trout put into these lakes are able to grow to trophy size in 1 – 2 years, negating the need to stock larger broodstock.
4. Small Streams – Streams less than 33 feet wide and having flows less than 19 CFS that do not have a sufficient living space to adequately accommodate the larger broodstock.

Lesson 15: How Much Water Do We Use?

Timeline: This lesson requires two class periods.

Preparation:
Duplicate Household Water Usage handout (1 per student, some may require 2).

Standard Correlations:
KY POS—Science Grades 4-8

Procedure:

1. Discuss water usage with students. Ask them to think about all the ways they and their families use water at home. Remind them to include things like watering the lawn, washing a car, doing laundry, washing dishes, etc. Write their responses on the board.
2. For each water usage listed, ask students to estimate how many gallons of water are used. If there is a wide range suggested, see if you can get students to come to a consensus of how much water is used.
3. Based on the list, ask students to each estimate how much water their family uses each day. Give students 5 to 10 minutes to calculate their family's usage. Have students divide the number of gallons they came up with by the number of family members to get an average of each person's daily usage.
4. Call on a few volunteers to share their water usage averages with the class. Point out to students that these are estimates. Tell them that over the next 24 hours they are going to monitor their families' water usage.
5. Distribute Household Water Usage to each student. Read over the handout with them. Have them compare actual water usage for each activity with their estimates. Explain that they should interview each family member to find their daily water activity and the number of times they did the activity, such as, brushing their teeth. Have students complete the sheet as a homework assignment.
6. When students have completed their Household Water Usage charts, have them work in small groups.
7. Provide each group with a Water Usage Chart. Have students use the chart to determine how many gallons of water was used for each activity. Have them write the number of gallons used and multiply that by the times per day to get the daily use for that activity. Have students total each individual's daily usage, add them together and divide by the number of people in their household to find the average.
8. Call on volunteers to share their findings. Have students compare their estimates to the actual amount of water used. Point out that the average American uses 100 gallons of water a day. The average person in a developing country uses just 13 gallons a day. Discuss with students what might account for the discrepancy.
9. Brainstorm with students ways that they might cut down on water usage. Write their suggestions on the board. Suggest students encourage their families to adopt some of these water-saving practices to see if they can bring the total water usage for the class down.
10. You may wish to conduct the water usage survey again a few weeks later to see if the water-saving practices were effective. Have them calculate the savings per home, per year. If people in your area pay for water, have students calculate the monthly water bill before and after conservation measures are adopted.

Household Water Use

Your Name: ______________________________________ **Date:** ___________

Family Member: ____

Activity	X/day	Gallons Used	Daily use
Wash hands		.25	
Brush teeth		2	
Wash face		3	
Flush toilet		2-7	
Laundry		40/load	
Shower		25-40	
Bath		35-50	
Wash car		80-100	
Hand wash dishes		20	
Machine wash dishes		12-20/load	
Water lawn		6,797/acre	
Food prep/drinking water		1	
Total			

Family Member: ____

Activity	X/day	Gallons Used	Daily use
Wash hands		.25	
Brush teeth		2	
Wash face		3	
Flush toilet		2-7	
Laundry		40/load	
Shower		25-40	
Bath		35-50	
Wash car		80-100	
Hand wash dishes		20	
Machine wash dishes		12-20/load	
Water lawn		6,797/acre	
Food prep/drinking water			
Total			

Family Member: ____

Activity	X/day	Gallons Used	Daily use
Wash hands		.25	
Brush teeth		2	
Wash face		3	
Flush toilet		2-7	
Laundry		40/load	
Shower		25-40	
Bath		35-50	
Wash car		80-100	
Hand wash dishes		20	
Machine wash dishes		12-20/load	
Water lawn		6,797/acre	
Food prep/drinking water			
Total			

Lesson 16: Fish Art (or Japanese *Gyotaku*)

Print on Paper or T-Shirts for Fund Raising Project

Preparation:
You will need to gather the materials described below. You can choose to have a small group of students do the *Gyotaku* on paper while the rest of the class is engaged in another activity like printing on T-Shirts for a local fund raising event. The local Trout Unlimited Chapter could sell these at their meetings or banquet. Another alternative is to have the entire class working in small groups do the Gyotaku. In that case you will need the following materials for each group of students.

Materials:
- Fresh trout
- Linoleum block print ink speedball, or any other thick water soluble ink for paper prints
- Or use paint colors (brown, olive, red, yellow) for T-Shirts
- Stiff 1 inch paint brush, a small brush (for painting eye)
- Modeling clay
- Lemon
- Old newspapers
- Paper towels
- Colored newsprint paper
- Hairdryer (optional)

Procedure:
1. Have students work in small groups. Instruct them to cover the work table with newspaper. Have them clean the outside of the fish by squeezing lemon juice on its body and gently wiping to remove the slime. They should be careful not to dislodge the scales.
2. Have them place modeling clay under the fins for support. The fins should be arranged to look natural. If the fish has been gutted, paper towels can be stuffed inside so that the belly is firm. The anus should be plugged with a piece of paper towel to avoid any leaking. Have students cover the eye with a small piece of cotton.
3. The fish must dry completely. A hairdryer can be used to hasten the process. Check for dryness Have students place a stack of newspaper sheets under the fish (sheet should be unfolded). by removing some of the clay. If the fins stay in place, students can proceed with the art activity.
4. Instruct students to brush a thin coat of ink on the fish, using the ½ inch brush beginning at the head and working down to the tail. The ink should be thick, not runny. When the fish is covered, reverse the direction of the strokes, going from tail to head. This puts ink under the edges of the scales and spines and will improve the print. The small brush should be used to coat the fish's lips and tips of fins and tail. Do not paint the eye at this time.
5. When the fish is inked, have students carefully remove the clay and slide the top sheet of newspaper out from under the fish so that the top sheet is clean.
6. Instruct them to take a sheet of newsprint and hold it several inches above the fish. The paper should be positioned so that the print will be made in the location and angle they desire. Let go of the paper and let it fall on the fish. Do not move the paper once it has touched the fish.
7. One student should hold the head of the fish while the other gently pats and presses it with his/her hands. All parts of the fish should be pressed so that there won't be any black or faint areas of the print. The fins must be pressed as well. Try not to move the paper around as it will cause smudging. If the paper wrinkles, that's okay. Try not to rub the same part twice. After the entire fish has been pressed, gently and carefully peel off the paper. Paint in the eye using the small brush (practice on scrap paper first). Allow the print to dry.

Lesson 17: Determining the Health of a Stream

Field visits to a stream and determining the health of the stream will help students make connections between the trout in the classroom aquarium and the trout in their natural habitat. They will gain an understanding and appreciation of the relationship between a healthy habitat and the organisms that live in that habitat. Several visits to the stream where the trout will be released will provide the optimal experience for students. Depending on where your school is located and the availability of transportation, this may not be feasible. In that case, a visit to a local stream—or even a local pond or lake, would still provide students with a valuable experience. Two visits is preferable, but if you have just one day then you should prepare your students to do both the stream assessment and macroinvertebrate population assessment on the same day. If you can't physically do a field trip, use the Leaf Pack Study Activity at the end of this section.

Preparation:
It is advisable for you to visit the site before the class visit in order to better plan the investigation and deal with any logistical problems. Duplicate the Stream Description handout for each student.

Materials:
– Water testing kit
– Thermometer
– Secchi disc
– Pencils, pens, colored pencils
– Stream Description handout

Standard Correlations:
KY POS Science 6 A.1, A.2, B.1, Grade 8 A.1, Grade 12 A.1, B.1

Procedure:
1. Call on students to name some factors that might affect the health of a stream. Suggest they consider both point source and non-point source pollution. (Pollutants restrict light needed by plant plankton and reduce food production. Fertilizers, pesticides, animals waste, and sewage runoff deplete oxygen and kill stream organisms.) List student responses on the board.
2. Tell students that they are going to visit a stream to assess how healthy the stream is and whether the stream would be able to support trout. They will do a visual assessment, test water quality, and then assess the health of the stream by conducting a macroinvertebrate population survey. Ask students to recall some of the stream habitat characteristics and water quality factors that are necessary for trout survival. Write responses on the board.

Stream habitat characteristics should include:
- Banks lined with vegetation, shady areas with overhang
- Gravel streambeds
- Calm shallow waters near the bank
- Deep pools with smooth surface water
- Shallow riffles with fast moving water
- Rocks

Water quality factors should include:
- pH (pH levels between 6.5 and 7.5)
- Temperature (cool water temperature between 48 degrees F. and 52 degrees F. is optimal; however, trout can survive at both slightly lower and slightly higher temperatures)
- Dissolved Oxygen (dissolved oxygen at 10-12 ppm is most desirable)

- Turbidity or sediment (clear water with little sediment is most desirable for trout)
- Pollutants (water free of pollutants)

Tell students that they will examine these characteristics and factors when they visit the stream. Have students work in small groups. Remind students to bring their trout journals and writing implements (pencils, pens, colored pencils) with them on the field trip. At the stream, have students spend 20 to 25 minutes drawing a map of the stream and its banks and noting vegetation, surrounding area (farmland, highway, industrial area, etc.), pollution (cans, paper, trash) both in the stream and on the banks. Give them additional time to write a description of the stream—including what they see, smell, hear, etc. Distribute stream description hand-out and have students use it to guide their writing.

Have each group test one water quality factor. Students can use a secchi disk or make a visual assessment for the turbidity factor. If time is limited, take a water sample and have it tested at a local laboratory.

Back in the classroom, discuss students' observations. Identify those characteristics and factors that are beneficial to trout survival and those that would be harmful to trout survival. If the stream is polluted, brainstorm to find solutions for making the stream healthier. Find out about land use regulations in your area. Develop a plan that is both appropriate and realistic for improving the stream's health. For example, plan a stream pick-up day. Have students along with family and friends meet at the stream to pick up trash and other debris. Have students hand out flyers in the community so that other residents can help.

Stream Description
After drawing a picture of what you see, write a physical description of the stream. Use these questions to guide your writing.

- How fast is the water moving? Is it clear, cloudy or muddy?
- Can you see any traces of chemicals, such as an iridescent film on the water?
- Do you see large rocks in the water? Are they smooth or rough?
- How many riffles do you see?
- Estimate the width and depth of the stream.
- Does the stream run in a more-or-less straight line or does it twist and turn?
- What is the streambed like? Is it sandy or rocky?
- Are there algae, weeds or other plants growing in the water?
- What is the stream bank like?
- Is it sandy or rocky? Does it look like it's eroding?
- Are there plants growing on the bank? Are there trees on the bank that provide shade?
- What evidence of human activity do you see? Is there trash or fishing tackle?
- Are sources of pollution evident—highway, parking lot, farm, industrial area?
- Does the stream smell clean or stagnant?

Lesson 18: Macroinvertebrate Survey

Part 1: Identification of Macroinvertebrates

Environmentalists, biologists, and water quality researchers all conduct aquatic macroinvertebrate surveys to measure the biological health of a stream. They monitor changes in the stream over time and assess the effects of environmental problems on stream life. Some aquatic invertebrates, such as mayfly larvae, gilled snails, and riffle beetles, are extremely sensitive to pollution. Some will leave polluted areas for friendlier habitats; others will die. Crayfish, sowbugs, and damselfly larvae are somewhat sensitive to pollution. They prefer good stream quality, but can survive in polluted conditions. Mosquitoes, worms, black fly larvae, and leeches have a high tolerance for pollution. They will thrive in polluted conditions. By surveying the numbers and types of aquatic invertebrates present, the health of the stream can be determined. You do need a permit to collect/possess macroinvertebrates. This activity requires two classroom periods in addition to the field visit, one before and one after the streamside survey.

Preparation:
Duplicate the Macroinvertebrate Identification handout.
Please use one of the slide shows listed below to introduce students to aquatic macroinvertebrates:

macro in water millcreek.pptx By Brian Radcliffe for Elementary and Middle Schools
Life Cycle of Macroinvertebrates.pptx By Don Thompson for High and Middle Schools

Materials for Part 2 and Part 3:
– Waders or high waterproof boots
– Thermometer
– Several light colored plastic wash basins
– Plastic containers for collecting invertebrates
– Dip nets or strainers
– Large spoons or small gardening spades
– Macroinvertebrate Identification handout

Standard Correlations:
KY POS Science 5.5 Grade 4 A.1, Grade 6 B.1, Grade 8 B.1, B.2, Science 5.10 Grade 6 A.1, B.1
KY POS Science Grades 6-12 when Life Cycle of Macroinvertebrates.pptx slide show is used.

Procedure:
Call on volunteers to name some of the foods that trout eat in the wild. Write the following on the chalkboard:

1. Arthropods (aquatic)
2. Arthropods (terrestrial)
3. Crustaceans
4. Mollusks
5. Nematodes
6. Flatworms
7. Annelids

Point out to students that these are some of the macroinvertebrates that trout feed on. Divide the class into small groups and assign one invertebrate to each group to research and report on. Each report should include a short description of the group, an overview of the life cycle of some of the members of the group, and conditions the members of the group must have to survive (clean water, cool water, oxygen, etc.).

Have students use the internet with Wikipedia and library resources to investigate their groups. Then have students present their findings to the rest of the class. Information should include the following: Arthropods (aquatic)—organisms with segmented bodies and hard exoskeletons. The most common arthropods are insects. Some are aquatic or have aquatic stages, like the damselfly.

1. Arthropods (terrestrial)-- organisms with segmented bodies and hard exoskeletons. The most common arthropods are insects. Terrestrial insects can fall from trees or vegetation on the bank into the stream where they become food for trout.
2. Crustaceans – a class of arthropods with hard exoskeletons. Crayfish are an example of a food trout eat.
3. Mollusks – many have soft bodies, some have hard shells. Clams, mussels, and slugs are common mollusks.
4. Nematodes – roundworms—which trout eat.
5. Flatworms – planaria are aquatic flatworms which trout eat.
6. Annelids – worms with segmented bodies. Leeches and earthworms are annelids.
7. Tell students that they are going to visit a stream in Part 2 to take a survey of the aquatic invertebrates.

Ask:

- How could a survey be useful? (It could be useful in assessing the health of a stream. In addition, if the food a trout eats is not available, then it is not a good habitat for trout.)
- Do different parts of the stream need to be surveyed or sampled? Why? (Yes, because different invertebrates inhabit different parts of the stream.)
- Are the numbers and kinds of invertebrates found important? Why? (Some invertebrates might be less tolerant of pollution than others. If they are not present in the stream, it would mean that the stream is possibly polluted.)
- Distribute the Macroinvertebrate Identification hand-out and have students read over and identify the organisms on it. If necessary, review the meaning of larva, pupa and nymph. Tell students these are the organisms they will be collecting in order to determine the health of the stream.
- If time permits, tell the students to form groups of three or four students and distribute the "Catch the Critter Game". Distribute the macroinvertebrate cards among the groups. Explain the rules of the game and let them play the game for about 15 minutes. Stop the game and have them see if they can calculate their scores using the weighted values for those invertebrates most sensitive to pollution in the formula using the cards they have drawn.

If time does not permit, you may make another classroom lesson using the game, "Catch the Critter" at another time. The game may target a lower grade level than the one presented in this lesson.

The game can be found at http://www.troutintheclassroom.org/teachers/library/catch-critter-game

Before making a trip to a stream, for Elementary or Middle Schools, you may want to ask your mentor to ask Brian Radcliffe if he could schedule a lesson using his slide show Macro in Water Millcreek.pptx. If he can't make dates that are convenient to you, the slide show is available electronically and is named: macro in water millcreek. It has 28 slides with Macro Slide Notes.docx.

There is another slide show geared toward High School and Middle School named: Life Cycle of Macroinvertebrages. It covers "macro" identification, metamorphosis and biotic indicator types for water quality. You can omit the slides with greek names or simply divide the show into two parts, since it contains about 56 slides and 28 is about all you can handle in 45 minutes. There is a Life Cycle of Macroinvertebrates.pdf for comments suggested per slide.

Macroinvertebrate Survey

Part 2: Field Trip

Before conducting the field trip, it is best to visit the site to determine if there are any potential hazards, such as poisonous plants, dangerous wildlife, etc. Check the stream for depth, velocity, and temperature. Identify several different areas of the stream as collection sites (for example, shallow areas near the bank, areas in the middle of the stream, riffle areas, etc). You should be able to wade the stream.

Procedure:

1. Review ground rules and safety rules with students prior to the field trip. Divide the class up into small groups. Distribute several Macroinvertebrate Survey sheets to each group. Explain that groups will use one survey sheet for each area in the stream that they sample. They will begin downstream and work their way upstream to avoid muddying locations they might want to sample later. They will first describe the part of the stream they are sampling. (Students might be encouraged to make a simple map with a star or arrow indicating where along the stream the sample comes from.) Is it a location near the bank, mid-stream, near a riffle? Is the sample from the streambed, from under a rock, or from the plants on the bank? How deep or shallow is the area they are sampling? What is the water temperature?
2. Describe the procedure for collecting invertebrates. Muckraking: Use a large spoon or gardening spade to scoop up some muck from the bottom of the stream. Put it in the dishpan. Look for things that are moving. Add some water and swish it around as you look for organisms. Collecting from under rocks:
3. Simply turn over rocks and look for scuds, nymphs and other arthropods. Collecting from the water:
4. Use a strainer or dip net to catch organisms you see moving in the water.
5. After collecting, carefully move any invertebrates into the collection containers. Be sure to label the containers with the name of the site where the organisms were collected. Repeat the procedure.
6. When students have sampled several areas and collected invertebrates from each area, have them return to the classroom to assess their data and draw conclusions.

Macroinvertebrate Survey

Part 3: Assessing Data and Drawing Conclusions

Materials:

- Macroinvertebrate Identification Sheet
- Macroinvertebrate Survey Sheet
- Macroinvertebrate Background Information/Assessment Worksheet
- Hand lenses
- Insect field guides
- Old newspapers
- Tweezers (optional)

Procedure:

1. Discuss the field trip with students encouraging them to share their observations. Tell students they will now identify and record the macroinvertebrates they collected and use the data to determine whether or not the stream is healthy.
2. Have students work in their original groups. Distribute Background Information/Assessment Worksheet to students. Review the background information with them. Have them identify those organisms that are tolerant to pollution, somewhat tolerant, and sensitive. Review the formulas for determining index value. Cover work areas with newspaper. Have groups work with the organisms they collected their sites.
3. They should use the Macroinvertebrate Identification sheet (and insect field guides, if needed) to identify each organism. The type of organism found should be recorded just once. (For example, if three mayfly larvae are found at three different sites, only one check is marked on the assessment sheet.) After identifying each organism students should calculate the water index value for each group and the water quality rating for the stream.
4. When groups finish, allow them time to discuss their findings within the group. Call on one person from each group to present the group's findings to the rest of the class. Have them write the water quality ratings on the board and ask students to compare the findings. Discuss the diversity of organisms found. Were there a large number of pollution tolerant organisms? How did they compare to the number of pollution sensitive organisms found. Based on their findings, have students determine whether or not the stream is healthy.

Macroinvertebrate Background Information

Environmentalists, biologists, and water quality researchers all conduct aquatic invertebrate surveys to measure the health of a stream. They monitor changes in the stream over time and assess the effects of environmental problems on stream life. Some aquatic invertebrates, such as mayfly larvae, gilled snails, and riffle beetles, are extremely sensitive to pollution. Some will leave polluted areas for friendlier habitats; others will die or will be unable to reproduce. Crayfish, sowbug, and damselfly larvae are somewhat sensitive to pollution. They prefer good stream quality, but can survive in polluted conditions.

Mosquitoes, worms, black fly larvae, and leeches have a high tolerance for pollution. They will thrive in polluted conditions. By surveying the diversity of aquatic invertebrates present in a stream, the health of the stream can be determined.

Assessment Worksheet

Stream name: ________________________________Site location: __________________________

Put a checkmark next to the name of each macroinvertebrate that you found.

Sensitive to Pollution	Somewhat Sensitive to Pollution	Tolerant to Pollution
___ Mayfly larvae ___ Stonefly larvae ___ Caddisfly larvae ___ Dobsonfly larvae ___ Gilled snails ___ Planarians ___ Water penny larvae ___ Adult Riffle beetle	___ Clams ___ Cranefly larvae ___ Crayfish ___ Alderfly larvae ___ Scuds ___ Sowbugs ___ Damselfly larvae ___ Dragonfly larvae ___ Whirligig beetles ___ True bugs (including water boatman, backswimmers, water scorpions, water striders)	___ Lunged snails ___ Black fly larvae ___ Midge larvae ___ Leeches ___ Worms ___ Mosquito larvae
Types found ___ x 3 = _____ index value	Types found ___ x 2 = _____ index value	Types found ___ x 1 = _____ index value

To determine the water quality rating, add the index values together. Then compare them to the chart below.

Water quality rating	Stream health assessment
11 and below	Very poor
11-16	Fair
22-27	Good
27-32	Excellent

Macroinvertebrate Survey Sheet

Date: __________ Stream location: ______________________ Stream temperature: ____

Approx. stream width: _________ Approx. stream depth: ____________

Group members:

Site location: (draw a simple map and identify location of the site using a *)

Observations:

Macroinvertebrates and Chemical Water Testing

Location:	**Date/Time:**
Class/Names:	

Air Temperature	
Water Temperature	

Dissolved Oxygen (DO)		Measures the amount of oxygen gas dissolved in the water. Best if between 8 and 12 parts per million (ppm)

Electrical Conductivity (EC)		Measures dissolved ions in the water. Low - less than 200 High - greater than 800

pH		Acidic (below 7) or Basic (above 7). Best if between 6.5 & 7.5

Macroinvertebrate Tally

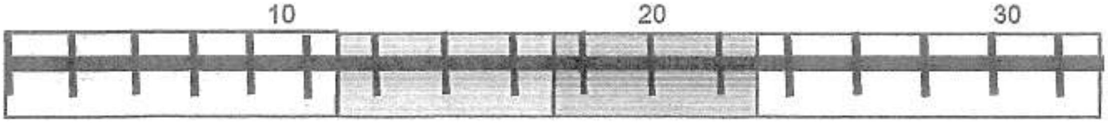
Group I Taxa	Tally	Group II Taxa	Tally	Group III Taxa	Tally
Water penny Larvae		Damselfly Nymphs		Blackfly Larvae	
Mayfly Nymphs		Dragonflyl Nymphs		Aquatic Worms	
Stonefly Nymphs		Cranefly Larvae		Midge Larvae	
Dobsonfly Larvae		Beetle Larvae		Left-hand Snails	
Caddisfly Larvae		Crayfish		Leeaches	
Riffle Beetle Adults		Scuds (sidswimmers)		Bloodworms	
Right-hand Snails		Clams			
Planaria (flatworms)		Sowbugs (isopods)			
Number taxa present:		Number taxa present:		Number taxa present:	
Times Index value of (3):		Times Index value of (2):		Times Index value of (1):	

Total Index Value:	Other organisms seen:

Biological Quality Assessment Scale

Poor (0=11) **Good (17 - 22)**

0 10 20 30



Fair (12-16) **Excellent (23+)**

Lesson 19: Leaf Pack Study

Prepared by: Kristina Rogers, Loyalsock Township High School from the website www.Lamotte.com

Timeline: This lesson should come after students have been introduced to and worked with macroinvertebrates.

Materials:

- Access to local stream
- Leaf Pack from LaMotte Company, or a simple onion sack from the grocery store, data sheets
- Identification cards and sorting charts from the Leaf Pack kit, downloaded from the Internet, or from Golden Guide's *Pond Life f*rom St. Martin's Press, which is an excellent field guide.
- Magnifiers and stereo microscopes if possible
- White trays
- Bowls
- Brushes
- Petri dishes
- Strainers
- Classification keys can be ordered through Save Our Streams.

Procedure:

1. Explain the concept of a leaf pack to students and discuss how they may be used to study a stream community. Involve your students in deciding what will be studied, reminding them that they must have a control leaf pack.
2. Divide the class into small groups and have them decide on experimental leaf packs. Some choices of variables may include different types of leaves in the leaf pack or different locations of the leaf pack. Have the students develop a hypothesis about what will happen to each leaf pack.
3. After students have designed a study and written a hypothesis they should share their ideas with the class and receive constructive feedback. As the teacher, you will get a chance to hear all the students' ideas and make sure that the experiment is controlled and acceptable. Other students will have a chance to hear different ideas and make suggestions about the different experiments.
4. Have groups bring in various leaves to be tested. Each bag will need about 10 cups of leaves.
5. Have groups work through the lab activity and prepare the leaf packs.
6. Obtain and copy the data sheets from The Leaf Pack Network.
7. After each group has prepared their leaf packs, schedule time to place them in the chosen stream.
8. The leaf packs should be kept in the stream for at least a week, preferably three, then retrieved and brought back to the classroom for the macros to be observed as soon as possible. You will find the most macros in the fall and late spring.
9. Retrieve the packs on the day you will be doing the classification activity with your class. If you wait, many of the macros will die as the water warms. Most aquatic insects can be refrigerated or kept in coolers with ice overnight. Some invertebrates are very sensitive to changes in temperature.
10. The laminated flashcards and the sorting sheets found in the LaMotte Leaf Pack Kit are excellent resources, or use available handouts. Students can classify what they find in the leaves. If your macros are abundant you might also consider preserving some of the larger ones of each type or species for later use and study.

11. Have students use magnifiers to make careful observations. They should go back and forth between what they are looking at and the handouts, field guide, or cards with the illustrations.
12. Students should record what they are finding and how many of each.
13. Draw conclusions about water quality based on Lesson 14 worksheets.

References:
LaMotte Company, Stroud Water Research Center "Leaf Pack Network."
Washington Virtual Classroom "Macroinvertebrates."

Glossary

Acid rain: Rainwater with an abnormally low pH level, generally caused by industrial pollution.
Adaptation: The ability of an organism to adjust to a change.
Alevin: Larval fish that receive nutrients from a yolk sac.
Ammonia: NH3, a waste produced by eggs and fry.
Annelid: advanced, segmented worm.
Aquatic: inhabiting a fresh water environment.
Aquifer: An underground layer of sand, porous rock, or gravel containing water.
Arthropod: Organisms from the phylum Arthropoda, characterized by a hard exoskeleton and segmented appendages.
Benthic: Living in or at the bottom of a sea or lake.
Brood stock: Sexually mature fish from which eggs and milt are taken.
Brood year: The year eggs are produced.
Button-up: The stage in fry development when the belly seam closes as the yolk sac is consumed.
Catch and Release: The practice of releasing, live, all the fish caught.
Competition: The utilization of common resources that are in short supply by a number of organisms.
Condensation: The process by which a gas is changed into a liquid.
Consumer: An organism that eats (consumes) other living things.
Dissolved Oxygen (DO): Oxygen in its gaseous form dissolved in aqueous water.
Ecological Niche: Role of an organism in its habitat and its interactions with other organisms.
Ecology: The science that studies the interactions among living organisms with each other and their environment.
Ecosystem: A living (biotic) community and its non-living (abiotic) environment.
Egg: A mature female sex cell, also called the ovum.
Eutrophication: The process by which plant nutrients cause algal blooms resulting in oxygen depletion.
Eyed Egg: A stage in the development of the egg in which the embryo's eye can be seen.
Food Chain: A description of an ecosystem that focuses on the dependence for food of organisms upon others in a series beginning with plants and ending with top predators.
Food Web: A description of an ecosystem that focuses numerous connections among organisms.
Fry: Larval fish that no longer depend on their yolk sac for nutrients and actively seek food.
Generalist: An organism that feeds on a variety of other organisms.
Gill: The breathing organ that fish use to exchange oxygen from water with carbon dioxide from their blood.
Green Egg: A newly spawned egg that is very vulnerable at this stage of development.
Habitat: The area where an organism normally lives that provides the organism with food, water, and shelter.
Hatchery: A location where fish eggs are collected, incubated, hatched and reared for release.
Hydrology: The study of the Earth's waters, their distribution, and the cycle involving evaporation, condensation, and precipitation.
Invertebrate: An organism without a backbone.
Kype: The hooked lower jaw of a spawning male trout.
Larva: In most insects, the immature, flightless stage that transforms into a resting stage called a pupa or another stage before becoming an adult.
Metamorphosis: The physical change that some organisms undergo as they mature from egg to adult.
Milt: A milky fluid produced by male fish that contains sperm.
Nematode: A roundworm from the phylum Nematoda.
Nonpoint Source Pollution: Pollution caused by land use practices, rather than from a single, identifiable source.
Nutrient: A substance that provides nourishment and encourages growth.
Nymph: An immature larval stage of various insects.
pH (the power of Hydrogen): A measure of the acidity or alkalinity of a substance. The pH scale indicates the concentration of hydrogen (H+) ions in the substance.
Point Source Pollution: Pollution that is caused by a single, identifiable source.

Pollution: Contamination of air, water, or soil.
Pollution Tolerance: An organism's ability to withstand the effects of pollution.
Pool: A deep area within a stream that is characterized by low velocity.
Predator: An organisms that kills and eats other organisms.
Prey: An organism that is eaten by other organisms.
Producer: The first trophic level in a food web. Plants, for example, convert the sun's energy into food that consumers can access by eating the producers.
Redd: A nest dug in the gravel by a female fish during spawning. The eggs are deposited in the redd where they incubate until hatching.
Respiration: The process by which oxygen is exchanged for carbon dioxide.
Riffle: A shallow portion of a stream where water breaks over rocks producing surface agitation.
Riparian: Of or pertaining to the banks of a river or stream using grasses and trees as a riparian buffer.
Sac-fry: A newly hatched alevin with the yolk sac still attached.
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Salmonid: A fish in the trout or salmon family.
Sediment: Solid matter that settles to the bottom of a stream, lake, or pond.
Spawning: the act of laying and fertilizing eggs.
Specialist: An organism that eats only one type of food or prey.
Temperature: A key habitat component of the classroom aquarium. Temperatures must be kept at 42^{o} F. to 55^{o} F. for egg and fry survival.
Trophic level: An organism's place in the energy pyramid. Producers are found at the first trophic level, primary consumers are found at the second level, secondary consumers at the third level, etc.
Turbidity: Cloudiness in the water caused by sediments that have been stirred up.
Vertebrate: An organism with a backbone.
Watershed: A drainage area or basin in which all water areas drain or flow toward a central collector (such as a stream, river, or lake) at a lower elevation.
Yolk sac: Sac attached to newly hatched fish which contains nutrients for growth.

Trout Unlimited Today

Mission:
Trout Unlimited (TU)'s mission is to conserve, protect, and restore North America's trout and salmon fisheries and their watersheds. TU accomplishes this mission on local, state and national levels with an extensive and dedicated volunteer network. TU's national office, based just outside of Washington, D.C., and its regional offices employ professionals who testify before Congress, publish a quarterly magazine, intervene in federal legal proceedings, and work with the organization's 125,000 volunteers in 500 chapters nationwide to keep them active and involved in conservation issues.

History:
July 2004 marked the 45th anniversary of TU's founding, on the banks of the Au Sable River near Grayling, Michigan. The 16 fishermen who gathered at the home of George Griffith were united by their love of trout fishing, and by their growing disgust with the state's practice of stocking its waters with "cookie cutter trout"— catchable-sized hatchery fish. Convinced that Michigan's trout streams could turn out a far superior fish if left to their own devices, the anglers formed a new organization: Trout, Unlimited (the comma was dropped a few years later).

From the beginning, TU was guided by the principle that if we "take care of the fish, then the fishing will take care of itself." And that principle was grounded in science. "One of our most important objectives is to develop programs and recommendations based on the very best information and thinking available," said TU's first president, Dr. Casey E. Westell Jr. "In all matters of trout management, we want to know that we are substantially correct, both morally and biologically."

In 1962-63, TU prepared its first policy statement on wild trout, and persuaded the Michigan Department of Natural Resources to discard "put-and-take" trout stocking and start managing for wild trout and healthy habitats. On the heels of that success, anglers quickly founded TU chapters in Illinois, Wisconsin, New York, and Pennsylvania. TU won its first national campaign in 1965: Stopping the construction of the Reichle dam on Montana's Big Hole River. Five years later, TU helped secure a ban on high-seas fishing for Atlantic salmon. And in 1971, TU took legal action to protect the last free-flowing stretch of the Little Tennessee River. Perhaps one of the most significant early applications of the Endangered Species Act, the action stopped the Tellico dam, but only temporarily: An eleventh-hour congressional appropriations rider later doomed TU's victory.

The Kentucky Councilman, Warner “Sandy” Broughman and Gary S. Rose started Trout Unlimited Bluegrass Chapter’s first Trout in the Classroom program at Liberty Elementary School in the Science Club taught by Kristi Fehr and assisted by Sara Fenton-Wells and Gary S. Rose. Their vision and foresight along with the keen insight of Warner “Sandy” Broughman who initiated the program in 2008, helped to make it a wonderful success. The 2009/2010 program is off to a great start with 7 schools in Kentucky and everyone involved is excited about the impact this will have on the student’s understanding of their watersheds and the relationship they have to conservation and urban areas.

The Trout in the Classroom program in Kentucky is helping Trout Unlimited to meet the challenges of coldwater conservation and protect our rivers and fisheries for generations to come.

Background on Trout in the Classroom

Students in California and other western states had the initial classroom rearing facilities for salmon in the western U.S. The North Jersey Chapter of Trout Unlimited pioneered the Trout in the Classroom program with Hopatcong science teacher Ellen Soriano in the early 1990s. The chapter purchased the equipment to raise the trout, and eggs were supplied at no charge by the Musky Trout Hatchery. As part of her work with coldwater fisheries, she and her students successfully petitioned the state legislature to designate the brook trout as the “state fish”. As a result of her work with Trout in the Classroom, the national office of Trout Unlimited presented her with an award at their national meeting in 1993. The students at Hopatcong School also received a regional EPA award from Vice President Al Gore.

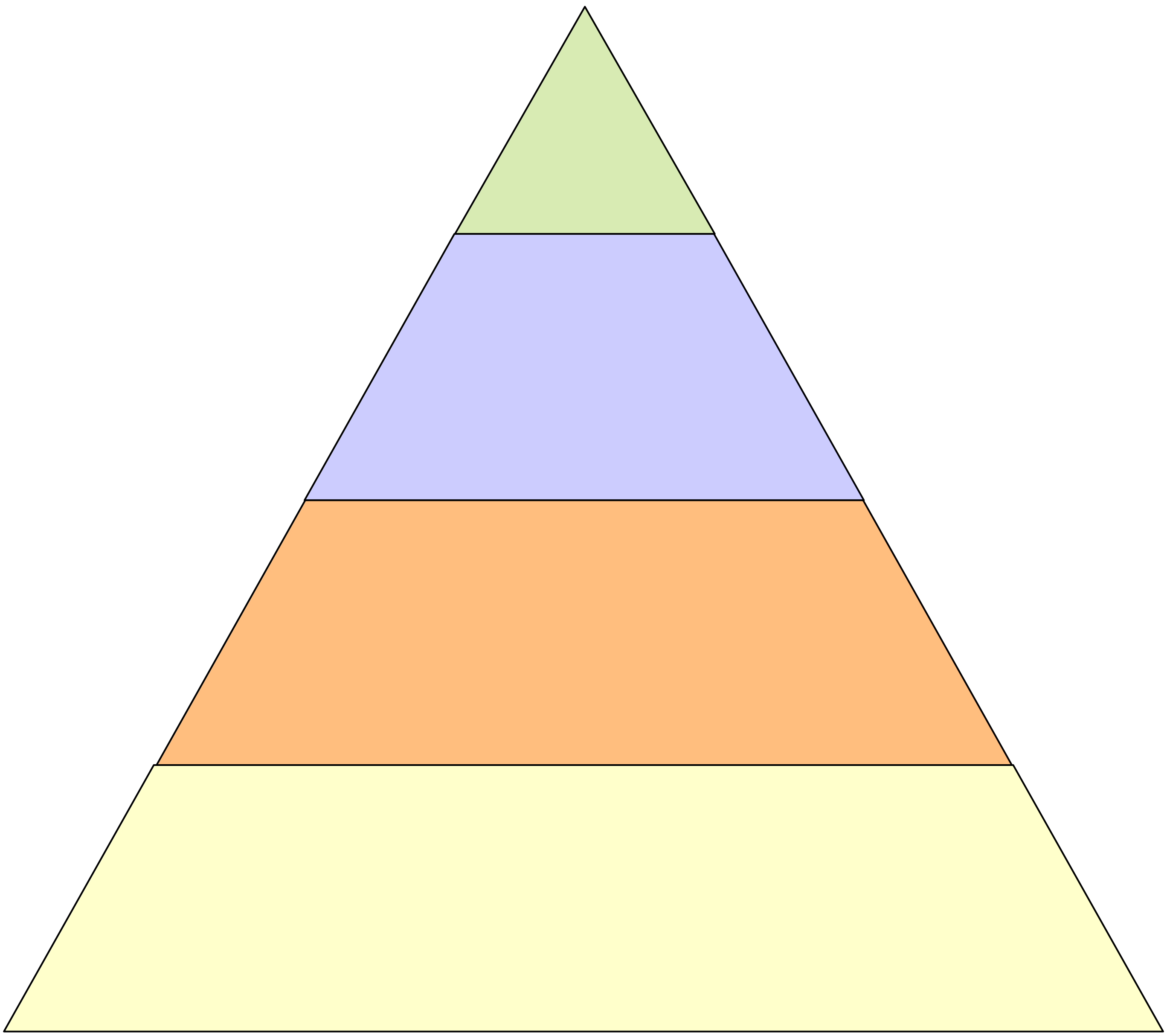
North Jersey TU continues to support the program by loaning equipment and assisting with the efforts of Sparta Middle School teacher Marilyn Steneken who has taken the program to new heights. Other New Jersey chapters of Trout Unlimited have pledged to support teachers who want to get started.
In 1995, Trout in the Classroom was brought to classrooms in New York City and the upstate watershed region by energetic and conservation-minded Joan Stoliar. Her vision was to connect these students and help develop in them an awareness and understanding of their shared water resources. With the support of Theodore Gordon Flyfishers, Inc., Joan worked to install chilled aquariums in four classrooms. These students and their teachers enthusiastically raised their trout and released them as fingerlings the following spring. It was a very successful year.

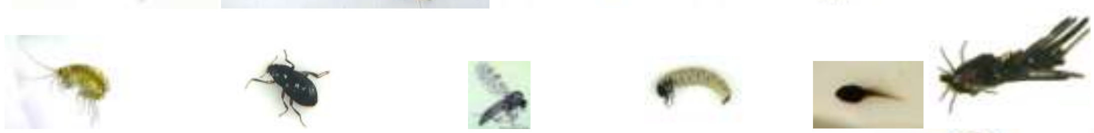
Word of the program rapidly spread and soon other schools were setting up chilled aquariums in their classrooms. By the end of the third year, nineteen schools were participating in the program. When Joan Stoliar passed away, her equally enthusiastic husband, Arthur, carried on her legacy. He continued to expand and promote the program, bringing Trout in the Classroom to over 100 classrooms in 2004. In the same year, Trout Unlimited, a national cold water conservation organization, agreed to help promote and coordinate the program. The first full-time Trout-in-the-Classroom Coordinator was hired through funds and in-kind donations raised by Trout Unlimited, the Catskill Watershed Corporation, and the New York City Department of Environmental Protection. As part of this growth, this curriculum was developed through the financial support of Susan and Peter J. Solomon, the Peter J. Solomon Family Foundation, and the Peter J. Sharp Foundation.

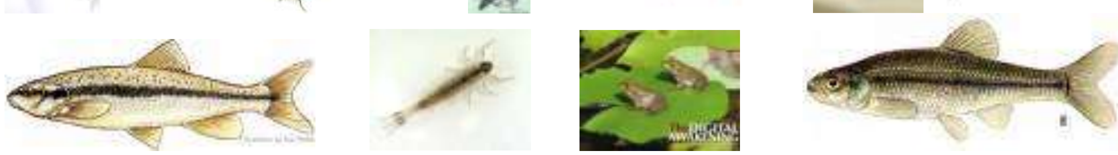
The program’s success is reflected in the stories that teachers tell. Brian Hugick, an Earth Science Teacher at Somers High School, had one student who frequently cut class. He put the student in charge of the morning trout feedings. The young man did not miss a day after that and requested to assist in the trout release. Natasha Walkowtiz, a teacher at Harlem Day Charter School reported that both kindergartners and first graders were writing observations about the trout. Other teachers reported that students, who had never before taken an interest in science, were now very involved in it. By raising trout, students connect to the natural world around them—specifically the rivers and streams that sustain their communities. Warner “Sandy” Broughman, Kentucky Trout Unlimited councilman who, tells of a couple who drove up from Breathitt County to the East Fork Indian Creek release point last year to see the difference “Trout in the Classroom” had made in their grandson. They told Sandy he was not interested in school at all until the eggs arrived. After that, his enthusiasm for science skyrocketed and his grades shot up in all of his classes to A’s and B’s.

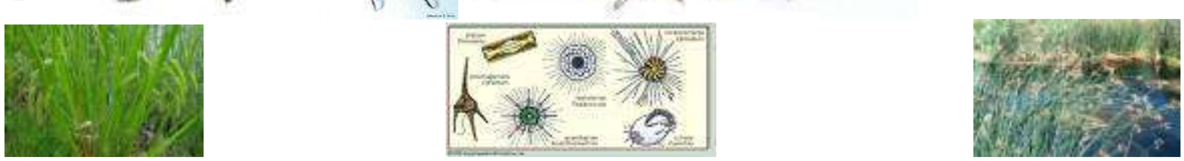
Addendum – Classroom Projects

Food Chain Energy Pyramid

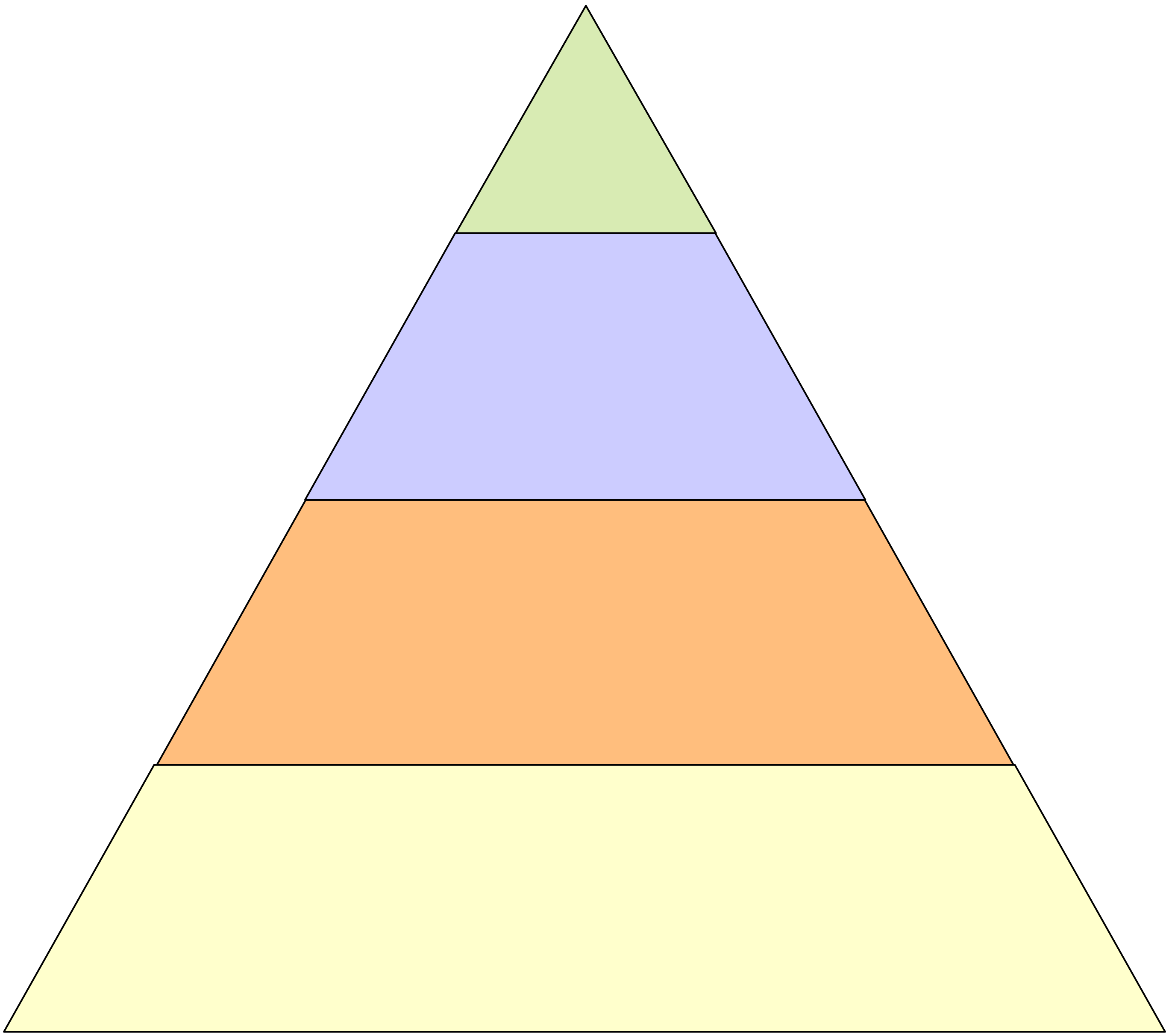








Food Web Energy Pyramid





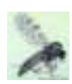








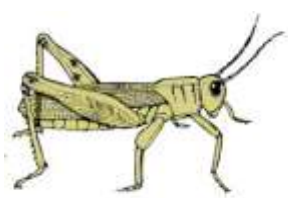




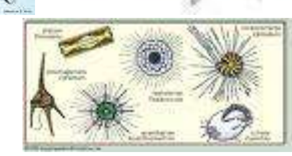













CAM Jr/Sr High - Battle Ground, WA
Aquatic Macroinvertebrates - Set A

01 - Yellow Stonefly larva

02 - Aquatic Earthworm

03 - Flat-headed Mayfly larva

04 - Gilled Snail

05 - Spiny Crawler Mayfly larva

06 - Midge larva

07 - Golden Stonefly larva

08 - Net-spinner Caddisfly larva

09 - Riffle Beetle larva

10 - Flat-headed Mayfly larva

11 - Casemaker Caddisfly larva

12 - Blackfly larva

13 - Small Minnow Mayfly larva

14 - Cranefly larva

15 - Little Green Stonefly larva

16 - Free-living Caddisfly larva

17 - Pron-gilled Mayfly larva

18 - Riffle Beetle adult

19 - Slender Winter Stonefly larva

20 - Saddle-casemaker Caddisfly larva

21 - Flatworm (Planaria)

22 - Ameletid Minnow Mayfly larva

23 - Water Mite

24 - Spiny Crawler Mayfly larva