Aquatic Ecology
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Introduction to Aquatic Ecology:
Why Include Aquatic Ecology Activities in 4-H Sportfishing?
Carl Richardson

It goes without saying that sportfishing activities will be the focus of your club activities. This leaders' manual, and your own experiences will guide you in planning these activities. Such activities will likely include casting practice, tying flies and building lures, taking fishing trips and keeping a fishing journal. All these examples have obvious connections to sportfishing and youth development. However, there is a set of knowledge and skills that you as an angler and leader will unknowingly draw on when leading your group in any activity. Do you know what that is? It's your knowledge about aquatic ecology!

What is Aquatic Ecology?
Aquatic ecology is the study of aquatic organisms, the ways they interact, the places they live, and the things they do. While the field of aquatic ecology is extensive, there are a handful of key concepts, terms and ideas that are most important to fishing. Those key concepts are listed at the end of this introduction. They are taught and reinforced through the activities in this section.

Don't be Intimidated
You don't have to be an expert on this subject to lead activities on aquatic ecology. Each activity includes basic background information on the concepts in the activity. There are also additional references & resources listed in each activity. You can consult these resources before, during and after the activity, to increase your knowledge or clarify some points.

However, you probably know a lot about the subject, but just don't realize it. Listed below are some questions that all anglers wrestle with, especially as they try to mentor youth just starting to fish! Most often the answers to these questions can be found in your knowledge of the ecology of the places you fish and the fish you chase.

Fishing Question: Which lure or bait do I use to catch fish?
Answer: With so many choices of artificial lures and natural baits, this choice can be a difficult one. The answer may be based on experience with something that works. However, the choice can be made more easily with a little knowledge about what the fish you are after eats.
Example: You know that largemouth bass love to eat crayfish, so you choose a lure that imitates a crayfish.
Aquatic Ecology Concept (s) (for definitions of these terms see the glossary at the end of this section) : Food chains, food webs, life cycles, lake ecology

Fishing Question: Where should I fish to catch (insert your favorite fish here)?
Answer: Selecting a place to fishBwhich lake, stream, bay or ocean, is one of the first choices we make as anglers. Most often we pick a place depending on what we want to catch, because we know it lives there. Once again, that is based on your aquatic ecology knowledge!
Aquatic Ecology Concept (s): habitat needs, adaptations, life cycles
Examples: You want to catch trout and/or salmon so you have to fish cold streams, rivers or lakes. You want to catch flounder so you fish back bays and saltwater estuaries.

Fishing Question: Where is the best place on this (lake, stream, bay, or ocean)?
Answer: Once you know the fish you are chasing lives in a particular waterway, where do you start fishing? You draw on your knowledge of the specific needs and preferences of the fish you are seeking.
Aquatic Ecology Concepts: life cycles, habitat needs of fish and the things they eat, habitat components, seasonal movements.

Fishing Question: We have been fishing in this spot for more than an hour but all we catch are little ones. Why?
Answer: The place you are fishing doesn't have any places for big fish or the food they eat to hide. Maybe this water doesn't have any big fish in itBjust for that reason. Or maybe all the little fish get eaten before they get big. The biggest fish (such as stripers and bluefish) are schooled together, so it's time to find another school
Example: Big trout and salmon are found in the some of the biggest and deepest holes, or near lots of overhead cover like tress and roots.
Aquatic Ecology Concept: life cycles, habitat needs, predator prey interactions, adaptations, populations.

Fishing Question: The fishing on this lake was great last year, now it is terrible. What happened?
Answer: Many factors influence fish populations. Maybe human activities changed the water temperature and the fish you are after prefer cold water. Perhaps weather conditions caused changes in the spawning season, or low survival of young.
Aquatic Ecology Concept: habitat needs, limiting factors, watersheds.

Need More Convincing?
As you can see from the examples, whether you realize it or not, aquatic ecology is an important tool in your tackle box. Understanding about fish, the places they live and the things they eat is just as important as learning to cast or tie knots. Check around, the anglers that enjoy fishing the most are just as knowledgeable about their fish as they are about their gear and tackle! Do you want your youth to enjoy fishing and make it a lifelong sport? Then teach them some basic aquatic ecology concepts by using the activities in this section!

Stewardship of Aquatic Resources

Another important reason to include activities which build on aquatic ecology knowledge is to ensure the future of fishing. One of the examples mentions a fishing spot that was impacted by human activity. Is there anything your youth do in their everyday lives that also impact the places they fish? Could your 4-H youth do anything to improve and protect the places they fish? Youth come up with the answers to these questions in some of the activities you will lead them through. When we change our actions in an attempt to protect (or improve) our environment, it's called stewardship. Stewardship of our aquatic resources is critical to the future of fishing.

Aquatic Ecology is a Fishing Skill, so Teach it That Way!
As a leader, will you tie on every hook or lure? No way, you will lead members through activities where they can learn to tie their own knots! When you teach them knots will you only talk to them and explain how to tie knots? No, each person will likely practice (and practice), teach others and do other hands-on activities to learn how to tie knots. You will need to teach aquatic ecology in the same mannerBthrough hands-on activities. The activities in this section use real field/outdoor experiences, models, games, demonstrations and simulations to teach and reinforce important aquatic ecology concepts and ideas. Each activity includes a glossary, important background information for you and youth and step by step instructions for each hands-on activity. Rarely will you be in front of your club just talking to them about these important conceptsBat least if you want them to learn best you won't be! While this would be the easiest way for you, it's certainly not the best way. After all, we know that 4-H is all about providing youth an opportunity to learn by doing! When they learn they grow. When they grow, they become better prepared to deal with the world in which they live.

That is exactly why this section of the handbook was prepared. You will find lesson plans for hands-on activities designed to teach specific concepts. These activities or those they were adapted from have been used by educators around the country to teach those same concepts. These lessons are designed to help you create good learning opportunities for your youth. You don't need to be an expert in fisheries or education to create these situations, just use this section as your guide.

Tips for Teaching Aquatic Ecology and Biology

Make the teaching activity **relevant** to youth lives and daily activities

1. One method is to explain how you use the information being presented.
2. Ask youth how they could or would use the information or concept. This is best done before digging too deep into a subject. This way, the topic has greater valueBthey can see the use or benefit before getting into the activity.

Use the known to teach the unknown. Professional educators call this technique "bridging." In bridging you use terms or situations members are all familiar with, then compare/contrast that to the unknown subject you are teaching.

Don't get caught up in scientific terminology, jargon or scientific names. There are simple terms that often mean the same exact thing. A good example is the term *benthic macroinvertebrates*. These are the small critters that live on the bottom. Which is easier to understand? It is as technically accurate to refer to the Salmonidae family of fish as the "trout and salmon!" Often, we end up spending time memorizing terms and definitions rather than important concepts

On the other hand, don't water down important, real concepts with fake easy answers. Kids want the truth and appreciate being challenged at the level that seems age- and developmentally-appropriate. Likewise, there are many ecological clichés out there that don=t make sense (like Athe balance of nature@) Use the information found in this introduction, each lesson, references and resources to give good, sound definitions. Also follow this curriculum so that activities are sequenced in a good, workable order for your learners.

Take advantage of **teachable moments**. These are unplanned opportunities to teach, that often come up when we are outside. For example; on a fishing trip a club member catches a bluegill, or other fish with spiny rays. They notice how sharp the spines areBor maybe they don=t notice. Take advantage of the *teachable moment*, point out the spines and ask the all-important questionB**WHY?**

It's okay to say "I don't know". Don't attempt to make up answers to questions you don't know. When you don't know, say it and then make it a *teachable moment* by saying, "let's find the answer to that question together."

Weave aquatic ecology into other youth activities. Concepts are boring and useless ideas (unless you play trivial pursuit) if they are not tied to something important and concrete. So what if mayflies and some other aquatic insects go through incomplete metamorphosis? This concept takes on a whole new meaning when linked to fly tying activity. Likewise, the way a sunfish build a nest in particular spots on a lake and guard their young can be pretty boring stuff. However, tie that in with selecting a spot to fish on a lake in early summer and you are on you way to building good anglers, stewards and young people!

Challenge members to investigate on their own. Exploration, individual or in small groups, is an important scientific idea and is important to youth development. So is collaborationBwhere the group works together to solve a problem.

Get older youth involved in mentoring younger youth. Many 4-H programs have groups of youth of various ages. One way to challenge other youth is to have them plan for, teach and mentor activities with the younger members. Older members could make models they use in teaching, and can learn more about these topics. In turn, younger youth benefit from the mentorship of teens closer to their own age than adults.

Find ways for families to be involved. Look for and suggest opportunities for short or even long-term extended study activities families can do between your more organized meetings or events. These can be simple neighborhood/watershed investigations or long-term stewardship or science projects. Be sure to welcome family members to your meetings and events. Have ways that adult family members can help.

Practice makes perfect. Don=t expect the activities and simulations to work on the first try. Practice them beforehand. Set everything up and try the experiment or activity before demonstrating it for your youth. This is a great role for your older youthBthey can pilotBor test pilot activities and experiments.

Aquatic Ecology Concepts

Listed below is an outline of important concepts and ideas youth should know, understand and be able to apply to their fishing, and daily activities. The activities introduce or reinforce these concepts and will refer back to this outline. Terms are defined at the end of this section in the glossary and in each activity.

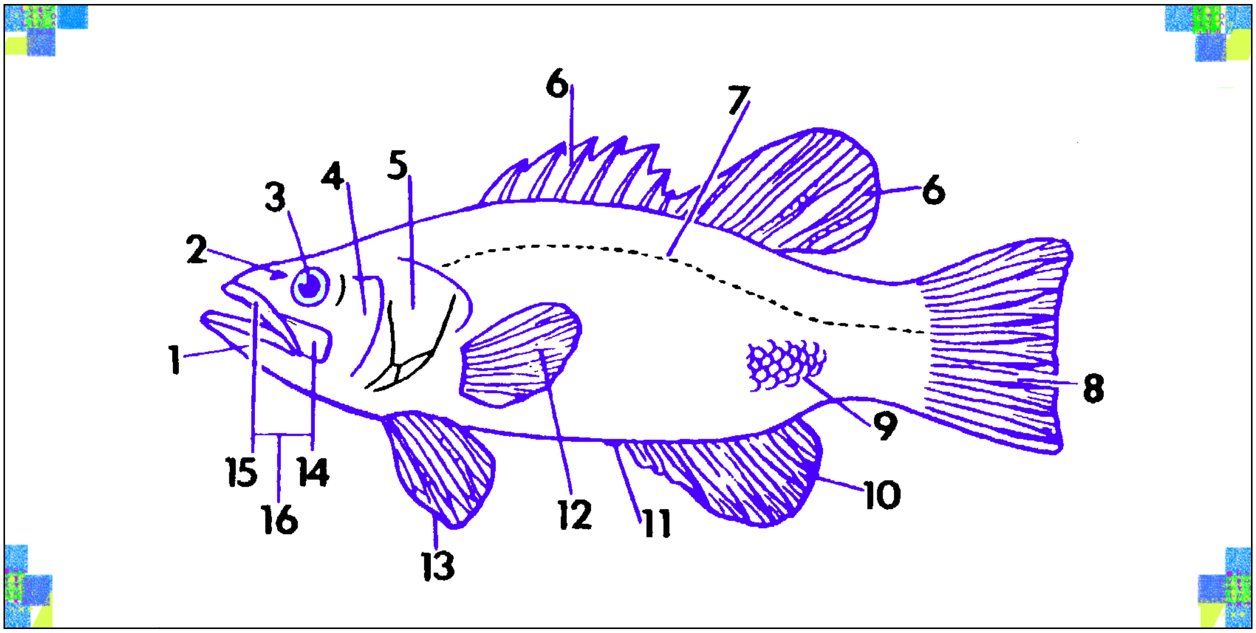
I. All organisms have specific habitat needs and requirements. They will only be found where those needs are met in just the right amount.

- A. Aquatic organisms need food, specific physical habitat requirements (shelter, spawning habitat, protection from predators etc.) and water.
    - 1. The amount of food (or energy) available to an organism limits the size, number and activity of that organism.
        - a. Energy (or food) is gathered and stored moves from one level to another in a food chain.
            - (1) Producers
            - (2) Consumers
            - (3) Decomposers
        - b. Each link in a food chain is important, and if one link is missing, the chain is broken
        - c. Many chains are linked together in a food web.
    - 2. Water cycles throughout the earth in one of its three phases: ice, water or water vapor and the steps in that cycle are precipitation, evaporation and transpiration, condensation and percolation.
        - a. Water in contact with the Earth is influenced by the forces of gravity, the composition of the Earth and climate.
            - (1) The land drained by a specific waterway is called a watershed.
                - (a.) Activities within a watershed influence the aquatic habitats.
                - (b) As water moves down a watershed it is changed.
            - (2) Water is called the universal solvent because it dissolves many things.
                - (a.) Minerals and materials in the Earth and in the atmosphere can dissolve in water.
                - (b.) Things that don=t dissolve can be carried by water
            - (3) Water that moves causes changes to the Earth
- B. Fish are specially adapted for life in water
- C. Organisms interact with each other and their environment

II. When things influence or alter those requirements, the types and kinds of organisms present change.

Fish Parts

Project F.I.S.H. website



FISH BODY PARTS:	
1. Mandible **2. Nares - Nasal Opening** **3. Eye** **4. Cheek** **5. Operculum** **6. Dorsal Fins** **7. Lateral Line** **8. Caudal Fin**	**9. Scales** **10. Anal Fin** **11. Anus** **12. Pectoral Fin** **13. Pelvic Fin** **14. Maxilla** **15. Premaxilla** **16. Upper Jaw**

<u>FUNCTIONS & FISH FACTS</u>

1. 16. Mouth. The jaw area of fishes can be quite expandable. When a fish feeds it opens the mouth and creates a suction action that sweeps water and food items into it.

Did you know that fish are some of the biggest seafood eaters in the world?! Squid, shrimp, and their neighbor fish are among their favorite foods.

2. Nasal. Fish can smell things in the water with their two blind sacs called nares.

3. Eyes. Most fish have well developed eyes which are located on the side of the head. This positioning allows the fish to see in every direction.

The flash of bright and shiny lures helps get their visual attention!

6. 8. 10. 12. 13. <Fins> Fish swim by flexing their bodies and use their fins to help maneuver, stabilize and balance.

4. 5. Gills. Fish breathe with their gills taking oxygen from the water as it passes over the gills and filtering to the bloodstream.

1. 4. 5.Can fish taste? Yes, they have taste buds in the lining of its mouth and in the gills.

7. Lateral Line. Serves as a motion detector to transmit information to the fish's brain about the flow of surrounding water and the movements of other organisms.

Ever watch a school of fish swim smoothly about without bumping into each other?

8. Tail Fin. The primary organ for generating thrust (movement) for most fish.

There are four shapes to caudal fins:

1) **rounded** and 2) **truncated** are usually slow, powerful swimmers that can travel long distances;

3) **lunate**, long pointed ends are the fastest fish and can maintain rapid speeds for long duration; and

4) **forked**, sharply pointed < forked look are typically a constant moving species. The more active the fish, the deeper the < fork angle.

Some fish have spots on their tails which confuses predators because the spots look like eyes. While the predator is trying to decide if he is looking at the front or back end of the fish, and by the time he figures it out, the slippery fish escapes!

9. Scales. Bodies of most fishes are covered with scales, which are bony or horny shaped plates forming overlapping rows of many scales. A thin epidermis usually covers the scales making the fish feel really smooth and slippery to touch.

Getting to Know Your Local Fish

Adapted from Ohio Sea Grant's Oceanic Education Activities for Great Lakes Schools

Objectives.
Participating young people and adults will:
1. Develop and use a dichotomous key
2. List general characteristics of fish
3. List distinguishing characteristics of fish families.

Youth Development Objectives
Participating young people will:
1. Enhance ability to acquire, analyze and apply information
2. Develop analytical skills
3. Develop/enhance communication skills and working with others
4. Enhance enjoyment of fishing and other aquatic resource related outdoor recreation

Roles for Teen and Junior Leaders
!. Assist with preparing materials (making fish cards)
2. Assist members with sorting and key construction
3. Share how important it is to correctly identify fish

Potential Parental Involvement
1. See ARoles for Teen and Junior Leaders@ above.
2.

Evaluation Activities/Suggestions
1. Youth should demonstrate the use of their key
2. Each group should be able to switch keys and items, and the keys work with other groupsBthe keys are not dependent on who does keying
3. Brainstorm characteristics of all fish
4. List different families of fish found locally.

Best Time: after basic fish biology activities: fish prints, etc., before fishing trip and/or aquatic sampling trip.

Best Location: Indoors, outdoors with picnic tables

Time Required: Part 1 20-30 minutes,
Part II, at least 30 minutes. May be conducted over two separate meetings.

Equipment/Materials
For Demonstration: Several pieces of one of the following:
fruit (apples, oranges, etc.) writing instruments
music cd=s
easel pad & markers or chalkboard and chalk

Enough for Each Group
Photos or illustrations of fish native to area
Information about the fish families
Paper and pencil
Assortment of different shapes of pasta or assortment of nails and screws.
Any or all References listed below or other source of information on local fish

Safety Considerations
If fasteners are used, caution should be exercised with nails and screws

References
Brooks Lawrence M. *Peterson Field Guides: Freshwater Fishes*, Page,, M. Burr, Houghton Mifflin, Boston Massachusetts, 1991. ISBN 0-395-53933-1

Quinn, John R., *Our Native Fishes: The Aquarium Hobbyist's Guide to Observing, Collecting and Keeping Them: North American Freshwater and Marine Fishes*, The Countryman Press Inc.,1990 The Countryman Press Inc., PO Box 175, Woodstock, Vermont 05091, ISBN: 0-88150-181-6

Schmidt, B, 1991, *Sportfishing and Aquatic Resources Handbook*, pp 56-86, Kendall Hunt Publishing, Dubuque IA ISBN 0-8403-6599-3

Schmidt, B, 1997, *Advanced Sportfishing and Aquatic Resources Handbook*, pp 67-97, Kendall Hunt Publishing, Dubuque IA. ISBN 0-7872-3544-x

Smith, C. Lavett, *Fish Watching: An Outdoor Guide to Freshwater Fishes,* Cornell University Press, 1994, Cornell University, Ithaca, NY
ISBN: 0-8014-2827-0

Lesson Outline

Presentation

I. Definition of a Key
- **A. Make one of two choices**
- **B. Sort into smallest possible groups**

II. Classify familiar things
- **A. Start with largest group**
- **B. Look for small differences so can be sorted into two groups.**
- **C. Identify characteristics for each smaller group that allows for further sorting.**
- **D. Continue sorting until items can=t be sorted any further.**
- **E. Write steps down as questions with two choices or flow chart or tree.**

Application

Introductory Activity
EXPLAIN that scientists use tools called keys to identify things. These keys are made up of a series of questions with two choices, with each choice leading to another question. The choices are often based on characteristics of the things being sorted. Ultimately the choices end with the things being sorted down to the smallest groups, usually toB*species.* **EXPLAIN** that a key can be constructed to sort anything.

DEMONSTRATE how a key works with the demonstration items (in this case we will use fruit).
All these items are fruit.
1a. Eat the skinBgo to 2
1b. Peel the skinBgo to 3

2. Seeds in core or covered by hard case-- APPLE
3. Seeds not in core or hard caseBORANGE

WRITE these questions/choices on easel pad/blackboard. A tree diagram can also be constructed (this may be easier)
EXPLAIN THAT THE GOAL OF BUILDING A KEY IS TO SORT ITEMS UNTIL THEY CAN=T BE SORTED ANY FURTHER.

EXPLAIN that they will construct a key to sort out common things (nails or pasta). **DIVIDE GROUP** in smaller groups of four or five. **PROVIDE EACH GROUP** with collection of items to sort & construct key with, paper and pencil.

DIRECT each group to prepare a key using sorting and grouping techniques based on characteristics of the items they are sorting. **LET THE GROUPS GET STARTED, THEN STOP THEM AFTER A FEW MINUTESBMAKE SURE THEY ARE USING TERMS THAT ARE UNIVERSAL OR WELL DEFINED.** ***For example: colors, sizes, shapes.*** **EXPLAIN** that scientists use a common set of termsBtheir own languageBeveryone using the key will know what the characteristics mean.

II. Classify familiar things

A. Start with largest group

B. Look for small differences so can be sorted into two groups.

C. Identify characteristics for each group that allows for further sorting.

D. Continue sorting until items can=t be sorted any further.

E. Write steps down as questions with two choices each or as tree with two branches each

Listed below is a sample key for fasteners (nails and screws)

Fasteners

1a. Has head and smooth shankCgo to 2
1b. Has threadsCgo to

2a. Head is twice as big as the shankBgo to 3
2b. Head is less than twice as big as the shankBgo to

3a. Shank is less than 1" longCshingle nail (roofers nail)
3.b Shank is longer than 1"Ccommon nail

4a. Made of galvanized metal or coatedBgalvanized finishing nail
4b. Not made of galvanized metal or coatedBfinishing nail

Pasta Example:

1a. HollowBgo to---.2a
1b. Not hollowCgo to---.3a

2a. Objects with a bend......................elbow macaroni
2b. Objects without a bend..................rigatoni

3a. Thin and round..........................spaghetti
3b. FlattenedCgo to-----4a

4a. Long and wide..........................lasagna noodle
4b. Short and narrow.......................egg noodle

III. Keys should be universalBothers can use and sort into same smallest groups.

DIRECT GROUPS to switch keys and mixed up items with other groups. Other groups should be able to **SORT** items using key into the same smallest group. Once all groups are finished **DIRECT ONE GROUP TO SHARE AND DEMONSTRATE THEIR KEY.**

EXPLAIN that they will now make a key for fish found in their area.
BRAINSTORM characteristics that all fish have. The attached glossary and references can provide youth with source of this information. **LIST** other features or characteristics that they can use to sort and classify into smaller groups

IV. Things to use to classify Fish

A. All Fish Have

1. Backbones
2. Scales or plates
3. Slimy skin
4. Fins
5. Gills
6. Live in water
a. freshwater
B. saltwater

B. Fish characteristics

1. Color pattern
a. stripes
b. spots

2. Fin arrangement
3. Body shape
a. streamlined
b. flattened

DISTRIBUTE FISH CARDS, PHOTOS OR ILLUSTRATIONS and glossary. Be sure that each in the group gets a good look at the fish.

V. Group sorts fish illustrations/photos

1. **GROUP DECIDES HOW BEST** to divide the fish into two groups based on one characteristic. **GROUP SORTS** fish pictures into two piles according to that characteristic. **WRITE THAT CHARACTERISTIC**, which will be the first question on their key, or branch on the tree. On line 1a and 1b fill in the characteristic and the next step to identification.

A. First level

2. Next, take the fish from one pile and divide them into two more piles and fill in the key with 2a and 2b or two additional branches. Continue dividing until remaining fish can=t be sorted any further.

B. Second level

3. Have the youth check their keys when they are finished. They should be able to pick up any fish picture and follow the key to find the name of the fish. For the key to be correct, this should work with all the fish in the group's pile. (Keys may differ from group to group, but as long as it works within the group for all the fish, it should be correct.)

C. Additional levels as needed

4. Groups may exchange their keys and set of pictures, but ask the youth not to turn the cards over until they have identified the fish and want to check their answer. See if others can identify the fish using only the descriptions in the key.

5. From their dichotomous keys, the youth will be able to see the major characteristics that help in identifying fish. They will also be able to see similarities between fish and this will help them to group the fish according to family.

6. By looking back through the steps used to key out an item, you can get a list of the item's characteristics. From the example above, the egg noodle is described as not hollow, flattened, short and narrow. This is easily done by looking at the set of choices and writing down the one that is true for a specific item. Follow the numbers through the steps they will be able to do later in the evaluation chart and continue writing down characteristics true to the item until you reach the identification stage. Explain and practice this with the youth so.

7. Now pass out the information about fish families. Have the youth first physically group the fish cards by family, then develop another key to identify fish families. Again, for the key to be correct, the key will have to work for all fish in the family. Finally, groups may exchange keys and fish cards to test each other's keys.

Lesson Narrative

Background:
Scientists use keys to identify things and put them in groups based on how they are alike. This activity will introduce youth to a dichotomous key. In dichotomous keys, things are divided into two groups each time a characteristic is considered. This concept is sometimes difficult for youth to grasp. It is most easily conveyed by having the youth physically group the items as they are discussed. Begin by choosing one characteristic that will be represented by two piles -- items that have this characteristic and items that do not. Separate one of the piles into the same type grouping as the original and keep subdividing the pile until all of the items have been identified. Then go to the second pile and do the same thing, all the way down to the identification stage. Many variations are possible when developing a dichotomous key. The best way to check your key is to give it to someone else, along with one or more items, and have that person identify the item(s) using the key. By looking back through the steps used to identify an item, you can get a list of the item's characteristics.

Dichotomous keys can be used to classify anything. Youth will have the opportunity to construct a key that classifies a variety of fish and then a key to identify fish families of local area. All fish are alike in some ways. All fish have gills and scales (with a few exceptions). Fish differ from each other in several characteristics: head shape, spines, number and placement of fins, and fin types. Color is not a good distinguishing characteristic because it will vary with changes in the physical or physiological state of each fish, or with environmental changes. Youth may need to be reminded of this often since it is a very popular way of grouping things. The pictures, descriptions and glossary of distinguishing characteristics are included to help with developing a key and identification.

Sixteen families of fish are typically recognized in local area.

1. Sturgeon family – Acipenseridae
Upper lobe of the tail fin is longer than the lower. Five rows of bony plates shield the body. A shovel-shaped snout and sucker-like mouth with four barbels in front of the mouth aid in locating food. Fish of this family in local area are shortnose sturgeon, lake sturgeon and Atlantic sturgeon.

2. Gar family – Lepisosteidae
The upper and lower jaws form a long, slender snout. The body is covered with thick bony scales. These fish range from 30 - 50 inches in length. Fish of this family in local area are longnose gar and spotted gar.

3. Bowfin family -- Amiidae
The body is covered with heavy scales. The single long dorsal fin is separated from the broadly rounded tail fin. A pair of short barbels are found in the nostril area. The fish of this family in local area is bowfin.

4. Herring family -- Clupeidae
These fish have mid-belly scales that are sharpened in "saw-tooth" arrangements. There is no lateral line along the sides. The body is compressed from side to side and is very narrow when look at from head on. These fish have bright silvery scales.

5. Trout and salmon family -- Salmonidae
These fish have an adipose fin, small scales, a squarish or forked tail (depending upon the species), and an axillary process at the base of the pelvic fins.

6. Smelt family -- Osmeridae
These fairly small fish may grow to be 9 inches long, have an adipose fin but no axillary process, have large silvery scales, a large mouth with strong teeth and a slender body. The fish of this family in local area is rainbow smelt.

7. Pike family BEsocidae
Local area is the only place in the world where all members of the pike family can be found. They have a duck-bill snout and a single dorsal fin placed far back and above the anal fin, with a forked tail. Fish of

this family in local area are northern pike, muskellunge, tiger muskellunge, chain , grass and redfin pickerel.

8. Minnow family -- Cyprinidae

Fish from the minnow family make up 25 percent of our total fish fauna by species in local area. They have a single, soft-rayed dorsal fin and several rows of hard teeth (or tooth-like structures) found on the hindmost gill arches. They are important food for many larger fish. Fish of this family in local area are common carp, river chub, golden shiner, common shiner, creek chub, and fallfish.

9. Sucker family -- Catostomidae

A single soft-rayed dorsal fin, single row of teeth, and an anal fin placed farther back on the belly than on minnows is characteristic of fish in this family. They also have a mouth that is directed downward, thick fleshy lips, are robust and of moderate size. Fish of this family in local area are quillback carpsucker, white sucker, hog sucker, and redhorse sucker.

10. Catfish family -- Ictaluridae

These fish have well-developed pectoral spines, an adipose fin directly joined to the tail fin or not connected (depending upon the species), eight flashy head appendages (barbels, or "whiskers"), and a well-developed spine in the dorsal fin. Fish of this family in local area are white catfish, channel catfish, brown bullhead, black bullhead, yellow bullhead, and flathead catfish.

11. Temperate bass family -- Percichthyidae

Members of the temperate bass family have a spine on the outer rear portion of the gill cover, and a conspicuous patch of gill-like, secretion-emitting tissue found under the surface of the gill cover. Fish of this family in local area are white perch, white bass, striped bass (rockfish), and striped bass hybrid.

12. Sunfish family -- Centrarchidae

These fish have a single dorsal fin composed of soft and spiny rays and have three or more spines in the anal fin. They lack a spine on the gill cover. Fish of this family in local area are largemouth bass, smallmouth bass, spotted bass, rock bass, redbreast sunfish, green sunfish, pumpkinseed sunfish, bluegill sunfish, redear sunfish, white crappie, and black crappie.

13. Perch family -- Percidae

These fish have one or two spines in the anal fin. The majority of the species in this family belong to a group called darters which are important as forage for other fishes and as water quality and habitat indicators. Local area has at least 18 species of darters. Yellow perch and walleye are highly regarded for their sporting and eating qualities. Fish of this family in local area are yellow perch, walleye, sauger, and darters.

14. Drum family -- Sciaenidae

The freshwater drum is the only representative of a large group of marine species found in temperate and tropical coastal waters around the world. The spiny and soft-rayed portions of its dorsal fin are narrowly joined. The soft-rayed portion of the dorsal fin is much longer than the spiny-rayed portion and the lateral line continues to the end of the tail. The first anal spine is very small and the second very large. The only fish of this family in local area is the freshwater drum.

15. Sculpin family -- Cottidae

Members of this family have large, flattened heads and large pectoral fins. The body is largely scaleless with some scattered areas having small, sharp scales called prickles. Fish of this family in local area are mottled sculpin and slimy sculpin.

16. Freshwater eel family -- Anguillidae

Very long and slender bodies are characteristic of this family. Also, minute scales embedded in the skin, no pelvic fins, and the dorsal fin co anal fin. The only representative of this family in local area is the American eel.

Glossary

adipose fin -- small, fleshy fin on the back and near the tail of certain fishes.
anal fin -- single fin on underside of fish between the vent and tail.
axillary process -- elongated, membranous material occurring at base of pectoral and pelvic fins.
barbel -- slender, fleshy projection on the head, usually around the mouth.
bony plates -- hard, heavy scales.
caudal fin -- tail of a fish.
dorsal fin -- fin on the back of a fish; bay be divided into parts on some species.
fauna -- animals living in a particular area.
gill arches -- bony structures that give internal support to the gills.
gills -- organs through which oxygen is absorbed from the water; protected by gill cover.
lateral line -- line of scales running lengthwise on each side of a fish with openings or pores connected to a sensory canal.
pectoral fin -- uppermost fins on either side of the body and usually just behind the gill.
pelvic fin -- fins on either side of the body, below and often behind the pectoral fins.
ray -- bony structure supporting the membranes of the fin.
soft-ray -- flexible, jointed rays supporting a fin.
spine -- sharp, pointed structure.
spiny-ray -- stiff, hard and unjointed bones supporting a fin.

Exhibit or Sharing Suggestions

1. Gather photos and create a poster or display
2. Have youth demonstrate the construction and use of a key

Community Service and AGiving Back@ Suggestions

1. Create bulletin board or display for local bait and tackle shops, to assist anglers with fish identification, especially fish that are hard to identify, and identification is important.

Extensions or Ways Of Learning More

1. Using the same techniques, sort aquatic insects collected in AAquatic Adventures@ activity
2. Create keys and laminate or put in sheet protectors. Use these keys when fishing to assist with fish identification.
3. Invite a biologist to speak on how keys are used in their occupation.

Water We Eating

Adapted from Aquatic Guide-8 1987, 1992 Council for Environmental Education. Reprinted with permission from Project WILD, Project WILD Aquatic Education Activity Guide. The complete Activity Guide can be obtained by attending a Project WILD workshop. For more information, contact the national Project WILD office at 301-493-5447.

Objectives
Participating young people and adults will:
1. Identify foods derived from aquatic sources and their geographic origins
2. Describe importance of aquatic environment as food sources
3. Describe importance of water in our diets.

Youth Development Objectives
Participating young people will:
1. Develop critical thinking skills.
2. Acquire and analyze information
3. Develop problem solving and decision making process.

Roles for Teen and Junior Leaders
1. Assist with gathering materials
2. Serve as group leaders on field trips
3.

Potential Parental Involvement
1. See ARoles for Teen and Junior Leaders@ above
2. Conduct survey at home of food derived from aquatic sources.
3. Describe and discuss any cultural link to food derived from aquatic food sources.

Evaluation Activities/Suggestions
1. Name five specific foods derived directly from aquatic sources. List their country or region of origin.
2. Name an aquatic plant or aquatic animal that you can find in a local store and that is also found growing or living in your state.
3. Name an aquatic product that is used in food production but is not necessarily eaten directly. How is it used.
4. Describe three ways that aquatic habitats are important to humans as food sources.

Best Time: anytime, although good introductory activity

Best Location: indoors, grocery store

Time Required: from 20-45 minutes

Equipment/Materials
world map
easel pad
markers
tablets or notepads
pens or pencils
If field trip not possible:
empty food containers
magazine or newspaper food/grocery advertisements

Safety Considerations

References

Council for Environmental Education, 1992, *Project WILD Aquatic Education Activity Guide*,
Watercourse and the Council for Environmental Education, 1995, *Project WET*, Montana State University, Bozeman MT, 406-994-5392

Lesson Outline

Presentation Outline	Procedure
	For Younger Youth
I. Water is used directly or indirectly to prepare food. A. Direct 1. fish, seafood products 2. ingredient B. Indirect 1. irrigation 2. processing	2. Have youth **BRAINSTORM** the ways they use water in meals or meal preparation. **CATEGORIZE** the uses as indirect (washing food) and direct (ingredient, source of ingredient).
IF FIELD TRIP IS POSSIBLE:	Field Trip Option 3. **BRAINSTORM A LIST** of all the things that they would expect to find in a supermarket or grocery that come directly from aquatic environments. They may need help with what constitutes an aquatic environment. Be inclusiveBeverything from ocean to pond, from swamp to river, is appropriate.
II Teams record observations	4. Obtain permission from the manager of a local supermarket or grocery to bring your class to the store to find out how many things come from aquatic environments. Have the youth form three-person team and **design a form to record information** on. Construct a mural of pictures and advertisements to show aquatic foods and their sources. 5. **Compile a master a master list of aquatically-derived products.** If necessary, do research to answer the following: Where do they com from? How are they obtained? Where and how are these products processed? How are they used. 6. On a world map **locate the origins of as many items** on the list above as possible. 7. Ask the youth to draw a picture of the aquatic food products they most like to eat, or make a collage of such products from magazine pictures. 8. Summarize the lesson by emphasizing how much every aspect of our lives depends upon aquatic environments. Point out that aquatic environments

not only provide us with all the products the youth listed but they provide the natural home for countless life forms.

For Older Youth:

1. Ask the youth to make a list of all the things that they would expect to find in a supermarket or grocery that come directly from aquatic environments. They may need help with what constitutes and aquatic environment. Be inclusiveBeverything from ocean to pond, from swamp to river, is appropriate.
2. Where possible, identify the product, its uses and its source of origin. One clipboard per team is adequate. They should trade off the task of recording. Assign each team of three a specific aisle to survey. Advise them of common courtesies such as carefully replacing items they examine. The entire class should visit the fresh and frozen fish counter, if there is one, and list the names of the fish and shellfish being sold. The frozen fish should also be listed. Canned fish and shellfish products should have the location of the cannery noted. When all this is completed, thank the manager and return to the school NOTE: if a field trip is not possible, you might use supermarket advertisements in newspapers as a source of aquatic products. Cupboards and pantries at home could be another source. You and/or the youth might bring a representative variety of items to school to show the diversity of foods and other goods people use from aquatic environments. Or, use photos from a variety of magazines.
3. **Compile a master list of aquatically-derived products**. If necessary, do research to answer the following: Where to they come from? How are they obtained? Where and how are these products processed? How are they used?
4. On a world map **locate the origins of as many items** on the list above as possible.
5. Have a **discussion or brainstorm a list of natural and human** activities that impact the availability of aquatic food products.
6. **Summarize** the lesson by emphasizing how much

every aspect of our lives depends upon aquatic environments. Point out that aquatic environments not only provide us with all the products the youth listed, but they provide the natural homes for countless life forms.

Lesson Narrative

Background

Aquatic habitats (oceans, estuaries, marshes, lakes, rivers, etc.) provide humans with a wide array of products which are sold commercially. Some of these are obvious; e.g., fish, shellfish, wild and domestic rice, and cat food. Other items like fertilizer, soup stock, watercress, water chestnuts and vitamins are not so well know. Seaweed, for example, is a source of algin, carrageenan, and agarBused as stabilizers, thickeners and emulsifiers in hundreds of food products. These seaweed derivatives are used to make the texture of things like ice cream and shampoo smooth and creamy; and to help keep ingredients like the chocolate in chocolate milk in suspension. Certain types of seaweed, which are actually forms of algae, are consumed directly by humans. For example, nori is used in sushi, and irish moss, lauer and dulce (dulse) are used in other dishes. In another example, the meat in oysters is eaten directly by humans; oyster shells are ground up for use as calcium supplements for humans and poultry.

Another source of aquatic food products is aquaculture. Aquaculture is an ancient form of cultivating aquatic plants and animals for food. Early Egyptians raised fish for food in small ponds. Today china may have the most advanced aquaculture programs. Nearly 40% of the fish consumed in China comes from fish farms. N the United States, aquaculture produces many fish common to our markets. Perhaps as much as 99% of the rainbow trout consumed in the United States comes from aquaculture. As we use the terms, aquaculture typically refers to freshwater programs, and mariculture to marine programs, for raising aquatic plants and animals for commercial purposes. Catfish, lobster, shrimp, oysters and salmon are all examples of aquatic animals now being raised commercially through aquaculture and mariculture programs. The hatching and raising of aquatic animals for release in streams, lakes and oceans is also considered a form of either aquaculture or mariculture.

It is also important to realize that all the food we eatBwhether or not it comes from an aquatic sourceBuses water at some time, directly or indirectly in its development, processing or distribution. Agricultural uses of water account for 33% of human use of water in the United States. That means that over 600 gallons per day for each person in the United States is being diverted by irrigation and livestock use from the natural aquatic sources. It takes about 40 gallons of water to produce a single egg, 80 gallons per ear of corn, and 2,500 gallons for one pound of beef.

This activity does not specifically address potential ethical questions which may be raised concerning human aquaculture and mariculture practices. It is designed to focus on youth= recognizing the role of water in the production of foods, including from aquatic environments.

Exhibit or Sharing Suggestions

1. Present collage or mural of food products.
2. Give presentations on production of food products.

Community Service and "Giving Back" Activities

1. Present lesson to community groups/classroom

Extensions or Ways of Learning More

1. Visit food production facility to learn how water is used in process.
2. Visit a fish hatchery or other aquaculture facility
3. Research aquaculture and mariculture. Compare the food produced by each to the food produced through commercial fishing. What kinds are produced by each? What impacts, if any, are there on population of fish and shellfish as a result of each approach?
4. Determine how agriculture, and particularly irrigation, affects natural aquatic habitats.
5. Compare aquatic products found in conventional markets in the United States with products found in markets specializing in foods from Asia. (Japan, China, Philippine, Viet Nam, etc.)
6. Classify the aquatic food products according to the kinds of aquatic habitats in which they are found: salt-water (ocean, estuary, marsh, etc.) and freshwater (lake, pond, stream, river, etc.)
7. Invite those working in aquaculture or food production to visit group.

Kitchen Table Water Cycle

Carl Richardson

Objectives
Participating young people and adults will:
1. Observing water cycle on a small scale
2. Describe steps in water cycle
3. Describe how energy from the sun drives the water cycle

Youth Development Objectives
Participating young people will:
1. Develop analytical skills
2. Observe and acquire information about model and analyze
3. Problem solving
4. Build and use models

Roles for Teen and Junior Leaders
1. Assist with organizing materials and setting up activity.
2. Photographer or recorder of events.
3. Assist with clean up.

Potential Parental Involvement
1. See ARoles for Teen and Junior Leaders@ above.
2. Collect data on weather, especially precipitation
3. Identify activities that may influence the water cycle

Evaluation Activities/Suggestions
1. Youth label steps in water cycle on blank chart
2. Youth describe steps in water cycle
3. Youth write narratives in fishing journal about path of a single water droplet as it moves through the water cycle

Best Time: as an introduction to water and watersheds unit.

Best Location: indoors

Time Required: 15-45 minutes

Equipment/Materials
incandescent lamp or lamp (desk or table lamp, workshop light)
large clear glass bowl or baking dish (preferably Pyrex)
small saucer of water
ice, ice pack or cold cloth
paper towels or blotter paper
tablet, notebook or journal
easel pad & markers or blackboard

Safety Considerations
glass bowl or dish should be pyrex or other material that can tolerate heat extremes. Caution should be exercised around the light, as it gives off heat. Extreme caution must be exercised when electrical appliances or items are near water. This can be a deadly combination. Outlets or extension cords with ground fault circuit interrupters (GFCI) should be used.

References
Caduto, M. J., 1985, *Pond and Brook: a Guide to Nature in Freshwater Environments,* Prentice Hall, Englewood Cliffs NJ
ISBN 0-87451-509-2

Schmidt, B, 1991, *Sportfishing and Aquatic Resources Handbook*, pp 43-44, 48-55, Kendall Hunt Publishing, Dubuque IA
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Schmidt, B, 1997, *Advanced Sportfishing and Aquatic Resources Handbook*, pp 99-103, Kendall Hunt Publishing, Dubuque IA. ISBN 0-7872-3544-x

Lesson Outline

Presentation	Application
I. Steps in the water cycle A. Precipitation Liquid or frozen water falling on Earth 1. snow 2. rain 3. sleet & hail 4. fog B. Evaporation & Transpiration 1. Evaporation: water vapor given off by non-living things 2. Transpiration: water vapor given off by plants C. Condensation Results from cooling of vapor, forms clouds, fog D. Run off Liquid form moving on surface of Earth E. Percolation Liquid soaking into ground F. All driven by energy from sun	1. **Brainstorm** the steps in the water cycle
II. Build model	2. **Divide available materials** among groups of youth. 3. Fill saucer with water 4. Place bowl or baking dish over the saucer, with paper towels or blotter paper at opposite end of bowl 5. Place light above the bowl, directly over the saucer. Water in the saucer will increase in temperature and evaporate. 6. **Have youth record their observations.**
III. Observe and record	7. After several minutes cool the opposite side of the dish with either a cold cloth or ice pack. 8. At this point water vapor will begin to cool, condense and fall on paper. **Have youth record their observations** 9. After several minutes of Amaking rain@, turn off the light.
IV. Ask youth to describe observations	10. **Ask youth to summarize what they observed or noted.**
V. Summarize observations	11. **Summarize** their observations on easel pad or blackboard.
VI. Make comparisons to model	12. **Ask youth to identify what components of this model cycle represent.** Lamp=Sun Saucer of water= oceans, lake, evaporation & transpiration Ice pack, cold cloth=cooling effect in atmosphere, forming clouds blotter paper=ground (percolation) 13. **Ask youth to identify human activities than can influence this cycle, list them.**

Summary Activity

1. Have youth label blank water cycle, or draw water cycle, with steps labeled

Lesson Narrative

The water cycle is very important to all of us. Each living creature needs water to survive. The way water moves throughout the Earth is called the water cycle. As water moves through this cycle it changes phases; liquid, vapor and solid. All the water in the Earth has been moving around the water cycle for as long as we know. There is a limited amount of water on the earth. It may take thousands to millions of years for a single water drop to complete the cycle, depending on where it ends up. For example water that forms polar ice caps or deep underground for example will remain there for thousands of years (if not longer). Water that falls on a sidewalk for example may evaporate as soon as the sun comes back out. This is an important concept to understand, as even slight influences on the cycle can have far reaching and long lasting impacts on other steps in the cycle.

The sun is what started this cycle moving, and keeps it moving to this day. Energy from the sun causes surface waters to evaporateBor change from liquid to vapor form. This is the step that. The vapor rises into the atmosphere (because warm air is lighter). When it reaches the atmosphere it cools and condenses or returns to its liquid form. Many water drops condense and collect to form clouds. When there are few clouds, the water stays in vapor state. Air at a given temperature can only hold so much water, much like a sponge. When the Asponge@ can=t hold anymore, rain falls. Rain can also fall when the air is cooled by mountains, colder winds or weather systems.

Rain, snow and fog make contact with the Earth. Some, pulled by gravity flows away from where it fell. This water gathers and collects in ditches, which gathers into larger streams and rivers. This is called runoff. Water that doesn't run off, may soak into the ground. This is called percolation. This water gathers and collects in soil and rock formations, and is called groundwater. Water may remain underground for very long periods of time. It may also emerge from underground in form of springs, rivers or streams.

Precipitation also lands directly on plants, such as grass, trees and flowers. Some of this water is used by the plant. The plant will also draw water from the soil. This water is used by the plant for important functions, for example important minerals are dissolved in the water. Water is also a by product of photosynthesis. Photosynthesis is when plants use sunlight to produce their own food. Plants give off excess water through special Avalves@ or cells on leaves. This giving off of water is called transpiration. Once again the sun is the energy driving this cycle.

In this way water falls to earth, is used by plants, soaks in or gathers. This water eventually evaporates or is given off by plants (transpiration). Evaporated water condenses and forms clouds. The clouds, when they can=t hold anymore, give off precipitation and the cycle makes another trip.

Exhibit or Sharing Suggestions

Display models.
Create narratives or drawings of the water cycle, and label steps, things that influence water cycle.
Give presentations where youth model or act out the steps in the cycle.

Community Service and AGiving Back@ Activities

Attend public meetings on issues that can influence the water cycle. For example paving prevents water from soaking in or percolating. Explore the impacts of this interference to groundwater, and other surface waters.

Extensions or Ways of Learning More

Visit local water authority to determine sources of community drinking water. Water for human use comes from surface waters or wells. Explore how the water cycle can influence the amount of water available for us to use in our homes.

Build a Watershed: Just Add Water!

Objectives

Participants will be able to:

1. Define and describe a watershed
2. Understand the term "drainage basin".
3. Describe factors about the landscape which influence the path water takes on its path down the "mountain".
4. Make inferences about the statement, "We all live downstream."
5. Reason how land use can influence aquatic habitats.

Life Skills

- Responsible citizenship
- Communication
- Concern for others,
- Concern for the environment
- Self-responsibility
- Critical thinking, decision-making

Roles for Teen and Junior Leaders

1. Assist with organizing materials and setting up activity.
2. Photographer or recorder of events.
3. Assist with clean up.

Evaluation Activities/Suggestions

1. Have youth describe why the water gathers collects and moves down the watershed.
2. Ask youth to describe how the water cycle influences aquatic habitats.
3. Have youth review map of local area and identify nearest river and stream.
4. Ask youth to describe how the landscape influences the waterways in a watershed.

Best Time: Anytime. However this should serve as an introductory activity. This activity introduces a very important foundation concept; that is - other lessons build upon this one.

Best Location: outdoors; if indoors take precautions for potential mess created

Time Required: 20-30 minutes

Equipment/Materials

Newspaper
large white garbage bag or landscape plastic
two or more spray bottles
water
Kool-Aid or similar powder drink mix without sugar (optional)

References

Caduto, M. J., 1985, *Pond and Brook: a Guide to Nature in Freshwater Environments*, Prentice Hall, Englewood Cliffs NJ ISBN 0-87451-509-2

Schmidt, B, 1991, *Sportfishing and Aquatic Resources Handbook*, pp 43-44, 48-55, 72-73, Kendall Hunt Publishing, Dubuque IA ISBN 0-8403-6599-3

Schmidt, B, 1997, *Advanced Sportfishing and Aquatic Resources Handbook*, pp 99-101,107-108, Kendall Hunt Publishing, Dubuque IA. ISBN 0-7872-3544-x

Lesson Outline

Preparation

Fill spray bottles with water; use at least two and can use more.

Find a nice level spot that can get wet or is easily cleaned up, preferably outside.

Presentation	**Application**
I What is a watershed A. Definitions B. Examples of watersheds	Ask youth to **BRAINSTORM** definitions of the word watershed. **LIST** their responses on a blackboard, easel pad. **EXPLAIN** that sometimes models are used to teach and we are going to build a model of a watershed. **BRAINSTORM** list of nearby waters and watersheds.
II. Water cycle 1. Precipitation 2. Evaporation & transpiration 3. Percolation (soaking in) 4. Condensation (forming clouds) 5. Run off	Ask youth to **BRAINSTORM** sources of water we fish . Likely they will say precipitation, from upstream or underground.. **EXPLAIN** that group will be building a watershed and demonstrating what happens when it rains Crumple newspaper sheets and form a pile. Use at least six sheets; use more to make a larger watershed. Cover the pile with a large white plastic bag. This is the watershed Youth with spray bottles **SIMULATE** "precipitation" over the watershed by spraying the plastic with the spray bottles. (Note: setting should be set to mist). Youth should **OBSERVE** and **DESCRIBE** how water gathers and flows, due to gravity to lower end of watershed especially the paths run-off takes (simulated streams and rivers). If necessary **SHOW** how small streams gather and collect other streams and how these larger streams gather others forming "rivers."
III. Land and its influence on the path water takes 1. Topography –"lay of the land" 2. Climate - How much precipitation 3. Ground/bedrock "how much can soak in or run-off	**ASK** youth to **ANALYZE** what they **OBSERVED** and relate that to places they fish**.** Then **ASK** what things in the model influence this model and the path water takes as it move through. They should identify factors like climate, slope of land, composition of the ground, amount of rain. **USE** probing questions like: "what do you think would happen if..." flattened or raised hill; used a garden hose; used newspaper instead of plastic.
4. Human activity	**SIMULATE** human disturbances (such as pollution or erosion) with kool-aid or other power drink mix. **ASK** youth to

OBSERVE what happens to water downstream of this "spill."
ASK youth to **DESCRIBE** what they **OBSERVE** and how activity in the watershed can affect downstream habitats.
ASK youth to **DESCRIBE** activities in their own watersheds that might impact the water they drink and/or fish in.

CLOSE the activity by **ASKING** youth to define: watershed, the factors that influence path water takes as it moves through a watershed and what is meant by "we all live downstream."

Summary Activity

1. Do a quiet reflection and ask youth to visualize their favorite river or stream (or for saltwater habitats the inlets and outlets of bays etc.). Have them list in their journals or on separate paper the things that influence the path that water takes. Have them describe in their own words how humans use the land, and how those activities can influence the watershed.

Background:

Precipitation that falls on land either soaks into the ground or runs off. Water that does not soak in runs off into streams. Streams usually follow well-defined paths or channels. Channels then converge into a river. These small streams, channels and rivers are draining a particularly well-defined land area. This area is commonly known as a watershed.

A watershed is the land area drained by these particular bodies of water. The land area of a watershed is defined by elevated lands, primarily hills and mountains. Elevated lands separate watersheds from one another by causing precipitation run-off to run in different directions -- down one side or the other.

All watersheds eventually empty their waters into larger bodies of water (such as the Missouri or Mississippi River). These larger bodies of water then transport their waters to the seas and oceans (such as the Great Lakes, Gulf of Mexico or Pacific or Atlantic Ocean) Watersheds can be enormous or quite small. Large, well-established watersheds supporting major rivers are known as river or drainage basins.

Understanding what a watershed is and how it functions helps one to comprehend "connectedness." Some of the precipitation that falls in your backyard runs off to ditches, storm sewers and brooks. Eventually, it flows into a creek, lake, or river. This body of water is then used by others for drinking, swimming, fishing, and other activities. Wildlife, too, are dependent upon these waters.

Adaptions:

- Create two watersheds; one with no pollutants and one with powdered chocolate drink mix (simulate soil) sprinkled over the area. The color of the watershed will change colors when the precipitation and runoff occur.
- Change the shape of the watershed (height, slope, flatness) and see the difference s in flow speed and retention. Add a small sponge to one of the low areas to represent a wetland.
- Let youth make additional modifications to the watershed to stimulate discussion.

Exhibit or Sharing Suggestions

1. Draw maps of watersheds
2. Build more detailed models
3. Write essay or short narrative on path of a single raindrop beginning as it falls and moves through the watershed.

Community Service and AGiving Back@ Activities

1. Label street storm drains with message reminding citizens where water goes. Example: *This water goes to the _ ________ river.*

Extensions or Ways of Learning More

1. Talk a walk along a stream or river noting tributaries, land use. Maps or written descriptions can be prepared from this information.
2. More detailed scale models can be built using modeling clay and paint trays.
3. Contact the local extension office, conservation district, water authority and natural resource agency. Find out what they do to protect watersheds.
6. Add food coloring to one of the bottles. This bottle can then represent some disturbance in the natural system such as acid precipitation. Now see what happens when this mist falls. Compare to a real watershed.

Links to Other Programs

Using the models or maps prepared, identify potential fishing hotspots.

Dissect a River

Ontario Ministry of Natural Resources, *Fishways*

Objectives

Participating young people and adults will:

1. **Isolate and order any stream or river system in their state or local area.**
2. **Predict the characteristics along various parts of a stream**
3. **List at least two human impacts affecting river systems.**

Youth Development Objectives

Participating young people will:

1. **Enhance ability to acquire and analyze information.**
2. **Enhance ability to work with others.**
3. **Enhance problem solving skills.**

Roles for Teen and Junior Leaders

1. **Assist with mapping activity**
2. **Assist with gathering materials**

Potential Parental Involvement

1. **See "Roles for Teen and Junior Leaders" above.**

Evaluation Activities/Suggestions

1. **Given a map of a simple watershed, have youths order the streams and give a brief description of each order.**
2. **Predict features of a stream or river, just by knowing its stream order**
3. **Prepare a chart of major stream orders with features and critters likely to be found there.**

Best Time: after build a watershed
activity, prior to fishing river or stream

Best Location: Indoors, outdoors with picnic tables

Time Required: 60 to 90 minutes

Equipment/Materials State road map; colored pencils. local topographic or county maps (usually available from County Extension, Conservation District) especially those with local/regional major streams/rivers etc. tracing paper tablet paper pencils easel pad markers masking tape

Lesson Outline

Outline

I. Introduction: Types of flowing water

- **A. Brooks**
- **B. Creeks**
- **C. Streams**
- **D. Rivers**
  1. **small rivers**
  2. **Large rivers**

II. STREAM ORDER--Standard system for numbering/ classifying streams

- **A. Stream order**
  1. **First -headwaters**
  2. **Second -form when two 1's join**
  3. **Third - two 2's join**
  4. **Fourth-two 3's join**
  5. **Fifth-two 4's join**

- **B. Changes occur as stream order increases**.
  1. **Amount of water increases**
  2. **Water temperature increases**
  3. **Fish community changes**
  4. **Channel changes**

Presentation

1. Have youth **BRAINSTORM AND DISCUSS** all the flowing that they've seen (that is, creeks, streams etc.). **LIST** these water bodies. What do they have in common? How do they differ? **ASK YOUTH** if these descriptions be organized in any way? Do the same For example, do similar sized streams have similar characteristics?

2. **EXPLAIN** that, for scientific purposes, a numerical system has been devised to standardize the various components of a moving water system. This numerical system allows scientists to roughly determine the types of fishes that may inhabit that environment. **DISCUSS** the characteristics (water temperature, volume, velocity, bottom type, channel width, community members, fish species, etc.) that might change as the stream order increases from the headwaters to the mouth of the river. **EXPLAIN** that the majority of trout streams are first or second and in some parts of the country, third order streams.

3. **DIRECT** youth to devise their own technique for ordering streams or you may follow this approach. **DISCUSS** the system of stream ordering by having the class build a simple river system. **REFER BACK TO WATERSHED ACTIVITY** to refresh their

III. MAPPING ACTIVITY

A. FIND local community on state map

B. IDENTIFY local waterways

4. **DIVIDE** the class into small groups and give each group a state road map, sheet(s) of tracing paper, and topographic map. **DIRECT** youth to find their own community on the map and find the nearest river system. Have youth find their watershed, using the road map for guidance.

III. MAPPING ACTIVITY cont.

A. Mark highest points (from contour lines)

B. Streams and rivers, color coded by stream order

C. C. Points of human impact

Note: The youths local community may be part of another drainage system but the river closest to their community on topo maps available should be selected.

5. **TAPE** the topographic map to the desk or table. **PLACE** tracing paper over topo map and tape it into place.

IV. DISCUSSION SESSION

memories. Using the blackboard or chart paper, **ASK FOR A VOLUNTEER** to draw two first order streams, which join to form a second order stream and label each. Then ask a second youth to draw a similar configuration and link it to the first to create a third order stream - and so on until a fourth or fifth order stream is reached. When this river system is complete, they should realize that the land the river system drains slopes downhill from a divide (highest points) as the stream order increases, creating a drainage basin or watershed. Draw a line around the river system and label it as the watershed.

6. **EXPLAIN THAT THEY ARE TO MARK THE FOLLOWING ON THE TRACING PAPER,** using a different color for each:

a. Highest points surrounding the river/stream (determined from contour lines) they made some assistance on this task.

b. All the streams and rivers, using the same color for each stream order (red-first, blue-second etc.)

c. Major points of human impact (e.g. industrial plants, cattle crossing or watering locations, stream improvement projects, storm sewer outlets)

Once the exercise is complete, discuss the following questions with the class:

Could we identify fishing spots from these maps?
As the stream order increases, would humans impact on the river system tend to increase or decrease?
What effect could this have on the local fish community?
Is there evidence of these effects near your local community?

Lesson Narrative

River, stream, freshet, creek - there are many names for flowing water. Some, like creek and brook, are used interchangeably; others have unique specific meanings. Scientists generally refer to smaller bodies of flowing water as streams and larger ones as rivers. The area of land from which rainfall and melted snow drain into a particular stream or river is called its watershed. The high ground separating watershed is called a divide. Every place on earth is part of some watershed. Every watershed reflects the land it drains. The quality of water within a watershed and the species of fishes that can be found within its boundaries are directly linked to the quality of the land and any use it is put to by humans. As streams join other streams, a branching network, or river system, forms.

Stream ordering is a way of indicating in numerical terms the relative position of a stream within a much larger river system. Headwater streams that have no tributaries or branches are called first order streams. They usually begin from cool springs arising in a hillside or wetland, or as an outlet from a lake or pond. First order streams are usually narrow, shallow and steeply graded; they may have grasses, shrubs or trees lining their banks, shading the stream from the sun and keeping the water cold. They may flow quickly, scouring the bottom of all but rocks and large particles of gravel, and are often inhabited by cold-water loving fish species such as trout.

When two first order streams join, a second order stream is formed. Similarly, a third order stream is created by the joining of two second order streams, and so on. Where two streams of differing orders meet, the downstream portion retains the higher of those two orders. For example, second and third order streams would join and form a third order stream.

When does a stream become a river? Most scientists feel that a third order stream can be classified as a river. The volume of water in a river is much greater than that of a stream and often a valley has been cut or eroded by a river=s flow. The rate of flow in a river is usually much less than in a stream. The flood plain, or land periodically flooded by a river, becomes flatter, and silt and sand eroded upstream are often deposited on the bottom of the river bed as the river slows. The river=s water tends to be turbid because of the suspended particles of clay, silt, finely divided organic and inorganic matter, etc. It is also often warmer from exposure to the sun and frequently contains less oxygen. Fish species like carp, walleye, brown bullheads, channel catfish and lake sturgeon, which have adapted to warmer water and more turbid conditions, tend to inhabit these warm water rivers.

A river goes through a number of changes from its headwater source to its mouth where it empties into a large body of water such as a lake. Similarly, the character and quality of its fish community may change as the stream order changes and as human activity within the catchment changes.

Exhibit or Sharing Suggestions

1. Draw maps of watersheds
2. Build more detailed models
3. Write essay or short narrative on path of a single raindrop beginning as it falls and moves through the watershed.

Community Service and "Giving Back" Activities

1. Label street storm drains with message reminding citizens where water goes. Example: *This water goes to the ___ river.*

Extensions or Ways of Learning More

1. Contact the local water authority, watershed association, or river basin commission and request information on their watershed management and protection programs.
2. Visit the sites mapped for what map makers call ground truthing. Were the discussions and predictions accurate?

Links to Other Programs

Fishing Skills: identify potential hotspots, those places that likely have good habitat for the fish being sought.

What Are Aquatic Ecosystems?

MDC "Fishing for Answers"; written by
Jeanne Pyland & Bob Fluchel
Illustrations: Ann Grotjan

Main Ideas:

- Each of several types of aquatic systems is a balanced web of relationships.
- Flowing water and standing water ecosystems support life but in different ways.
- When people disturb an ecosystem, all living and nonliving parts are affected.

Objectives:

- Define ecosystem.
- Identify seven aquatic ecosystems.
- Compare and contrast living conditions of flowing water and standing water.
- Discuss the benefits of wetlands.
- Give an example of how people damage an aquatic ecosystem.

Key Words:

- ecosystem
- flowing water
- standing water

What Are Aquatic Ecosystems?

Two eyes are staring at you from the cattails near the pond bank. You her "jug-o'-rum, jug-o'-rum", then the bullfrog dives into the water. The frog is busy catching insects, smaller frogs, and small fish for food. In order to live, the frog also needs sunlight, air, soil, minerals, and water. The frog does not live alone. Like every living thing, it depends in some way upon certain other living and nonliving things. The frog is part of a particular **ecosystem**.

An ecosystem is a complicated web of relationships in a particular environment. Each ecosystem has living and nonliving parts. Plants and animals are living parts. Water, air, soil, sunlight, and minerals are nonliving parts. All parts of an ecosystem are connected to each other in many ways. Each is dependent on all others. All parts working together form the whole ecosystem.

Ecosystems that are focused on bodies of water are called aquatic ecosystems. Missouri has several kinds of aquatic ecosystems. Streams and springs contain running or **flowing water.** Ponds, lakes, and wetlands contain **standing water**. Streams can be either rivers or creeks. Rivers are larger than creeks. Lakes are larger than ponds. Springs bring groundwater onto the earth's surface. Wetlands are covered with shallow water at least part of the year. Missouri has two kinds of wetlands, marshes and swamps. Both kinds have plants growing out of their shallow waters. Marshes have cattails or other grass-like plants. Swamps have trees or woody shrubs. Swamps may also have some cattails or other grass-like plants.
Flowing motion, or current, presents living conditions for plants and animals different from those of standing water. Current tends to wash needed nutrients and minerals downstream. However,

current mixes plenty of oxygen into water, allowing plants and animals to survive. Standing water has no current. It is rich in minerals and nutrients compared to flowing water. Plant and animal life is more plentiful. Oxygen in standing water may be scarce in summer and winter. When clouds or snow and ice block the sunlight for many days, aquatic life may die. Plants cannot produce enough oxygen. Each ecosystem supports life differently.

People recognize the value of most aquatic ecosystems. However, wetlands seem useless to some people. Many have been drained for use as farm fields. Others have been filled with soil and used for building sites. Still others have been used for dumping chemicals and trash. We now know that wetlands are very important. They are natural sponges that hold and clean water. They provide places for wildlife and fish to live and reproduce. People need to replace lost wetlands and build new ones.

All aquatic ecosystems are very fragile. When people disturb their balance, all living and nonliving parts are affected. Fish, wildlife, and people cannot live without balances aquatic ecosystems.

Skills Challenge

Write true of false on the blank by each statement about ecosystems.

________ 1. Current is important to animal life because it mixes needed oxygen throughout the water.

________ 2. An ecosystem is a complicated web of relationships.

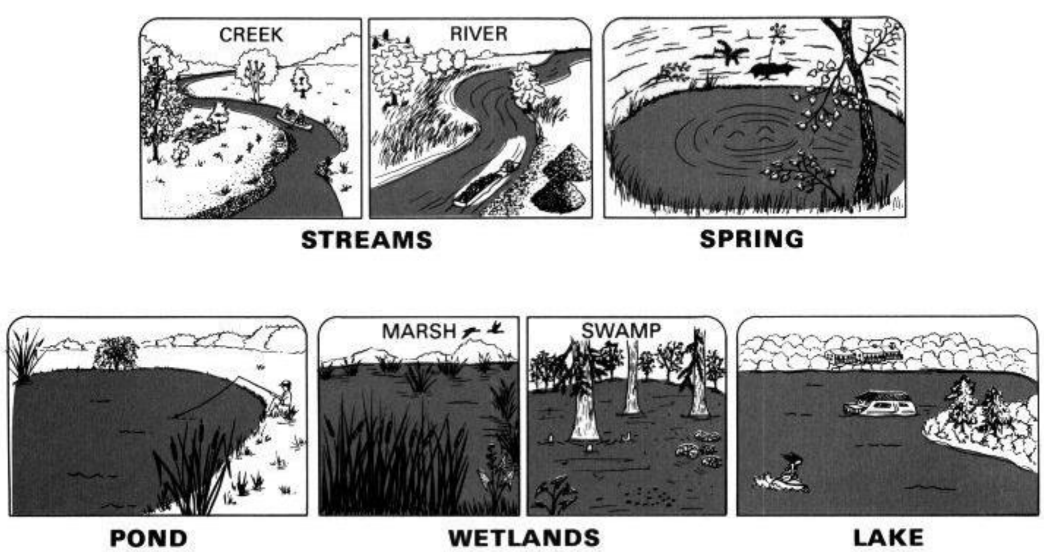
________ 3. An ecosystem has either living or nonliving parts but not both.

________ 4. An ecosystem that focuses on water is called an aquatic ecosystem.

________ 5. Changing one thing in an ecosystem affects many others.

The major ecosystems of Missouri are pictured and labeled below. Fill in the blanks with the ecosystem name that makes each sentence true.

6. __________________ bring underground water onto the Earth's surface.
7. Many __________________ have been filled or drained because some people think they are not important.
8. __________________ are like creeks, only larger.
9. Lost wetlands, like __________________ and __________________, need to be replaced.
10. __________________ are large bodies of standing water often used for boating.
11. Many land owners have built small _________________ to provide for the needs of fish and wildlife.
12. Small bodies of flowing water are called __________________.



How Do Pond Ecosystems Change?

From MDC"Fishing for Answers"
Written: Jeanne Pyland & Bob Fluchel
Illustrated: Ann Grotjan

Main Idea:

- Change is continual in pond ecosystems.

Objectives:

- Define population.
- Recognize stages of pond succession.
- Give examples of pond seasonal changes.
- Identify habitat needs of six aquatic plants or animals.

Key Words:

- ecosystem
- succession
- population
- community
- habitat

How Do Pond Ecosystems Change?

Have you ever returned to a pond you had visited before and found it had changed? Like all **ecosystems**, ponds change. No pond lasts forever. A pond forms, it matures and ages. Finally it is no longer a pond.

A pond can form when people or beavers build a dam in a watershed. Then it begins to gradually disappear. Over a period of many years soil is washed into the pond. Leaves and other plant material accumulate on the bottom. The pond becomes shallower and shallower. It may turn into a small marsh or swamp. Eventually it will become a weed patch and after many more yeas, part of a forest or prairie. A pond is a temporary ecosystem, although it may "live" longer than people live. The gradual change that turns a pond into dry land is called pond **succession**.

Although change is continual in a pond ecosystem, one thing remains the same. No matter what stage of succession a pond is, it provides homes for many **populations** of living things. A group of one kind of plant or animal living in the same ecosystem is called a population. For example, a group of bullfrogs living in a pond is a population. All of the populations of a pond depend on each other in many ways. They make up a pond **community**.

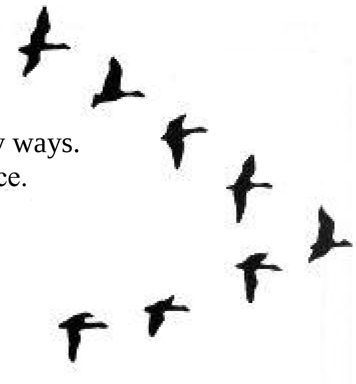
The makeup of a pond community changes from season to season because physical conditions in the environment change. Changes in day length, temperature, and rainfall affect a pond. A pond may dry up in summer or it may freeze to the bottom in winter. These events determine which populations of plants and animals survive and which disappear.

As seasons change, each population reacts in its own way. In winter, frogs and turtles hibernate in the mud on the bottom. Most ducks and geese migrate farther south when ice covers the surface. Many insects lay eggs and die. Fish become inactive in very cold water. When ice forms on the surface, fish move to deep water. When a pond is covered by snow, plants do not get enough light to produce oxygen. If a pond is not at least eight feed deep it many not hold enough oxygen and the fish might die.

During the growing season a pond provides **habitats** for many living things. Habitat includes all the food, water, shelter, and space needed to survive. Each species has its own set of living requirements. These requirements are found in different areas of a pond. Cattails grow only in the shallow water. Duckweed floats on the surface. Catfish dwell near the bottom. Bass and bluegill may be found in shallower waters. Mallard ducks feed in shallow water while geese graze on the bank. Each species lives only where it can, in its own habitat.

Skills Challenge

Circle the correct response.



1. What is the main idea of this chapter?
   A. All of the populations of a pond depend on each other in many ways.
   B. Geese migrate farther south when ice covers the water's surface.
   C. Change is continual in a pond ecosystem.
   D. Each species has its own habitat.

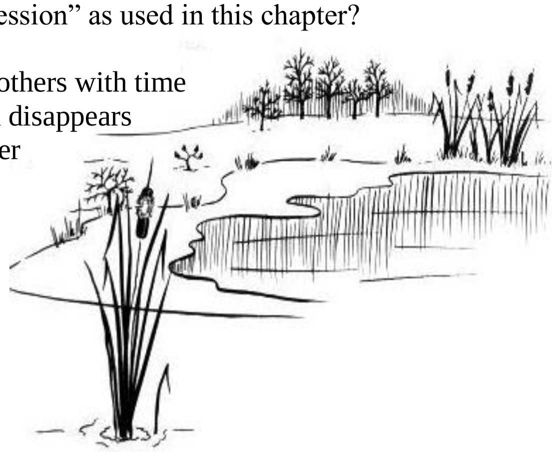
2. Which of the following is a good synonym for "migrate"?
   A. hide
   B. travel
   C. sleep
   D. stay

3. A word in this chapter that means "all of one kind of plant or animal living in the same ecosystem: is
   A. population
   B. succession
   C. physical condition
   D. growing season

4. A word in this chapter that means "to build up" is
   A. react
   B. float
   C. accumulate
   D. mature

5. Which of the following words of phrases does not describe "habitat"?
   A. a set of living conditions
   B. food, water, shelter
   C. an area or space
   D. a job or role
   E. special for each species

6. Which of the following does not define the word "succession" as used in this chapter?
   A. a gradual change with time
   B. the way plant and animal populations replace others with time
   C. the way a pond community matures, ages, and disappears
   D. the way one ecosystem changes to form another
   E. the way season change

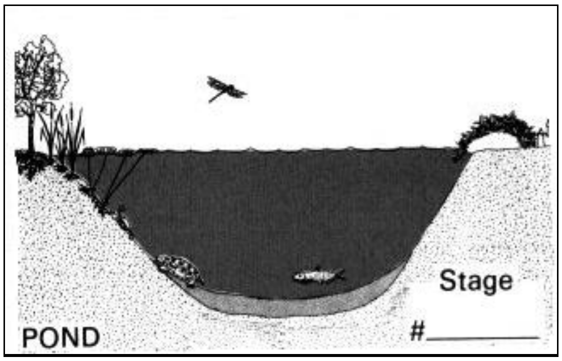


7. An antonym, or opposite, for "gradually" is
   A. quickly
   B. slowly
   C. carefully
   D. simply

A Pond: An Event In Time

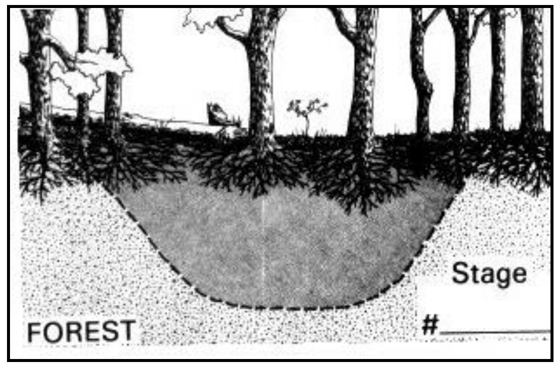
Over many years, a pond Life is only an event in time. The pond slowly changes and dries out. The types of food, shelter, and the amount of water available for animal life change. As this habitat changes, different animals move in and out.

The pictures below show four stages in the life of a pond. Number the stages from 1 to 4 in the order they would occur. Then read the habitat needs of the animals pictured. Select the two animals that would <u>most likely</u> live in each stage of pond succession. Write their names in the blanks below.



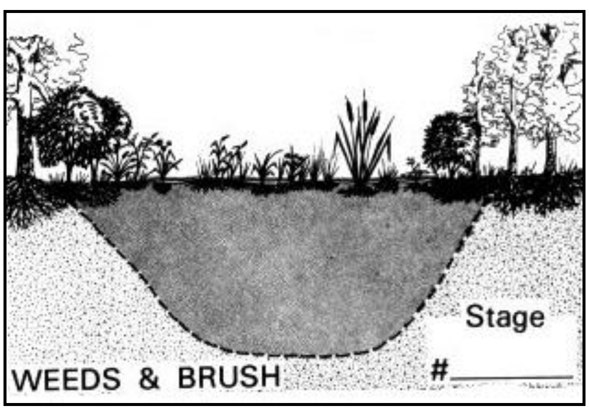
Animals:________________________________

____



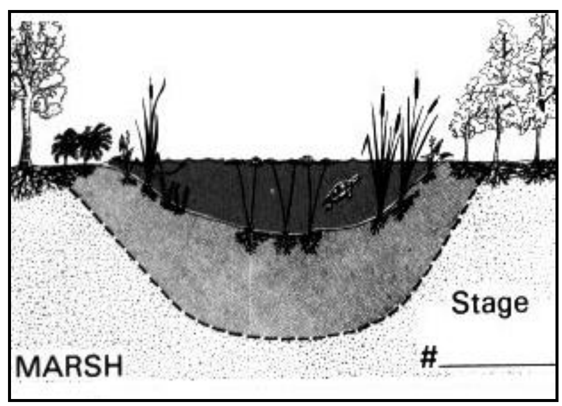
Animals:______________________________

____



Animals: __________________________________

____



Animals:______________________________

____






Animals	Habitat Needs
Beaver	bark, twigs, and buds of young trees, deep water
Rabbit	weeds, grass, seeds, brushy areas
Bullfrog	insects, crayfish, small snakes, shallow water
Bass	fish, crayfish, insects, frogs, deep water
Quail	weed seeds, insects, brushy areas, field edge
Squirrel	acorns, hickory nuts, walnuts, leaf buds, forest
Mallard Duck	seeds, water plants, insects, shallow water

Habitat - Temperature, Oxygen, and Turbidity

Compiled by George J. Babey[1][2]

Objectives

Participating young people and adults will:

1. Observe impacts of non-living factors on fish
2. Recognize the adaptations of local fish species to temperature, oxygen concentration and turbidity
3. Explore factors that cause changes in temperature, dissolved oxygen and turbidity in aquatic systems
4. Have fun while learning

Youth Development Objectives

Participating young people will:

1. Enhance critical thinking and deductive reasoning skills
2. Apply theoretical knowledge to actual situations
3. Form hypotheses
4. Enhance observation skills
5. Work together in teams and discuss observations

Roles for Teen and Junior Leaders

Lead demonstrations or group discussions Assist participants having questions or difficulties with techniques

Set up and take down teaching sites

Best Time: anytime, but this should be considered an intermediate level activity

Best Location: anywhere, table space is preferred

Time Required: 1 hour

Equipment/Materials paper towel paper plate pond water source gallon jars or small aquaria tropical fish food clean water gravel aquatic plants or plastic plants soil goldfish thermometer Secchi disk fish pictures or flash cards

[1] Connecticut Department of Environmental Protection, Fisheries Division, 79 Elm St, Hartford, CT 06106-5127

[2] Adapted from Bob Schmidt, Sport Fishing and Aquatic Resources Handbook

Observe application to fishing techniques

Safety Considerations Pond water may contain either infectious micro-organisms or tiny parasites. Normal hygiene, like washing hands before eating and avoiding ingesting pond water should be encouraged, particularly in areas with *Giardia* or similar organisms. No toxic materials are used in these exercises, but a shop apron may help protect clothing where soil and water are being used. For younger kids, using clear plastic jars rather than glass containers may reduce risk of injury and breakage.

Lesson Outline:

Presentation	Application
I. Why are non-living factors important? A. Basic to angling success 1. Critical to locating fish 2. Important to fish activity 3. Influence on angling strategies	**NOTE** that before catching fish, the angler must know how to find them.
B. Physical elements related to these factors 1. Depth, shape and orientation 2. Gradient and inflows 3. Weather and climate 4. Latitude and elevation	**NOTE** that physical characteristics of the body or water may have strong influences on these factors. **USE** leading questions to help participants **CONCLUDE** that various fish species have differing preferences in the factors being considered.
II. Adaptations of fishes to their environment A. Adapted to specific environments and conditions 1. Turbidity 2. Oxygen concentration 3. Water temperature 4. Factors often interact	**NOTE** that these factors are often interrelated. For example, higher temperatures generally produce lower oxygen concentrations and high turbidity tends to increase water temperature.

B. Turbidity - suspended solids in water

1. Silt or other soil particles
   a. Sources of turbidity from soil
      1) Bank erosion
      2) 2) Construction
      3) Poor farming practices
      4) Poor forestry practices
      5) Floods, ice scouring
   b. Impacts of siltation
      1) Gill damage
      2) Smothering eggs or young
      3) Covering spawning areas
      4) Reducing cover or changing types
      5) Reducing diversity of prey species
      6) Reducing productivity
      7) Reducing feeding success
2. Suspended algae or plankton
   a. Sign of high productivity
      1) Good primary production
      2) Good fish growth
   b. Excessive blooms damaging
      1) Loss of submerged vegetation
      2) Potential for fish kills
         a) Oxygen depletion at night
         b) Oxygen depletion in deep water

C. Oxygen concentrations

1. Source of oxygen in the water
   a. Diffusion from the air
   b. Mixing through surface turbulence
2. Oxygen production by photosynthesis by aquatic plants and phytoplankton
3. Factors reducing oxygen levels

If nearby sites are available, consider using a Secchi disk to **DEMONSTRATE** turbidity.

Have participants **SPECULATE** on sources of suspended soil in lakes or streams, allowing all potential sources. Be careful to **KEEP** human activities in perspective.

Lead youth to **BRAINSTORM** some ways that siltation and suspended soil can damage fish or their habitat.

NOTE that living things causing turbidity may indicate a fertile or eutrophic site with excellent growth and production.

NOTE that both summer fish kills and lack of oxygen in deep waters can result from excessive blooms of plankton.

Lead participants to **DISCUSS** ways that oxygen concentrations in the water can increase. **NOTE** the major sources may differ with the type of water body involved.

POUR water from one container into another. **ASK** participants what they observed. **NOTE** that the bubbles are the result of air being mixed with the water by surface turbulence.

Have participants **OBSERVE** living water plants (like *Elodea*) in bright sunlight. **NOTE** the tiny bubbles on the leaves are primarily oxygen produced during photosynthesis by the plant. **EXTEND** the concept to include oxygen produced by phytoplankton.

Ask participants to **BRAINSTORM** ways that oxygen can be removed from the water. **NOTE** that all living things consume oxygen as they respire. **ASK** how the

a. Respiration of aquatic organisms

b. Increased water temperature

c. Decomposition of organic materials

1) Detritus

2) Decaying animals

3) Sewage or other organic effluent

4. Critical factor in fish survival

D. Water temperature

1. Fish as "cold-blooded" animals

a. Body temperature near ambient

b. Some large species above water temperature

2. Temperature preferences

a. Cold water fishes

b. Cool water fishes

c. Warm water fishes

d. Tropical fishes

3. Impacts on fish distribution

a. Influence on fish distribution

1) Seeking preferred temperatures

2) Vertical movement in deep water

3) Use of cover or shade

b. Influence on oxygen concentrations

1) Temperature and oxygen

2) Turbulence and oxygen

c. Influence on activity and vigor 1) Peak activity and growth near preferred or optimum temperatures

2) Less active somewhat above

process of decomposing organic materials could affect oxygen levels. Lead them to **SPECULATE** on some sources of decomposing organic materials, including detritus, animal remains, sewage or other organic effluents.

Help participants **GENERALIZE** about types of fishes and their oxygen needs and preferences. **USE** their habitats as a cue to their oxygen requirements.

ASK participants whether fishes are "cold-blooded" or "warm-blooded" animals. Although some fishes can maintain a body temperature above that of the water in which they are swimming, fishes are poikilothermic or "cold-blooded" animals.

Have participants **PLACE** pictures of fishes into groups by their temperature preferences. **USE** a table of preferred temperatures as a reference after the fishes have been placed. **NOTE** that each fish species is adapted to a range of temperatures and that it is most efficient at or near its preferred temperature.

ASK participants what would happen if our body temperatures went up to 110°F or down to 80°F. Lead them to **CONCLUDE** that we would die under those conditions. **EXTEND** that notion to fishes, noting that most fishes must live in water that stays within a certain range of temperatures. If desired, **EXPLORE** the distributions of some selected fishes. **NOTE** that, where possible, fishes will seek out areas with water temperatures or oxygen concentrations in their preferred range.

ASK participants how they feel when the weather is very hot and muggy or extremely cold. **NOTE** that fishes tend to be most active and grow best near their preferred temperatures and less so as the temperatures move away from their optima. Some fishes become very inactive when temperatures vary greatly from their

optima, and death may result if the temperatures change too quickly or exceed their tolerance levels. **CONSIDER** using examples specific to your area.
and below preferred temperatures
3) Inactive well above or well below preferred temperatures
4) Death may result at extremes
a) Temperatures beyond tolerance
b) Changes too rapid

III. Influence of living factors
A. Overhead cover and shade
1. Influence on water temperatures
a. Reduced solar radiation
b. Cover reduces heat loss to atmosphere
c. Slower warming and cooling
2. Influence on runoff
a. Retards runoff
b. Increases infiltration into soil
c. Reduces siltation
3. Food source in upland streams
a. Detritus-based communities
b. Land productivity for aquatic animals
1) Food falling into streams
2) Detritus supporting invertebrate life
4. Importance of protecting riparian zones
B. Wetlands
1. Where land and water intermingle
a. Seasonal wetlands
b. Tidal wetlands
c. Permanent wetlands
2. Food production for aquatic systems
a. Rich in nutrients
b. Capture and consume nutrients
c. Rich "soup" for juvenile animals
1) Invertebrates
2) Fishes - spawning and nursery areas

NOTE that overhead cover and streamside or shoreline vegetation shade shallow waters, slowing heat exchange by sunlight. **ASK** if the overhead cover would act as a "blanket" when temperatures fall at night (*yes*).

Lead participants to **SPECULATE** about the role of ground cover and trees in reducing runoff, increasing water storage in the ground and reducing erosion. **NOTE** that all of these factors have a positive influence on aquatic habitats.

If these types of resources are available near you, ask participants to **REFLECT** on the presence of leaves and other dead land plants in the water. **NOTE** that these waters are often dependent upon land inputs to support the web of life in them.

NOTE that wetlands filter, store and clean water on its way into streams, lakes and seas. **EMPHASIZE** that the contribution to water quality, water storage and animal productivity is tremendous by all sorts of wetlands.

NOTE that many fishes and invertebrates use wetlands as either spawning or nursery areas for their young. **CHALLENGE** participants to develop a list of wetland creatures important to the angler directly or indirectly.

DISCUSS the role of salt marshes and shallow bays as rich feeding grounds for many species of fish. **NOTE** that some species are found inshore only seasonally when temperatures and feeding conditions support them.

USE local examples if possible.

Lead participants to **CONCLUDE** that the coastal waters change more quickly than deep waters because of sunlight penetration and absorption of sun energy by the sediments. **USE** local examples of seasonal migration

3. Capture sediments and purify water
4. Hold and gradually release water

IV. Marine environments
A. Salt marshes and shallow bays
1. Nursery areas and rich feeding grounds
2. Warmer than deep waters
3. Primarily "inshore" species

B. Coastal waters
1. Shallower waters
a. Warm and cool more readily
b. Better light penetration
c. Seasonal migrations to preferred temperatures common
2. Richer food supplies
a. Floating or swimming prey
b. Bottom dwelling prey

C. Deep waters
1. More stable conditions
a. Generally cold water
b. Little or no light penetration
c. Large bodies of nearly uniform water
1) Temperature
2) Salinity
3) Density
2. Rich in nutrients
a. Low primary productivity
b. Nutrient "rain" from upper levels
c. "Detritus" based communities

D. Upwellings and currents
1. Bringing deep waters to the surface
2. Highly productive areas
a. Rich in nutrients
b. Cold and oxygen enriched at surface
c. Sunlight for plankton growth

into and out of coastal waters if possible.

ASK why shallower areas may have richer food supplies. **NOTE** that both pelagic (free-swimming) and benthic (bottom dwelling) foods are available in these relatively shallow waters.

LEAD the group in discussing the relative stability of deep waters and the conditions that might be found in them. **CONSIDER** temperature, light, sources of food, sources of oxygen and other factors that the young people may identify.

EMPHASIZE the fact that light is essential for plant and phytoplankton production.

If possible, have participants **IDENTIFY** productive fishing grounds (e.g. the Grand Banks or the waters off Peru and Ecuador) where deep, cold waters are pushed to the surface by the action of currents. **ASK** why these waters are so productive when they reach the surface [*rich in nutrients, exposed to sunlight, and rich in oxygen*].

NOTE that the concentration of salts in the water also influences the types of fishes that may be located there.

E. Hypersaline and brackish waters

1. Salt tolerance differs
2. Fishes seeking water within tolerance range

a. Euryhaline fish - wide tolerance range

b. Stenohaline fish - narrow Tolerance range

V. Conclusions

A. Non-living factors influence fish distribution and abundance

B. Understanding non-living factors aids in fishing success

Summary Activities

1. How muddy is muddy?

Have participants extract water samples from several ponds or streams in your area. Thoroughly mix each sample (e.g. by shaking it). Extract smaller samples (about 1/4 cup) from each one for small groups of young people. Have them pour each sample on an individual white paper plate or bowl. Next have them spread a piece of absorbent paper toweling over the plate to soak up the water. When the toweling is saturated, remove it carefully from the plate. The remnant materials represent the sediment or soil particles that were suspended in the water. Note that some of the sediment may have been picked up on the towel. Encourage the groups to compare their results with the samples and discuss reasons for any differences they may observe within and between samples.

2. Polluting a pond

Consider demonstrating the effects of various pollutants and nutrients on pond water. This can be accomplished by adding fertilizer (nutrient), fish food (nutrient and organic matter), vinegar (acid), hypochlorite bleach (toxic material), salt (toxic material), or similar materials to the water. Have the participants observe the water daily for several days (usually a week is adequate). Encourage them to record their observations carefully, noting smell, water clarity, growth of algae or plankton, and any other factors they feel are important. Encourage them to compare their findings and to analyze the reasons for their observations. What would happen to other living things, like fish under the conditions tested?

3. Temperature effects on oxygen concentration

Provide participants with two clear jars. Fill each jar nearly to the top with non-chlorinated water.

Place one jar in the sun or otherwise heat it until its temperature has risen approximately 5°F. Maintain the other jar of water at room temperature. Place a goldfish in the room temperature jar and observe the goldfish. Count the number of times it opens and closes it operculum (gill cover) in 30 seconds, recording that number once a minute until you have at least five observations. Net the goldfish and place it in the jar of warmer water. Allow two minutes for it to settle down, and repeat the counting process. If the goldfish shows signs of distress (losing its orientation, turning belly up) stop the experiment and remove the fish to fresh water. If it gulps air from the surface of the water, record that as well. In which jar was the rate higher? What may have caused the observed difference? Which body of water had a higher oxygen concentration? Could there be any other explanations for the observed differences? [Increased metabolism could be a factor. This could be checked by observing the actions of the fish or by running the experiment until the fish began to gulp air.]

4. Turbulence effects on oxygen concentration

Provide the participants with three clear jars. Fill two of the jars nearly to the top, keeping both jars at room temperature. Place a goldfish in one of the jars. Wait for it to settle down (one or two minutes should be adequate) and observe the rate of its respiratory movements until at least five readings have been taken. Just prior to moving the fish to another jar, pour the water back and forth between the other two jars or shake one of the jars vigorously. Move the fish to the jar with the shaken water, and repeat the process. Did the turbulence cause an increase in oxygen concentration? How could you tell?

5. How Silt Destroys Water Quality

Build a small aquarium in a jar, with gravel and plants. Add some stones or other larger material if you wish. Place a small amount of soil in a small jar of water, shake thoroughly, and pour the muddy water into the aquarium. Allow the soil to settle, recording the conditions periodically. Repeat the process several times, noting the changes in the aquarium. Discuss the impact of sedimentation on the substrate and the plants in the aquarium. How would those changes affect animals adapted to living in the gravel or rocks? How would the sediment impact fishes that used gravel as a spawning bed? What are some things you can do to reduce the amount of sediment going into water courses in your area?

Lesson Narrative Introduction

To catch fish an angler must first locate them. Non-living factors are important, because fish orient to them, they influence fish activity, and they have an impact on the type of fishing strategy or techniques that will be effective. Factors like temperature, oxygen concentration, and turbidity can influence the types of fish present, their activity and their location in the water. Each fish species is adapted to an array of conditions. When those conditions are ideal, they thrive. When they are marginal, the fish may survive, but show poor growth or vigor. When they are beyond the range that the fish can tolerate, it must move or die.

Many physical elements are related to these critical non-living factors. The depth, shape, orientation and gradient in a body of water can influence all of these factors. The amount and timing of inflows and the nature of the watersheds is also influential. Both climate and weather have a strong influence on the fish species and populations present. Lakes with 80°F water may hold warm water fishes like largemouth bass, but species like brook trout cannot survive temperatures that high. They are more comfortable in 60°F mountain springs where a largemouth would be hard pressed to survive. Latitude and elevation, with their influence on local climate and weather, also contribute to these physical factors.

Turbidity

Turbidity is a measure of suspended solids in the water, usually measured by the amount of light penetration. A major factor contributing to turbidity is the amount of silt or other soil particles suspended in the water. Water borne soil can come from back erosion, activities that disturb the bottom sediments (like currents, winds or tides), construction activities, poor farming or forestry practices, surface mining, floods, ice scouring or similar actions.

The impacts of sediments are many. While suspended in the water, soil particles can clog or damage gill membranes in fish or other animals or reduce feeding success by sight-hunting predators. As the sediment drops out of suspension, it can smother eggs or young animals, bury spawning sites, eliminate cover (like rocks or rubble), bury aquatic vegetation, kill or eliminate habitat for prey species, cloud the water enough to reduce productivity by algae and plankton, or cover detritus with a layer of soil, making it unavailable as forage for detritivores. The result is a reduction in diversity of species present.

Another source of turbidity may be found in ponds or lakes. Suspended algae or plankton may cloud the water. This turbidity may be taken as a sign of high productivity or a eutrophic condition. Generally rich aquatic environments are somewhat turbid, while those with lower levels of productivity are clear. These more productive waters may show higher growth rates for fishes that can tolerate the conditions. Excessive blooms can be damaging, however. They can result in the loss of submerged vegetation by simply starving them for light. Fish kills are possible as deeper waters are deprived of oxygen or oxygen tensions drop during the night. Reduced oxygen levels in deeper waters of large lakes can result in the loss of species that require the deep waters for survival during hot weather.

Oxygen Concentration

Oxygen is just as important to fish and other aquatic organisms as it is to land animals and plants. Since oxygen is not very soluble in water, the amount in water under the best of conditions is much less than that found tin the air. Without adequate oxygen supplies, fish cannot survive. Further, some fishes require highly oxygenated water, while others can survive in water with very low oxygen tensions. Carp require much less oxygen for survival than do trout or salmon. On the other hand, they do require some dissolved oxygen; while some other fishes can survive by gulping air from the surface and using their air bladder or a labyrinth organ as a simple lung.

Oxygen in the water comes from many sources. Much of the dissolved oxygen simply diffuses into the water from the surface. Much more of it enters the water as a result of turbulence. Wind mixing, wave action, turbulent flow over rapids or waterfalls tends to oxygenate the water. At times, particularly around waterfalls, the water can become super-saturated with oxygen (and other gases). Still more oxygen enters the water as the result of photosynthesis by aquatic plants, algae and phytoplankton. As the plant splits water molecules to produce simple sugars, oxygen is released as a by-product. Oxygen is much more soluble in cold water than it is in warm water, so oxygen concentrations in cold water are usually much higher than they are in warm water under similar conditions.

Many other factors reduce the amount of oxygen in the water. All living things respire, consuming oxygen as they use energy to survive. As metabolic rates rise with temperature (within limits), the rate of oxygen consumption increases. Decaying plants or animals use oxygen from the water as they go through physical decomposition; and decomposers use oxygen, too. Many kinds of pollutants reduce oxygen supplies in the water as well. Some chemicals trap oxygen or consume it as they react. Others may result in consumption of oxygen as they are broken down by bacteria or other decomposers. Sewage contains nutrients that serve as fertilizers. They cause algae blooms that can cause severe oxygen depletion when the plants die and begin to decompose. Under those conditions, fish kills can take place. Often these are summer fish kills. Thermal pollution, the addition of excess heat to the water through industrial use, also reduces the amount of oxygen water can hold.

Oxygen levels are not necessarily the same throughout a body of water. Water below the thermocline may become oxygen depleted if excessive "rain" of dead plants and animals takes place. Wind mixing near the surface may result in high oxygen levels, at least temporarily. Fish will seek out areas with adequate oxygen for their needs, perhaps moving long distances to find suitable conditions.

Water Temperature

Although some large fishes maintain a body temperature higher than that of the surrounding water, fish are considered poikilothermic or "cold-blooded" animals -- animals whose body temperature approximates the temperature around them. Large sharks, tuna or similar species may produce enough heat by muscle contractions to keep their temperature a few degrees above the water, but they are the exception. Most fishes are small enough that their temperature and that of the water are very close.

Most fishes are adapted to a range of body temperatures. The enzymes that govern biochemical reactions work most efficiently at or near those temperatures, and their actions are greatly reduces if the temperatures are either lowered or raised appreciably from that optimum. Thus at temperatures well above or below the optimum, the bodily functions of the fish may become sluggish or the fish may die. Humans have a temperature that varies around an average of about 98.6EF, but individual humans may have temperatures slightly higher or lower than that average. Conditions may result in the temperature rising slightly or dropping slightly without serious implications. Severe changes, say on the order of 10-15ºF can result in death as the enzymes become denatured or fail to function adequately to maintain life. Fish experience the same situation, but often are tolerant of wider variations in temperature.

In general, fishes may be divided into several groups based upon their temperature preferences. Cold water fishes, like trout, whitefish and grayling, are adapted to relatively cold waters. These fishes can tolerate very cold water, but they cannot adapt to water much over 70°F. They prefer water temperatures well below their lethal upper limits. Cool water fish (e.g. pickerel, northern pike, yellow perch, walleye) are most active at moderate temperatures, but they can tolerate higher upper limits than can cold water fishes. Warm water fishes (e.g. bluegill, largemouth bass) are adapted to withstand higher water temperatures, growing and reproducing better as temperatures increase. Tropical fishes may thrive at still higher temperatures. Some are even adapted to very low oxygen tensions, being able to gulp air at the surface to supply their oxygen needs.

Clearly, the temperature preferences and adaptations of each fish species can have an influence on their geographic distribution. It also has a strong influence on their distribution in a body of water where variation in water temperature or related factors (like oxygen levels) are possible. For example, consider a deep lake with a mixed fish population. If the surface waters were about 80°F, one might expect to find bass and bluegills or other sunfishes in the warmer shallow waters. Yellow perch might be slightly deeper. Cold water fishes like lake trout would be found in the deeper waters in or below the thermocline, layers of water where temperatures change very quickly with depth. If the thermocline is down 20 feet on one side of the lake and 65 feet on the opposite shore (usually because of a seiche or other currents), an angler seeking these cold water fish would need to adjust his or her techniques to the depth at which the fish were locating their preferred temperatures. For pelagic fishes, leaving areas of preferred temperature to pursue prey species with slightly different preferences is common. Sometimes fish even can be found in areas where their temperature tolerances are exceeded if other conditions, like high oxygen levels mitigate (make better) the effects of the high temperature.

Some fishes have narrow ranges of temperature tolerance or preference. Others are very adaptable to temperature changes. Most fishes, however, must make those changes gradually. [Remember, water has a high specific heat and generally changes temperature quite slowly.] Thermal shock can take place when water temperatures change too rapidly to allow the fish to adjust. In some areas,
e.g. the Laguna Madre of Texas, major fish kills can take place when warm water adapted fishes are caught in very shallow water during winter freezes. Wind and shallow water combine to change water temperatures so quickly that the fish are shocked or killed. The same thing can happen if water warms too rapidly for cold adapted fishes.

The angler who understands the temperature preferences of fishes and the temperature structure of the body of water being fished will usually be able to locate fish successfully. He or she will also know how to keep baitfish from dying because of thermal shock.

Water Quality

Water quality is a complex set of parameters. Water chemistry, oxygen and other dissolved gases, and temperature all interact. If the water quality is good, more species of fish and larger populations of fish can be supported than if the water quality is poor. High quality water will have a high concentration of oxygen. It will have a pH (a measure of acidity -- technically the negative log of the hydrogen ion concentration) close to the neutral range -- slightly acid to slightly basic. It will be relatively free form suspended solids, except for algae and plankton; and it will be moderate in temperature during the hottest part of the year. Low quality water may be low in oxygen or even anoxic (no oxygen). It may be highly acidic or highly basic, creating conditions in which fish cannot survive, or it may contain high sediment loads or heavy concentrations of pollutants.
Thermal pollution may reduce of the quality of other waters. Some apparently beautiful lakes are completely devoid of fish because the water quality is inadequate for nearly all aquatic life. Some productive lakes or ponds are devoid of fish live because water quality drops below

tolerance levels at some time of the year. In many others, the array and abundance of fishes is limited by water quality considerations.

The impacts of water quality on fishes differs with the species and its tolerance. Some fish can live in extremely low quality water. Carp and gar, for example, can survive in water that is very warm, low in oxygen, and high in turbidity. Trout cannot. They require relatively clean, cold water with high levels of oxygen. In general, fish are more active, consume more oxygen and feed more often when the waters are at or near optimum levels of water quality.

The foraging habits of fishes differ and may result in differences in their reactions to water quality changes. Pelagic species, those that roam the entire water column or "free-swimmers", may move to areas of higher quality if local changes take place. Species like white bass, ciscoes, salmon, tuna, bluefish or dolphin are examples of fishes of this type. Benthic fishes, those that live on or near the bottom and forage their for prey, may find conditions so unfavorable that they are forced to abandon their preferred habitat. Some years back, the deeper levels of Lake Erie's Eastern Basin were nearly devoid of fish in the summer because of low oxygen levels. Eliminating phosphates from detergents and reducing the organic wastes added to the lake have restored this fishery.

One must understand that water quality must be within the tolerance limits of the fishes at all times. Even a brief pulse of intolerable water conditions can completely eliminate fish populations. Some lakes, ponds and streams in some regions of the continent are devoid of fish life, even though their waters are within tolerance limits for all but a few weeks of the year. Pulses of acidified rain or snowmelt cause tolerance levels to be exceeded for those short periods. If conditions are sufficiently stressful to kill fish during that period, those bodies of water are devoid of life for the entire year.

Influence of Living Factors Riparian Zones

Living things also contribute to these water quality measures. Overhead cover or shade reduces solar radiation striking the water during the day and reduces heat loss to the atmosphere at night. This combination of effects dampens changes in water temperature. In addition, vegetation has a strong influence on runoff, softening the impact of rain on the soil, increasing infiltration, and spreading runoff over a longer period of time. This reduces sediment loads.

Riparian (along water courses) vegetation also provides a food source for aquatic systems. Insects and other prey living on the land often fall into the water, providing food for fish or other aquatic organisms. Detritus (decaying organic materials, like leaves and twigs) forms the base of the food web in many streams. Decomposers feeding on the detritus provide food for first order predators and eventually support the fishes in those streams.

Maintaining healthy riparian zones is important both to water quality and to productivity of streams and rivers. These buffer strips between the land and the water are extremely valuable to many plants and animals, not only in the drier parts of the country, but throughout the continent.

Wetlands

Wetlands also provide vital service in maintaining water quality and productivity. These areas where land and water overlap come in many forms. Some are tidal, being dry or inundated as tides ebb and flow. Some are seasonal, storing water only during the wetter portions of the year and releasing it into the ground or watercourses during drier periods. Still others are permanent B bogs, fens, marshes and swamps that remain wet nearly all the time. Although the conditions in bogs and fens may be too acidic to be highly productive, swamps and marshes are extremely productive. Rich in nutrients and detritus, they feature a nutrient "soup" that nourishes many invertebrates and juvenile fishes. Often they serve as vital spawning and nursery areas for both sport and commercial species. They also capture nutrients and sediments, slowly releasing higher quality water to the watercourses they feed.

Marine Environments Salt Marshes and Shallow Bays

Like other marshes, salt marshes are profoundly productive nursery areas and feeding grounds for some kinds of fishes. Shallow bays, particularly those with patches of vegetation, are similarly valuable nursery and feeding grounds. Usually quicker to warm and cool than deeper waters, these shallow areas are rich in invertebrates and other prey species, making them very attractive to predatory fishes and plankton feeders as well. While many larval or juvenile fishes of pelagic species may be found in these habitats, many of the fishes found in these environments are "inshore" species that occupy these warm, rich waters seasonally.

Coastal Waters

Coastal waters, those areas near shore, are seldom as clear as the open ocean. Relatively shallow water permits wave action to stir up lots of sediment. The structure of the bottom will determine how mobile and persistent these sediments are. Like shallow bays, coastal waters tend to warm and cool more quickly than the open ocean. When the water is clear, light is able to penetrate to the bottom. This permits plants to grow at greater depths, providing an oxygen source, a foundation for aquatic food chains and some cover for marine life. Seasonal migrations timed to preferred water temperatures and movements of forage species are common. These waters share the salinity of the open ocean for the most part, and they provide both bottom and mid-water prey species and an assortment of predators adapted to those foraging areas. In general, the variety of life forms is greater in coastal waters than that found in the colder waters of the open oceans.

Deep Waters

The deep waters of the oceans provide stable conditions for the fishes living there. The deeper layers of water are generally cool to cold, but within the major bodies of ocean water the conditions are somewhat uniform with respect to temperature, salinity, and density. Little or no light penetrates to the bottom, but the overlying layers of water produce a relatively constant "rain" of organic material which supports a diverse array of animal life from scavengers to predators adapted to swallow prey nearly the size of the predator itself.

The nutrient "rain" into the deeper waters of oceans generates a nutrient-rich, cold body of water that can support abundant life when currents and upwellings bring the water to shallower levels.

Areas like the Stillwagon Banks or the Grand Banks owe their phenomenal fishing (at least historically) to this phenomenon. Similar situations occur in deep lakes. These conditions are often the result of currents encountering geologic formations or areas having different densities.

Hypersaline and Brackish Waters

Where saltwater and freshwater meet, gradients in salt concentration can be found. When salt concentration is too high to call the water fresh but less than that of open oceans, the water is brackish B a mixture of salt and fresh. These conditions are ideal for many types of coastal fishes and invertebrates. Organisms that can tolerate a wide range of salt concentrations are known as euryhaline organisms. Those that are able to tolerate only a narrow range of salt concentrations are known as stenohaline organisms. Some fishes, like salmon, eels or striped bass, are able to tolerate a complete range of salt concentrations from salt to fresh (and possibly back again). Others are restricted to a relatively narrow range of salt concentrations. Pupfishes, for example, are able to survive in the Red River between Oklahoma and Texas because the water is salty enough to prevent some predatory freshwater fishes from thriving in their habitat. As with other factors, fish tend to seek salt concentrations that are within their tolerance range.

Conclusions - Seasons and Movement

Non-living factors have a profound effect on the distribution and abundance of both fish and the foods that nourish them. Understanding those non-living factors can be critical in fishing success. Fish react to the changing water conditions -- temperature, oxygen concentration, turbidity, salt concentration, and more. Some of those changes are seasonal. Water temperature impacts fish metabolism as well as the availability of oxygen. If the near-surface waters become cold enough, fish will go to deeper water to seek refuge in the cold, but nearly constant temperatures found there. They may move either vertically or long distances to locate temperatures and other conditions that are optimal for them. Bluefish found in Florida during the winter, for example, may be found feeding along the Maine coast during the summer, heading back southward larger and heavier. Winter flounders may disappear in late spring as summer flounders move inshore to feed during the summer. Tuna found off Mexico in the winter may be off the coast of Canada during the summer. These seasonal patterns are part of the interaction between the fishes and their physical environment.

Anglers who use this type of information and the patterns that it shows become better anglers. Spending some time learning the physical preferences and tolerance limits of the fish being sought is worth the investment if one wishes to be a successful angler or student of the fish.

Exhibit or Sharing Suggestions

1. Prepare an exhibit based on one of the summary activities, showing the results of the experiments. Interpret the results using posters, other physical objects and discussion at an appropriate event or activity.

2. Prepare an exhibit, demonstration, or illustrated talk about non-living factors and their influence on fishes. Discuss the impacts of changes in the factor chosen from either a fishery science or angling point of view.

3. Study the habitat preferentia of a selected fish in your area. Present your findings to your 4-H Sportfishing group or to another interested group of people.

4. Study a local watercourse over the seasons, recording your observations and taking photographs to document your studies. Determine any sources of pollution, siltation or other factors that could be detrimental to fish in it. Present recommendations to your club or to another group on means of reducing the impact of those factors on the body of water.

Community Service and "Giving Back" Activities

1. Help install silt fencing or hay bales at local construction sites where erosion could carry soil into water courses.

2. Obtain permission to stencil storm drains with signs helping people know where anything that gets into the storm runoff will end up, e.g. “Caution drains directly into Long Island Sound” or “Please be Careful - Gulf of Mexico Watershed”

3. Choose a site to stabilize a stream bank by planting willows or similar action. Be sure to consult your local Extension office, conservation officer or fisheries biologist for assistance, technical advice and any required permits.

4. Prepare a photo story or presentation that can be shared with others concerning water quality issues in the local area. Share that story with your peers, adults, service organizations or conservation groups.

5. Join a wetlands development or enhancement group or join a water watchers organization. See what you can do in cooperation with your state conservation agency or other agencies in monitoring water quality.

6. Exercise personal environmental responsibility by:
   a. Re-seeding bare spots in your lawn
   b. Mulching flower or vegetable beds
   c. Being careful about damaging stream banks with bikes, motor vehicles or foot traffic
   d. Avoiding damage to streamside vegetation

Extensions or Ways of Learning More

1. Talk to a civil engineer or environmental engineer about erosion control practices on construction sites or about construction of water control devices.

2. Visit a waste water plant or sewage treatment plant to see how the wastes are handled and about the quality of water released to streams or lakes.

3. Visit a power plant and see how waste heat is handled. Ask about impacts on water quality and the measures taken to reduce impacts on fish and other aquatic life.

4. Visit a fisheries biologist and discuss some of the challenges to fish management in waters of interest to you. Ask what you could do to improve conditions for fish.

5. Visit local mills, processing plants or other industries to see how water is handled and what is done to treat the water before it is released.

6. Study an issue that interests you. Spend time in the library and in the field if possible. Consult knowledgeable people and develop a "white paper" on the topic or issue. Share what you have learned in a suitable group.

Homemade Sampling Gear: Making a Secchi Disk

The secchi disk depth is influenced by the amount of suspended plankton and other non-living particles (dirt, small pieces of organic material) in the water. Young game fish depend on plankton as food sources. Many species of baitfish feed on plankton.

Fish that depend upon vision to capture their food may be replaced by bullhead and other fish that feed by touch and odor if waters are constantly turbid from siltation. Turbidity caused by excess algae may indicate that oxygen levels are depleted. In this type of water, only fish that survive in low-oxygen environments, such as carp and member of the catfish family, may be present.

Biologists also use the secchi disk on ponds, lakes and slow moving rivers to determine the productivity of a given water. Unproductive waters have little turbidity, so the secchi disk can be lowered very deep (30 or more feet). Productive waters can have secchi disk depths of a few feet to a few inches.

Recently, observations have been made about the impacts of zebra and quagga mussels on algae-related turbidity. In zebra mussel-infested waters, the clarity of the water has improved dramatically due to the capacity of these organisms to filter huge amounts of water. This reduction if plankton can lead to game fish population crashes.

Building and Using a Secchi Disk:
A secchi disk is used to measure turbidity. By lowering the secchi disk until the black and white pattern is no longer visible, and noting the depth, a relative measure of turbidity may be obtained. Use the secchi disk to compare the productivity/ turbidity of a number of different lakes or ponds. It may also be interesting to measure the productivity/ turbidity of a lake or pond during different times of the year.

Materials Needed:
1. Wood (plywood works best) or 1/4" plastic disk, 6 to 8 inches (15-20 cm) diameter (the top of a large juice can or metal pie plate will work)
2. Hand drill
3. Black and white paint--exterior grade, flat
4. 20-50' piece of parachute cord or other nylon rope
5. Large metal washers (several ounces for each disk)
6. Eye bolt, three nuts and washer for each disk.
7. Stick or wooden dowel, about 1 foot (30 Cm) long
8. Two waterproof markers, different colors

Building the Secchi Disk:
1. Paint entire disk with white paint. If using wood, be sure to cover all exposed surfaces and edges.
2. Drill a hole large enough for the eyebolt to pass through in the center of the wood or plastic

disk. Thread one nut on eyebolt, followed by washer. Put eyebolt into disk and place washer and nut on bottom. Tighten. (Sequence should be eyebolt, nut, washer, disk, and washer nut. Washers used for weight threaded on bottom of eyebolt, held on with remaining nut.)
3. Divide the disk into quarters and paint alternating sections black and white.
4. Tie rope to eyebolt.
5. Tie the free end of the rope to the stick or wooden dowel.
6. Use the marker to mark off distances on the rope every 6 inches (or every 10 cm if metric). For example, mark every 1-foot interval (or 1 mete) with a red mark and every 6-inch (10 cm) interval with a blue mark.

Using the Secchi Disk:
1. Hold onto the stick and rope, and lower the secchi disk into the water until you can no longer see the painted surface.
2. Using the marks on the rope, determine how deep the secchi disk is when you lose sight of the black and white pattern, or the depth at which it reappears as you bring it back up.
3. This depth is your measure of turbidity. Use the same method each time you measure your turbidity. Is there any relationship between fish caught and turbidity? Does turbidity affect the color of the lure you use?
4. In this water, light travels to depths of twice the secchi disk depth. Below this depth little light penetrates.

Homemade Sampling Gear: Building and Using a Weighted Thermometer

You can measure water temperature easily in shallow water or at the surface using a weather thermometer tied to a string. However, water temperature in deeper water generally differs from that of surface water. Measure the temperature of deep water and compare it to the temperature of shallower water. To take water temperature in deeper water, you will need to make a weighted thermometer.

Materials Needed:
1. Empty soda can
2. Sand or pebbles
3. Short piece of wire or string - 10 inches (25 cm) long
4. Laboratory thermometer housed in clear plastic sleeve with an open loop at one end (must be able to read temperatures as low as 32 F (0 C). To avoid possible water contamination, do not use a mercury thermometer - instead, use a thermometer filled with red liquid. Thermometers are available for under $3 from NASCO, item #SB-19157 (800-558-9595).
5. Can opener
6. Long piece of sturdy string (depending on depth at which you plan to sample)
7. Waterproof markers, 2 different colors
8. Tape measure or yardstick

Building the Weighted Thermometer:
1. Put about one inch of sand or pebbles into the empty soda can so it will sink when submerged.
2. Make a small hole on the side of the can near the drinking hole where the can was originally opened.
3. Cut the bottom off the plastic thermometer sleeve to expose the bulb to the water.
4. Pass the short piece of string or wire through the loop of the thermometer and the plastic housing.
5. Place the thermometer in the can and tie or wire it securely to the can by passing the short piece of string or wire through the holes in the can, and through the thermometer housing.
6. Make three sets of small holes, equally spaced, around the top of the can with the can opener. This will allow you to create a tripod-like support to keep the can upright and balanced as it is lowered into the water.
7. Tie the long string securely to the can through the holes. Starting at the can, mark off the long string every foot and half foot with waterproof markers. For example, use red for the 1-foot intervals and blue for the half-foot intervals. This will help you to determine the depth at which the temperature is taken.

Using the Weighted Thermometer:
1. Lower the weighted thermometer into the water and let it remain there for five minutes, at the depth, which you wish to measure.
2. While waiting to bring the weighted thermometer out of the water, one of the club members can record the depth the temperature is being taken.
3. Bring the can to the surface quickly and read the thermometer. Make sure that the tip of the

thermometer has been in the water in the can when you measure the temperature.
4. Record the temperature of the water.
5. Take the water temperature at several different depths and locations around the body of water you are measuring and record the temperatures.
6. Take the water temperature in the same locations and depths, at different times of the day. Note any changes.
7. Keep a record of water temperature data for comparison purposes throughout the year. How does the temperature change? How does this affect the fishing?
8. A great project or demonstration for 4-H might be to compile temperature data at certain depths over a period of a year. Make graphs of the temperature at each depth. Plot the depths at which fish were caught. Can you draw any conclusions about the fish's temperature preferences?

Aquatic Adventures

Objectives
Participating young people and adults will:
1. Discuss the difference between the living and non-living components and how the two interact
2. Identify several aquatic plants, insects and animals
3. Piece together a simple food chain using the organisms they collected.

Youth Development Objectives
Participating young people will:
1. Gather and analyze information
2. Develop comfort and confidence when around water habitats
3. 3. Develop self confidence
4. Enhance enjoyment of fishing and outdoor recreation.

Roles for Teen and Junior Leaders
1. Assist with scouting out locations.
2. Safety monitors
3. Assist with identification of critters.

Potential Parental Involvement
1. See Roles for Teen and Junior Leaders above.
2. Conduct similar activities with the family.
3. Review field guides other books about critters.
4. Encourage >learn to swim= activities and other activities which increase comfort and confidence and safety around water

Best Time: anytime, although this activity can provide a great starting point for further study. This activity can also serve as a great finale to other related activities. Anytime the fishing is slow! Go Fish is a great introductory activity

Best Location: small stream, shallow
pond or lakeshore, beach

Time Required: 1 hour or more

Equipment/Materials Materials Sampling equipment (including any of the following: dip nets, minnow seine, window screen bug net, sieves, small shovels, bare hands, insect nets--see directions for making these in Critter Collector handout Magnifying lens, glasses or microscope.

Containers such as white trays, pans, small jars, to place critters collected. Identification aids such as *Golden Guide to Pond Life*, local, state or regional guides to fish and other aquatic life.
Tweezers, eye dropper (to pick up small critters), Thermometer
Waders, hip-boots, rubber boots, or "creek tennies" for each student in the water
OPTIONAL: pH and dissolved oxygen test kits

Evaluation Activities/Suggestions
1. Ask youth to sort organisms collected
2. Ask youth to use field guides to identify organisms
3. Use pictures or drawings as flash cards to test identification skills
4. Youth draw pictures of critters collected.
5. Youth draw food chain or web.
6. Prepare a habitat map of site, noting locations of critters, and physical habitat (bottom, flow etc)

Safety Considerations Anytime youth are in or near the water appropriate safety precautions must be made. Pick a location with a firm bottom and is easily accessible. The shallow end of pond, small creek or stream are ideal.. Visit the site prior to the session. Make sure participants know how to dress, i.e. old shoes, shorts, hip boots. All participants should wear shoes or boots. Throw bags and other lifesaving devices are also recommended. Extra caution must be used when collecting in cold water (less than 70 degrees. Youth should get out and take breaks. Blankets and dry clothes are also recommended.

Lesson Outline:

Presentation	**Application**
I. Community a. Non living 1. water (a) temperature 2. rocks, bottom 3. chemical (a) dissolved oxygen (b) pH b. Living 1. Fish 2. Insects 3. Other invertebrates	Take participants to site and **REVIEW** concepts of community, habitat, food chains and webs, living vs. nonliving. **TELL** them the ground rules, set time limits, and identify hazards. Should **DEMONSTRATE** use of sampling gear. Also **TELL** them to bring back anything they collect. Ask youth to **OBSERVE** the site & its features. **BRAINSTORM** the places where they would expect to find critters. **BRAINSTORM** list of critters they **PREDICT** will be found. Youth should **RECORD** information (names, drawings, sketches) about the critters they **COLLECT** or **OBSERVE.** Allow youth to sample site. If test kits are used, group can be divided between collection of non-living data and living data. Youth can **IDENTIFY** their catch either: (1) as they collect, (2) wait till the end to identify everything, or (3) a combination of (1) and (2).

After specified time call everyone back and collect sampling gear.

REVIEW the concepts discussed earlier such as living vs. non-living and have them relate their observations. Use this time to **DISCUSS** what was collected, **IDENTIFYING** as best they/you can (if you have no idea, use terms like six-legger).

Ask them to **ANALYZE** the information they have gathered and **DESCRIBE** a simple food chain using the critters collected. If you did any water sampling, discuss those results at this time.

Summary Activity

1. Using data collected earlier or a recapping of the experience, describe a simple food chain using critters collected.
2. Draw map of site, noting locations of types of critters collected, notable aspects (trees, stumps etc.).

Exhibit or Sharing Suggestions

1. Build collections of critters collected
2. Build model or draw diagram of the site with critters illustrated
3. Write a story about a typical day at this location, the interactions etc.

Community Service and Giving Back Activities

1. Work with local or state resource agencies to adopt a particular waterway. This may include litter pickup, water quality monitoring, in-steam habitat improvement, streambank plantings etc.

2. Share the data they collect, observations etc. with local newspaper.

Extensions or Ways of Learning More

1. Record your efforts and compare them with future outings to the same location. Compare/contrast any differences.

2. Repeat this adventure in a different body of water and compare and contrast these results. The works best when the differences are great. e.g. saltwater compared fresh, pond compared to stream.

3. Contact local office of state fish and wildlife agency. Invite a biologist to visit and discuss how similar techniques are used in doing their job.

Links to Other Programs People and Fish:

1. Use *Know Your Code* activity to formulate a code of conduct for conducting creek stomps
2. Use *Take Home a Limit of Litter* activity to conduct clean-up of site and determine who left trash

Fishing Skills

1. Match lures and flies to critters collected
2. Create site maps & Identify potential hot spots

Tackle Crafting

1. Use critters collected as models to tie flies or build lures.

SMART Angler's Notebook

by Rich Wood

Dobsonfly

Many people do not know what an adult dobsonfly looks like. However, many of those same people could easily identify the immature (larval) stage. It's called a hellgrammite. Dobsonflies belong to the order of insects called Megaloptera.

The fierce-looking, winged dobsonfly has a life cycle that lasts two to five years. They have complete metamorphosis. This is sometimes referred to as ELPA: Egg, Larva, Pupa, Adult. The larval stage, nicknamed a "hellgrammite," is the most familiar. These active critters are well-known by anglers and people who study aquatic life. Hellgrammites play an important role in the food chain. They are major underwater predators and are eaten by many species of fish. Dobsonflies are usually nocturnal.

Larvae

Hellgrammites are usually found in cool rivers and streams. They may also occur in lakes and ponds. They require good water quality with high amounts of dissolved oxygen. They live on the bottom and with strong legs cling to rocks and sticks. They can also swim easily forward or backward by wiggling their entire body. They may grow up to 5 inches in length. They have a strong set of mandibles (mouth parts) that can catch, hold and eat many aquatic insects and even small fish. These "pinchers" can grab anything that comes close to them, including unsuspecting fingers! Larvae breathe oxygen from the water through well-developed tufted gills on the abdomen. They may also live out of the water by using spiracles (breathing tubes) on the abdomen to breathe air. The larval stage may last one to three years.

Emergence

The larvae crawl out of the water and carefully choose a location. This site may be up to 50 feet from the water. Hellgrammites dig underground a few centimeters or may burrow under dead leaves, a rotten log or old tree stump. Here they change from larvae into pupae. The pupal stage may last from one to 14 days. Most dobsonflies in Pennsylvania emerge in spring and summer.

Adults

Adult dobsonflies live only a few days. They are large, weak fliers. Males have much longer mandibles than females. They use these "long jaws" to fight other males and grasp females for mating. Adults are eaten by many fish, birds and bats.

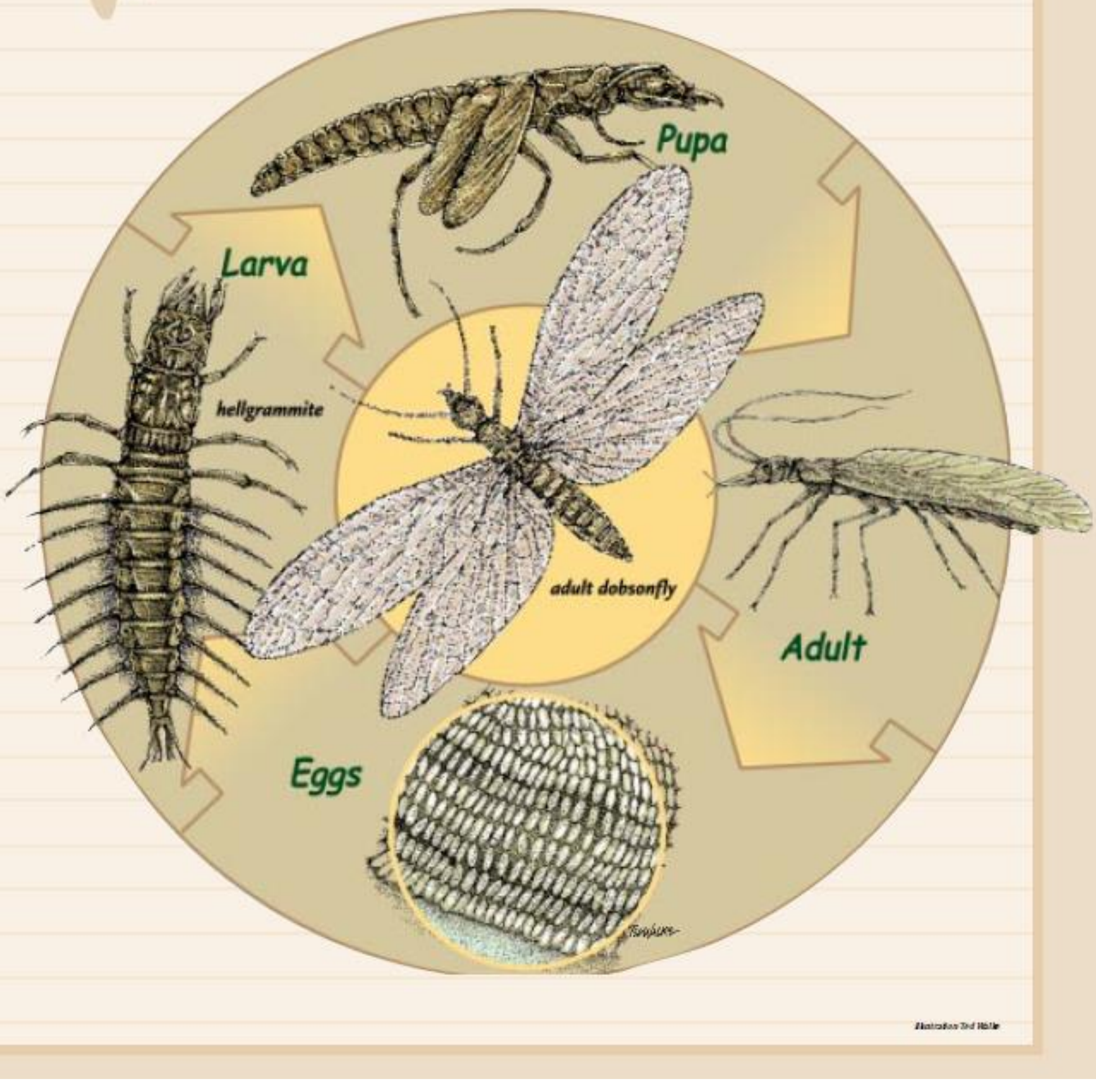
Mating

Using their long mandibles, males grab females around their wings. Mating usually takes place on the ground or on vegetation.

Eggs

Eggs are laid in masses, with many eggs in each mass. Females deposit their eggs out of the water. They may use bridge abutments, overhanging vegetation or rocks that stick out of the water. Hatching takes place at night as the new larvae drop into the water. Young larvae may hatch in a few days or may take up to two weeks.

There are about 50 different species of Megaloptera found in North America. This group includes dobsonflies, fishflies and alderflies.



SMART Angler's Notebook

by Carl Richardson

illustrated by Ted Walke

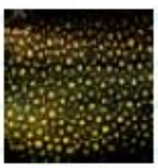
FISH COLORS

Pennsylvania's fish aren't nearly as colorful as some you might find hanging out on a coral reef somewhere. Yet, in their own right, many of our game fish and forage fish are very colorful. Have you ever seen a male brook trout in the fall? The males of all salmon that spawn in the fall become very colorful, and nothing compares to the colors of a brook trout. By comparison, the colors of fall leaves look pale. How about a bluegill or a largemouth bass? Have you ever noticed how brilliantly shiny an American shad is? What makes these fish, or any fish, colorful?


bluegill


pumpkinseed


carp


brook trout


rainbow trout


American shad


channel catfish


smallmouth bass


brown trout

What makes the colors?

Generally, colors are the result of reflected or absorbed light. Fish and other animals have special organs in the skin that produce color-causing chemicals. Some chemicals reflect light. Others absorb it, and we see colors. The iridescent look of an American shad or a shiner comes from chemicals produced by cells called *iridocytes* in the skin.

The colors of a bluegill come from cells called *chromatophores*. These are the cells that cause true colors. Each chemi-

cal results in a specific color. Chromatophores, depending on the species, produce a mixture of chemicals. This process is much like mixing paint at the hardware store.

What influences color?


Iowa darter, *Etheostoma exile*

Spawning males are usually very bright and colorful. The spawning process triggers the chromatophores and puts them in high gear. Fish under stress are often pale and discolored. Stressed fish put their energy into more important functions.

Color patterns

Fish tend to blend in with their surroundings. We all know that as camouflage. Fish that live in weeds generally have vertical bars or stripes. The ones that live in open water have horizontal stripes or countershading (where the belly is lighter than the back).


yellow perch–vertical stripes


striped bass–horizontal stripes

SMART Angler's Notebook

by Carl Richardson

Phytoplankton

Phytoplankton are the first link in many aquatic food chains. They are almost invisible without a microscope. Yet, they are the keys to good fishing, especially in lakes, ponds, and large rivers. Small animals called zooplankton eat them. Young gamefish, especially fry, eat zooplankton. These very small fish need lots of zooplankton to survive and grow into big fish. Not enough phytoplankton means fewer zooplankton. In turn, less zooplankton means that fewer fish survive and grow big.

Phytoplankton and zooplankton are two kinds of plankton.

Phytoplankton are very small, single-celled "plants." They have chlorophyll and can produce their own food–so we call them "producers." Most freshwater plankton are algae. But a few kinds of plankton, like a critter called *Euglena*, aren't. Some species cling together in long strings or mats. Others are free-living. Most just float around, but some do "move around." Some move as winds move the water. Others move up and down by controlling how much air is inside the cell. Still others squirt out cell fluid to "jet" around.

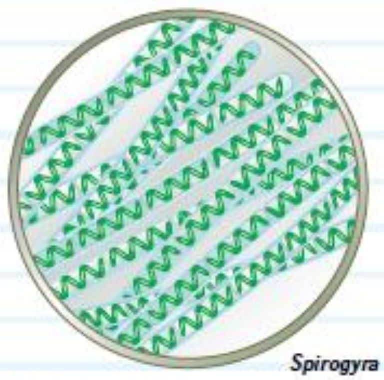
Phytoplankton are abundant in depths reached by sunlight. The amount of nutrients in the water controls the types and amount of phytoplankton. Phosphorus, nitrogen, and potassium are the key nutrients. When there aren't enough of these, especially phosphorus, phytoplankton aren't abundant. But too much isn't good, either. Many ponds, loaded with nutrients, grow large mats of phytoplankton. When these plants die and decompose, dissolved oxygen in the water decreases.

Understanding plankton won't help you catch more fish. Still, knowing about these critters can help you figure out why some waters are more productive than others.

Nostoc

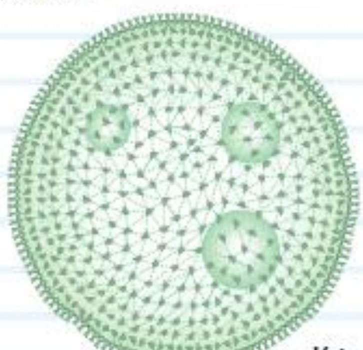
Types of phytoplankton

Nostoc, filamentous blue-green algae, can be enclosed in a large jellylike mass. This species is also found attached to rocks in streams (it's not called "phytoplankton" then).



Spirogyra

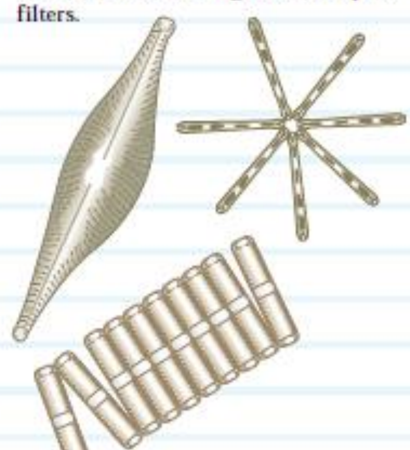
Spirogyra is a filamentous green algae that forms large, green mats on ponds and lakes.



Volvox

Volvox is green algae that clumps together in round colonies. Cells have tails, called "flagella," which move colonies around.

Diatoms are single-celled yellow algae. They have hard cell walls made of silica. Some cling. Others squirt out liquid to move about. Diatoms are common in lakes and ponds. They are also found in slow-moving rivers. The remains of prehistoric diatoms make up diatomaceous earth, which we use in gardens and pool filters.



Diatoms–a few of the shapes

Word Bank

Filamentous–a bunch of single cells clinging together in long strands, like spaghetti.

Plankton (plank'-ton)–from a Greek word meaning "wandering" or "drifting." Small plants and animals found in water.

Phytoplankton (fi-toe-plank'-ton)–from a Greek word meaning "plant plus plankton." Small, even microscopic plants that float or drift around. They are found in fresh water and salt water.

Zooplankton (zo-a-plank'-ton)–from a Greek word meaning "animal," and the word "plankton." Small, almost microscopic animals that live in fresh water and salt water.

Illustrations–Ted Walker

Aquatic Leaf Eaters

Plants are important links in any food web.

They are usually the first link in a food chain in the web. Plants are eaten by plant eaters. Plant eaters are eaten by predators. If there are no plant eaters, there are no predators.

In aquatic habitats, the plants may be tiny. These plants are called phytoplankton. Phytoplankton are plentiful in ponds, lakes and some large rivers. These habitats may also support large plants such as duckweed or milfoil. These plants are the foundation of food webs in those habitats.

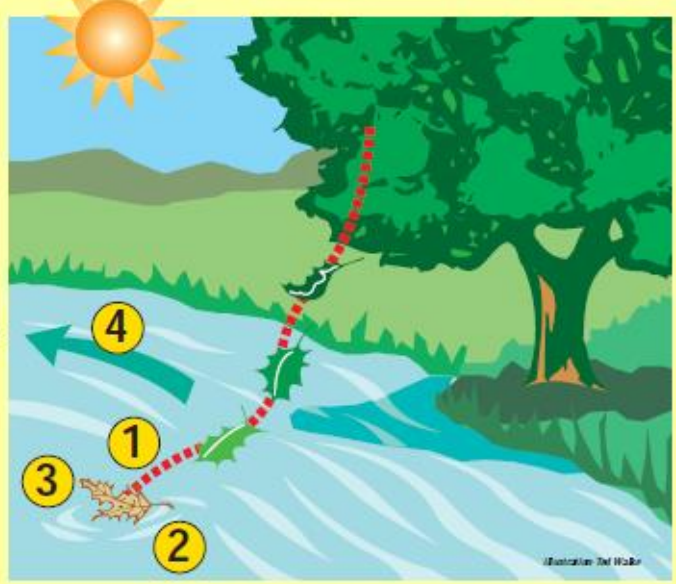
But some of the most important plants in some ecosystems are found outside of the water. This is true for small streams. Plant-eating insects depend on leaves and other material from streamside plants. Biologists call this stuff falling into the stream from plants "**litter.**" Bugs then feed on this litter.

Biologists call the bugs that feed on leaf litter "**shredders.**" Some species of stone flies, crane flies and caddis flies are shredders. They chew up the leaves when they fall into the stream.

Shredders get a little help, though. Fungus and small micro-organisms attach to leaves. They help "soften" the leaves, and make it easier for the insect to digest the leaves.

But it doesn't end there. The shredders give off waste. Those wastes are gathered or filtered by other insects downstream. These insects then feed on the wastes. ***That's recycling!***

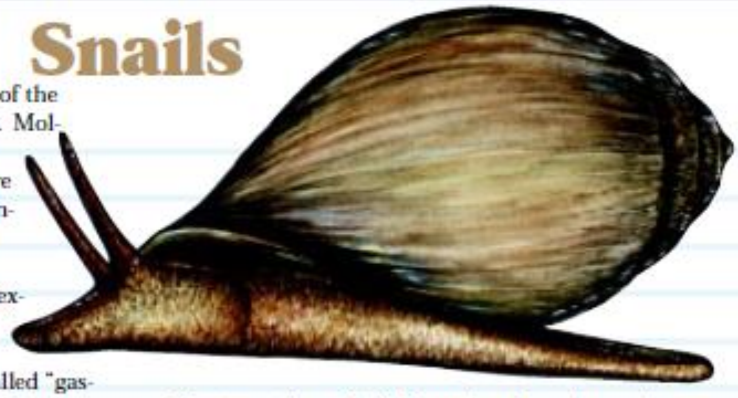
1. Leaf enters stream
2. Microbes and fungus attach to leaf and soften it
3. Shredders eat leaf
4. Wastes from shredders wash downstream.



SMART Angler's Notebook

by Laurel Garlicki

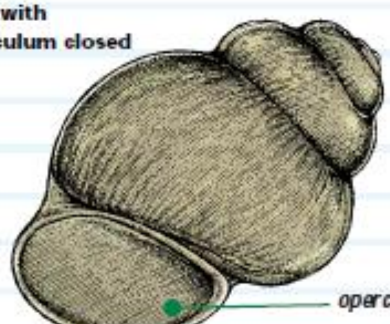
Snails



Snails, with clams and mussels, are members of the second largest group of animals, the mollusks. Mollusks vary in appearance from tiny snails to giant squids 20 feet or longer. Worldwide there are about 100,000 species of mollusks. In Pennsylvania, we have members from two smaller groups of the mollusks, the gastropods and bivalves. Clams and mussels are bivalves. We explored them in the September/October 1999 "SMART Angler's Notebook."

Snails are members of a group of animals called "gastropods." The word "gastro" means "stomach," and "pod" means "foot." Snails and slugs appear to be moving around or "walking" on their stomachs! Snails abound in shallow, slow-moving waters where food is abundant. They are found slowly moving about on the substrate, or scraping algae from rocks and plant stems using their rasp-like "tongue," or radula.

snail with operculum closed



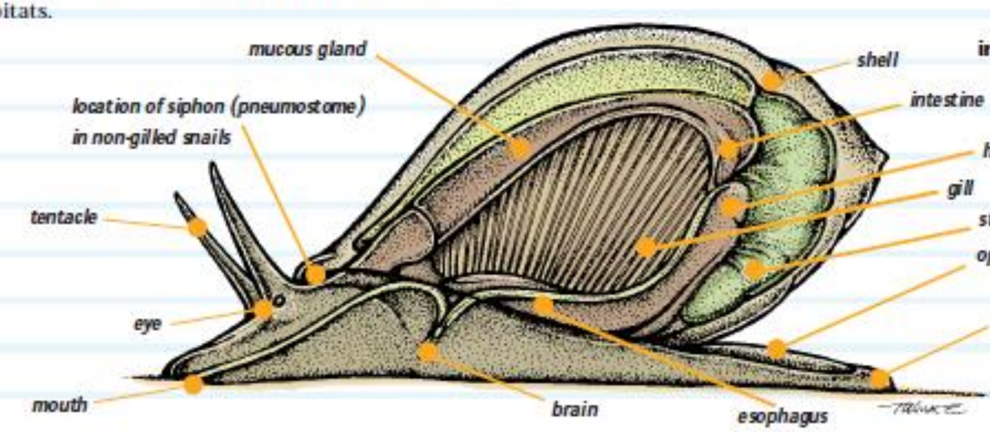
A snail's shell is composed of calcium carbonate (or lime), which is secreted by the snail's body. The largest numbers of snails are found in alkaline, or hard-water, habitats.

Most aquatic snails in Pennsylvania are hermaphroditic. This means that single snails have both the male and female reproductive organs. In some species, an isolated snail can self-fertilize and produce young. However, it is more common for each snail to act as male and female during the mating process. Eggs are laid in jellylike masses on rocks and plants in the spring. Egg-laying continues into summer and even early fall. The tiny snails develop within the egg mass. When the young snail leaves the egg, it has the basic features of an adult snail. It even has a shell with one or two whorls (twists). The typical life span of a snail is nine to 15 months. Some species may live two to four years.

The greatest natural predator of snails is fish. In Pennsylvania, snails make up a significant portion of the diet for suckers, perch, cutlips minnows, freshwater drums and sunfish. Snails are also preyed on by ducks, shorebirds and occasionally amphibians. Leeches, beetle larvae, water bugs, and dragonfly and damselfly nymphs may also feed on snails.

Snails burrow in mud and hibernate in areas where shallow ponds freeze solid during the winter. Some snails become dormant during dry periods in summer.

internal organs



Why Fish Need Trees

Trees do their job quietly. But their job is important. Each fall they remind us that they are there with a blaze of color. But if they

weren't, fishing in Pennsylvania would be very different.

Trout have very specific habitat needs. They can't live in places that don't meet those needs. This is true for all fish. That is why it is important to understand the importance of habitat. "Habitat" is the places where fish live. Trees play an important role in trout stream habitat. Really, streamside trees do several jobs. This issue of the PLAY Newsletter focuses on the importance of streamside trees to trout and other fish.

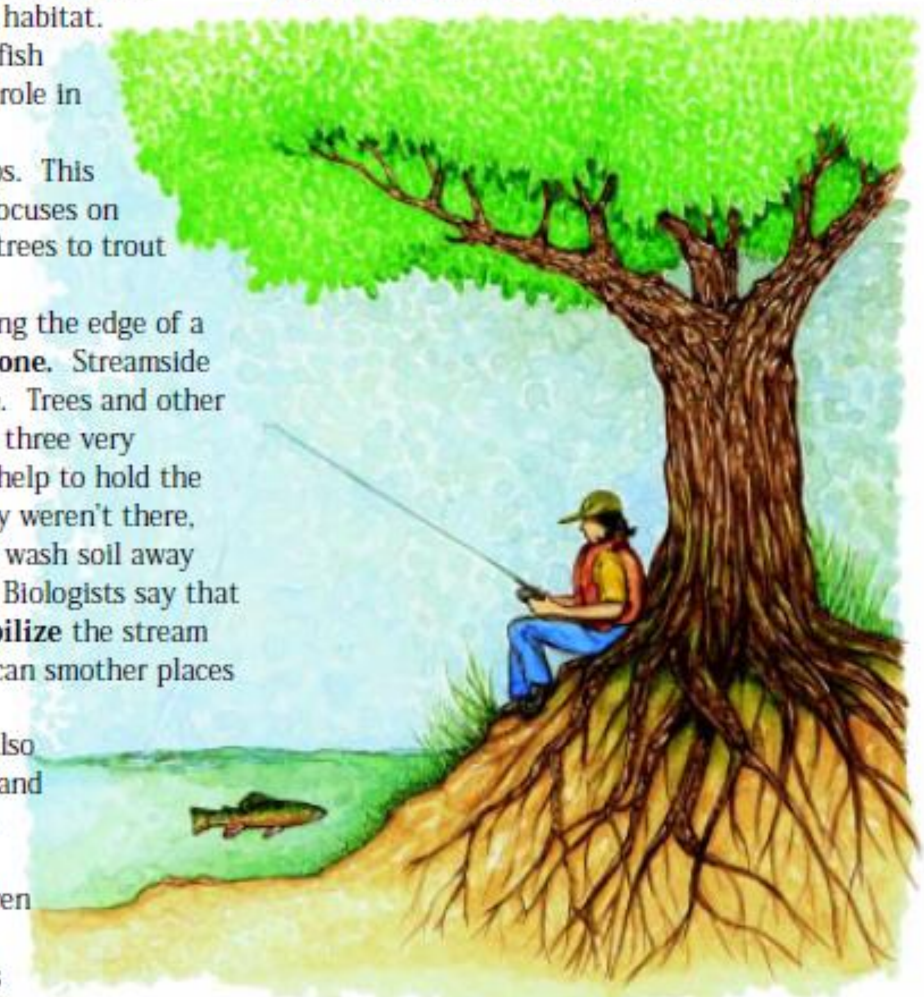
Biologists call the area along the edge of a stream or river the **riparian zone.** Streamside trees live in this riparian zone. Trees and other plants in the riparian zone do three very important jobs. These plants help to hold the stream banks together. If they weren't there,

high water would wash soil away from the banks. Biologists say that these plants **stabilize** the stream banks. That soil can smother places where trout eggs incubate.

Riparian trees and plants also offer **shelter** for trout. Trout and other fish hide from predators under roots and branches of streamside plants. Fish can even hide in the shadows of leaves. The shade from riparian plants also shields the water from the sun. This helps keep the water cooler in summer.

Streamside plants are important to stream **food** webs. Insects feed on leaves and other parts of plants when these plants fall in the water. Trout and other fish feed on these insects.

Streamside trees are important to all aquatic critters, not just trout. Read on and learn more about the important job of streamside trees.



SMART Angler's Notebook

by Carl Richardson

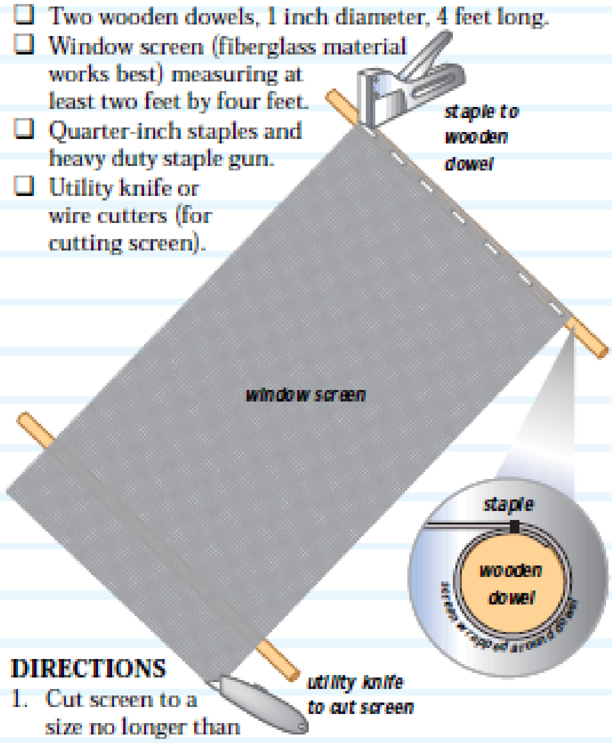
illustrated by Ted Walke

Critter Collectors

Kick Seine

Materials needed:

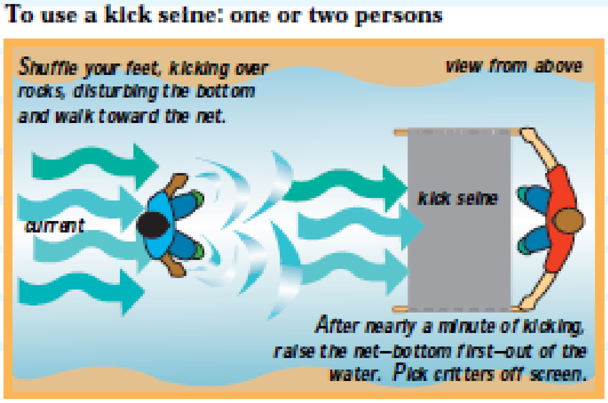
- ❑ Two wooden dowels, 1 inch diameter, 4 feet long.
- ❑ Window screen (fiberglass material works best) measuring at least two feet by four feet.
- ❑ Quarter-inch staples and heavy duty staple gun.
- ❑ Utility knife or wire cutters (for cutting screen).



DIRECTIONS

1. Cut screen to a size no longer than four feet. Fish and Boat Commission regulations limit the length of nets and seines to four feet. Seines larger than four feet require a special scientific collector permit.
2. Lay dowels along shorter edge of screen, lining up the bottom of screen with the bottom of dowels.
3. Wrap screen around dowel, one complete wrap. Staple screen to dowel rod, placing staples every six inches or so.
4. Repeat process on other dowel.

To use a kick seine: one or two persons



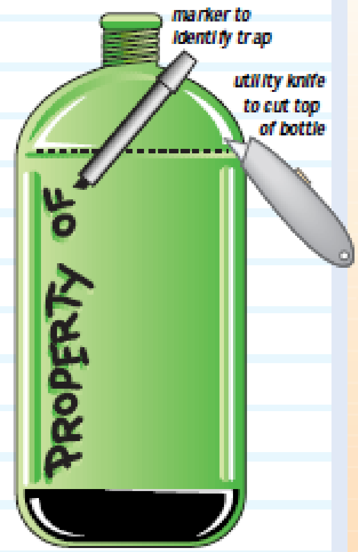
Soda Bottle Trap

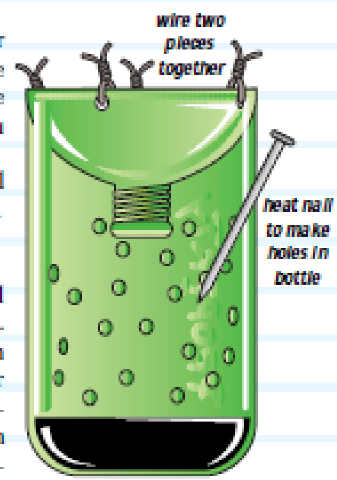
Materials needed:

- ❑ Two- or three-liter soda bottle. Use bottles that have an opening of less than 1 inch. Regulations prohibit traps with larger openings.
- ❑ Picture frame hanging wire (or other suitable rigid 18-gauge or smaller wire).
- ❑ Large nail (10 penny or larger).
- ❑ Wire cutters.
- ❑ Utility knife.
- ❑ Permanent marker.

DIRECTIONS

1. Using the permanent marker, write your name, address and telephone number on the outside of the bottle. Pennsylvania fishing regulations require that unattended traps be identified with this information.
2. Cut the top from the bottle just where the bottle begins to taper toward the opening.
3. Invert the bottle top and place it inside of the remaining portion of the bottle.
4. Heat the nail and make four holes in the two pieces. The wires used to hold the two pieces together will go through these holes.
5. Cut four pieces of wire, each about two inches long.
6. Wire the two pieces together and cut off excess wire. Make sure to leave at least one piece longer. This will be the one you use to open the trap.
7. Heat the nail and make several holes in the body of the trap.





To use the soda bottle trap:

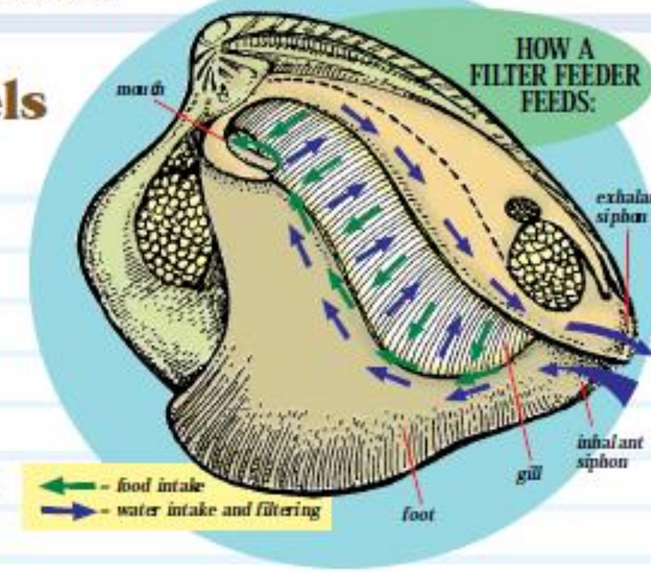
Place large metal washers or small stones inside the trap for weight. Traps are most effective when placed in shallows of ponds or lakes or the slower-moving portions of a river or stream. Trap can also be baited with bread. Be careful when using trap in early spring. Breeding or migrating salamanders may find their way into these traps. One salamander will attract others and soon you will have a bottle full of dead salamanders.

NOTE: *Pennsylvania Fish and Boat Commission regulations limit the number of baitfish and/or aquatic invertebrates (fishbait) you can possess daily to 50.*

SMART Angler's Notebook

by Laurel Garlicki

Clams and Mussels



Snails, clams, and mussels are members of the second-largest group of animals, the mollusks. Mollusks vary in appearance from tiny snails to giant squids 20 feet or longer. Worldwide there are about 100,000 mollusk species. In Pennsylvania, we have members from two smaller groups of the mollusks, the gastropods (snails) and bivalves.

Clams and mussels come from the subgroup known as bivalves. This word means "two shells." Clams and mussels are found on the bottom, or just below the bottom, in slow-moving rivers and streams in relatively shallow areas.

Bivalves are filter-feeders. They draw water into their soft body through a siphon. Inside the body, plankton is filtered out for food. The gills absorb oxygen. Water and wastes are then expelled through another siphon. Clams and mussels also create their shells from calcium carbonate. Lines, or rings, on the outside of the shell are growth rings, similar to the annual rings in trees.

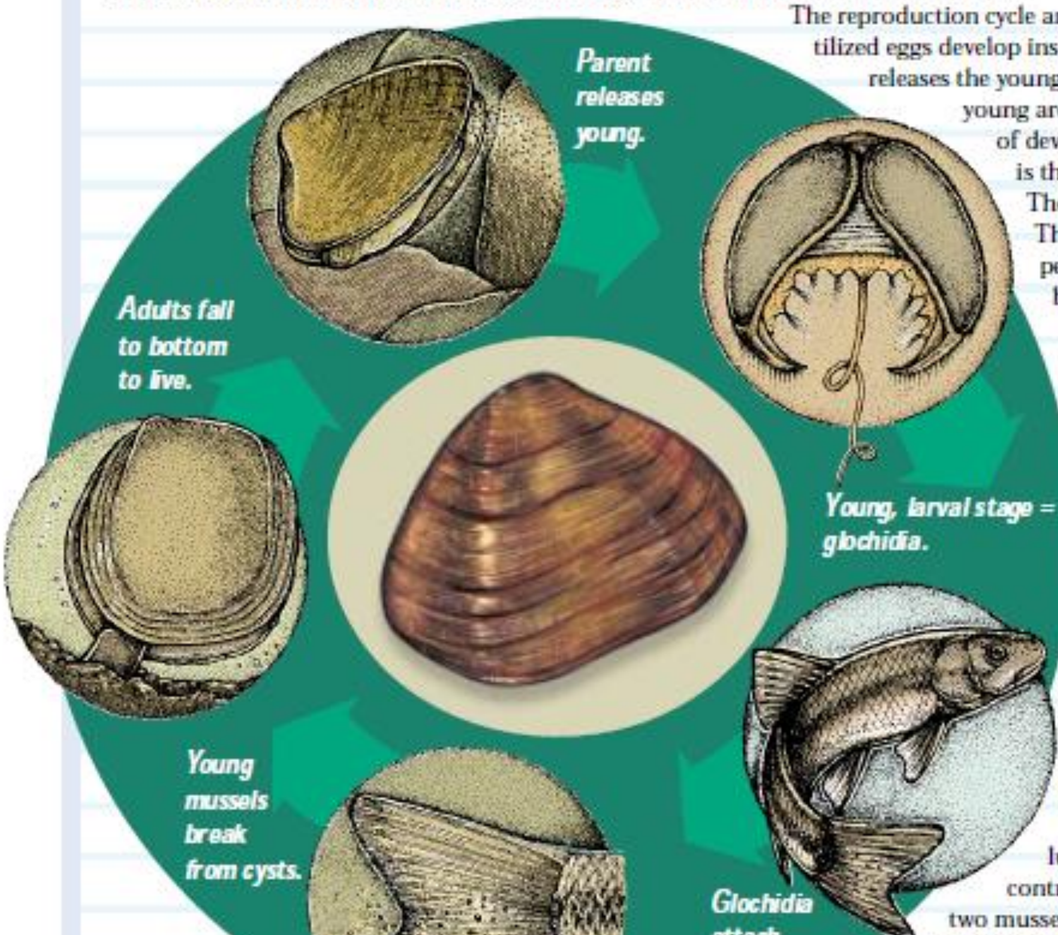


Illustration: Ted Walke

The reproduction cycle among bivalves is unusual. The fertilized eggs develop inside the parent's shell. The parent releases the young through the exhalant siphon. The young are fully formed or in the early stages of development. The young, larval stage is the size of a period on this page. They scatter and sink to the bottom. They wait there for a host. Unsuspecting fish brush against the bottom. The larvae usually attach to the fish's fins, body, or gills. The tissues of the fish grow over the tiny larvae and create a cyst. Then the young mussels or clams break out of the cyst and fall to the bottom to live the rest of their adult lives.

Mussels and clams in Pennsylvania have seen better days. Dams reduce water flow. Silt settles out of the water and smothers bottom-dwelling creatures. River dredging uproots mussels and clams. River dredging destroys their habitat. The loss of certain host fish has also affected mussel populations. Pollutants in the water have also contributed to their demise. Currently, two mussels in Pennsylvania are on the state and federal endangered species list. The PA Fish and Boat Commission is involved in studying about 20 more mussels because of the severe decline in their numbers.