# 2024 Lebanon County Envirothon Elementary & Middle School

## Resource Packet

## Aquatics

This packet contains study materials referenced in the 2024 Aquatics Objectives.

# Focus on Habitat: Wild Brook Trout

*by Walt Dietz, Northeastern ARPS*

**Brook trout** are one of Pennsylvania's most colorful fish. They can be found in clean, coldwater streams, ponds and lakes. They are members of the trout and salmon family, and are more related to chars, also members of the trout and salmon family, than to trout. Chars include lake trout, Arctic char and Dolly Varden trout. Wild brook trout are natives to Pennsylvania and have the honor of being named our "state fish." They have not been introduced to our waters like the rainbow trout or brown trout.

Brook trout have "worm track" markings on their backs and white lines along their fins. Other names for them include eastern brook trout, speckled trout, square-tail and brookie.

Brook trout like water with temperatures less than 68 degrees and lots of oxygen. This is why they are most often found in fast-moving streams or cold mountain lakes and ponds. A brookie might also be found in a meadow stream, as long as the water temperature is cold enough.

Finding good habitat is the key to catching this colorful sport fish. Look for them around tree roots, fallen trees, undercut banks and the edges of large rocks. You might even catch a wild brookie as it leaves cover to feed in a stream riffle or as it enters a quiet pool to sip a hatching mayfly.

A wild brook trout will live a short life of about two years (five years maximum). They usually don't grow more than 12 inches long. The best time to see a wild brook trout is in the fall when they spawn. The colors of male brook trout become much brighter. Females construct a nest on the gravel bottom of the stream. Unpolluted water and clean stream bottoms are important to the survival of brook trout eggs.

A brook trout becomes an important part of the food chain after it hatches. The food chain in a coldwater stream may look like what you see here. The energy for this type of stream comes from leaves, sticks and organic remains (detritus). Aquatic insects eat the detritus and then become a food source for smaller fish. A young brook trout eats small aquatic insects. Large brookies add crayfish, worms and small fish to their diet. The food chain doesn't end with the brook trout. Kingfishers, mergansers, raccoons or fishermen may turn the brook trout into a delicious dinner!

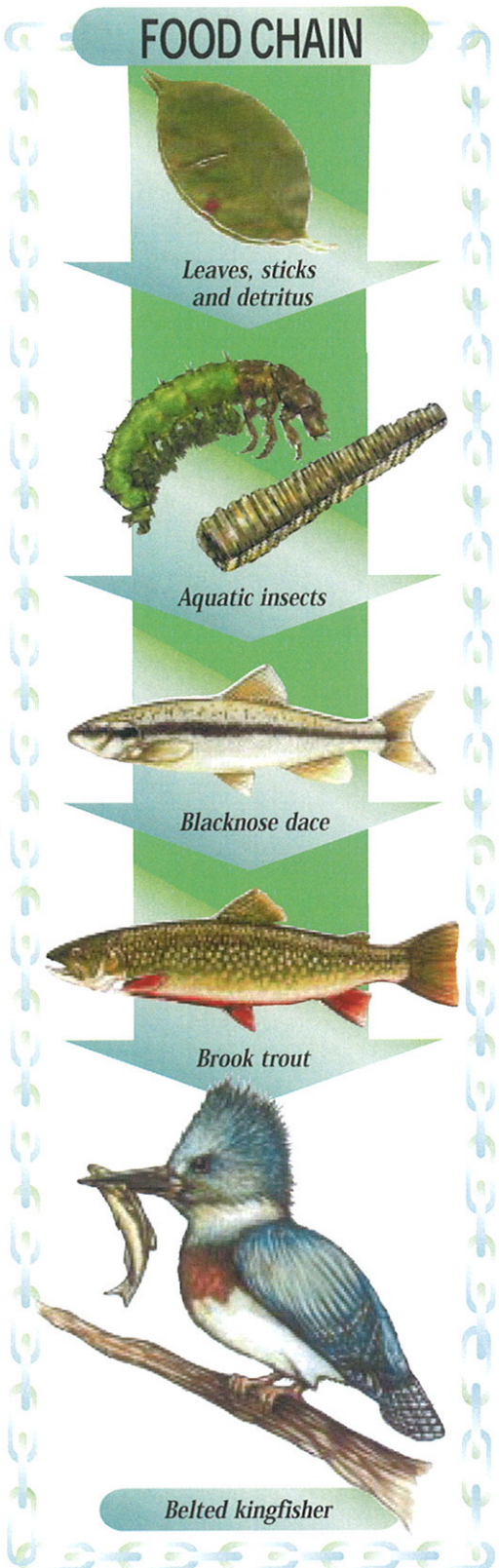
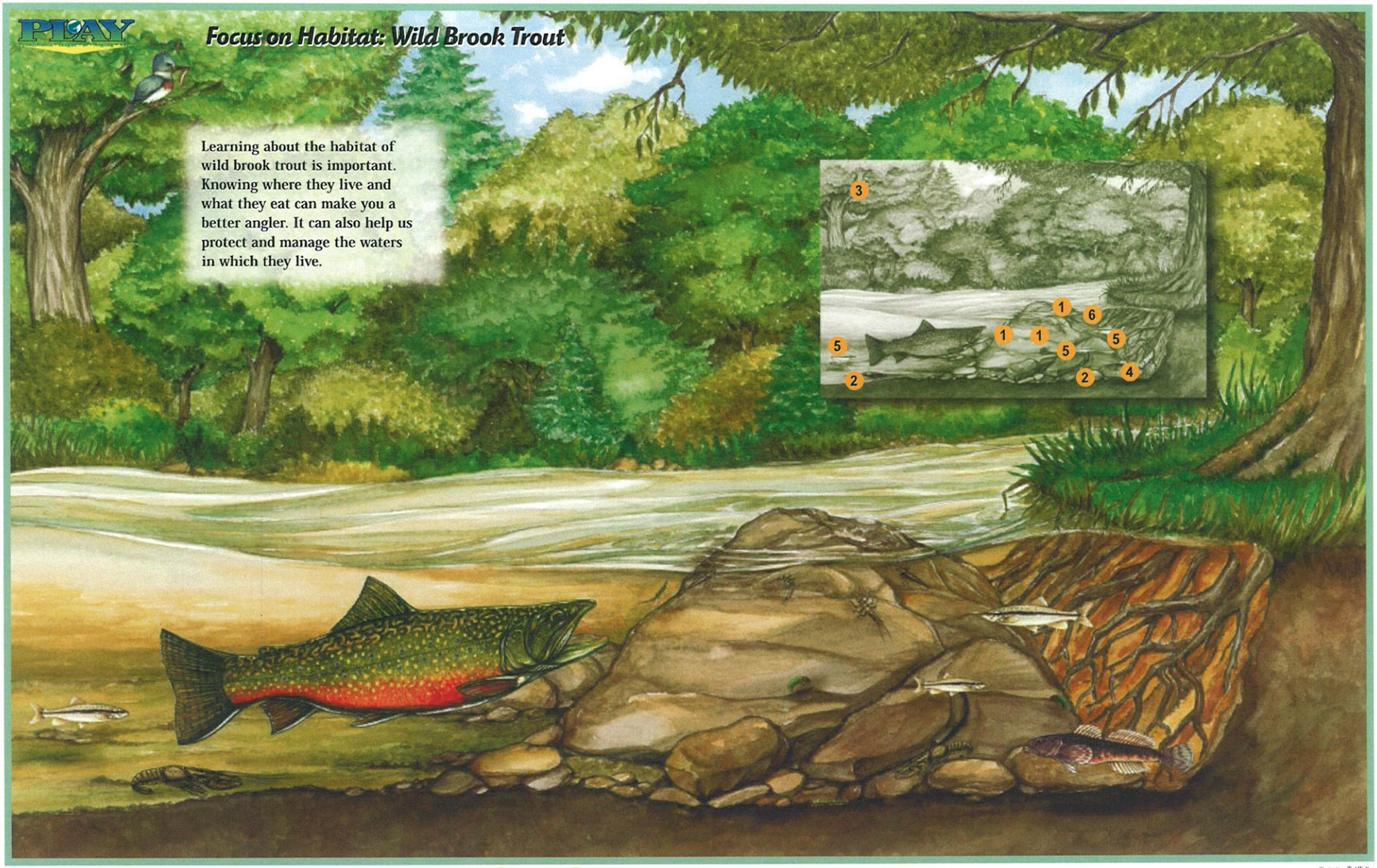



*illustration-Ted Walke*


PLAY
Focus on Habitat: Wild Brook Trout
Learning about the habitat of wild brook trout is important. Knowing where they live and what they eat can make you a better angler. It can also help us protect and manage the waters in which they live.
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1 caddisfly larva, stonefly and mayfly nymphs 2 crayfish 3 belted kingfisher 4 slimy sculpin 5 blacknose dace 6 water penny
illustration Ted Walke

# CRAZY CRAYFISH

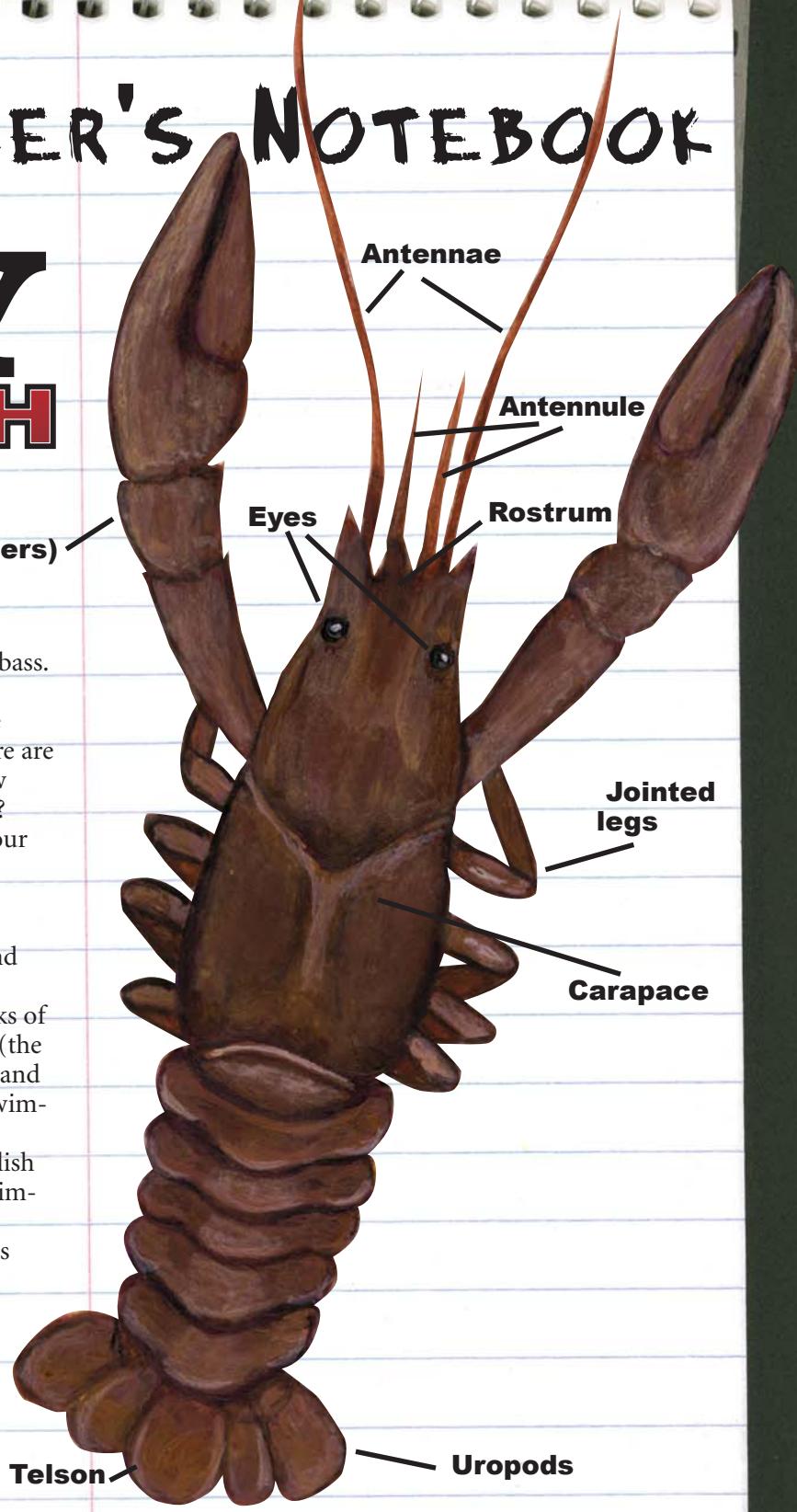
by Walt Dietz

Most anglers know that crayfish make great baits for bass. They probably also know that crayfish are related to crabs, shrimp, lobsters and even zooplankton like the water flea (Order Decopoda). But did you know there are 12 species of crayfish in Pennsylvania? Did you know that crayfish make great baits for other fish like trout? There is even a crayfish that has been introduced to our waters from other states. Let's take a closer look at crayfish.

Crayfish are easy to recognize with their pincers and armorlike carapace. Some people also call them "crawdads" or "crawfish." They are like the army tanks of the aquatic world, thanks to five pairs of jointed legs (the first pair are pincers). They can move over obstacles and in any direction—forward, sideways or backward. Swimmerets (small appendages) under the abdomen help them with swimming and balance. A cluster of purplish eggs can sometimes be seen attached to a female's swimmerets. Crayfish can also shoot backward by flexing their tail fan and contracting their abdominal muscles in the jointed tail. Break a leg, pincer or swimmeret? No problem: Crayfish can grow new ones!

A hard exoskeleton protects crayfish. Crayfish must shed, or molt, as they grow. Those empty "crayfish shells" you see in the water are really shed exoskeletons. Crayfish are very soft until the exoskeleton hardens. These "softshells" are vulnerable to predators.

Crayfish have amazing adaptations. They breathe through gills under the carapace. Their eyes are on movable stalks to allow sight in different directions. Antennae sense prey and predators. They emit chemical cues to identify one another and signal mating. They can even change color to match their habitat.




Crayfish are important as predators and prey in the aquatic food chain. They are omnivores (feed on plants and animals) and scavengers. They eat snails, insects, worms, tadpoles, dead aquatic animals, algae and vegetation. Crayfish also make a tasty treat for fish, reptiles and mammals. When taken from clean water and properly cooked, crayfish are a great meal for humans.

The rusty crayfish (*Orconectes rusticus*) was introduced from Midwestern states. It is sold commercially as fish bait. It is aggressive and competes with native species for food and space. It will also overgraze aquatic vegetation.

***Rusty crayfish have large pincers and often have two rusty spots on each side of the carapace.***

Help slow the spread of nuisance species. Don't release unused bait into the water. Examine or clean equipment to prevent transfer of plants and animals to other waters.

## Some Common Pennsylvania Crayfish

**Eastern crayfish or Appalachian brook crayfish** ***(Cambarus bartonii)***
Common in most of Pennsylvania.
Found in cold mountain streams under rocks or abandoned burrows.

**Northern crayfish** ***(Orconectes virilis)***
Found in northwest and southcentral Pennsylvania.
Lives in warm, turbid ponds and slow-moving water with vegetation and debris.

**Northern clearwater crayfish** ***(Orconectes propinquus)***
Found in northwest Pennsylvania.
Lives under rocks with muddy or sandy bottoms.

**Chimney crayfish or devil crayfish** ***(Cambarus diogenes)***
Found in western Pennsylvania.
Prefers low elevations, and burrows near spring-fed swamps or logged areas along streams.

**Allegheny crayfish** ***(Orconectes obscurus)***
Found in central and western Pennsylvania.
Lives under rocks with muddy or sandy bottoms.

**Monongahela crayfish or blue mountain mudcrawler** ***(Cambarus monongalensis)***
Found in southwestern Pennsylvania.
Burrows in foothills near water, and prefers clear water nearby or underground springs.

**Spinycheek crayfish** ***(Orconectes limosus)***
Lives in eastern Pennsylvania.
Prefers small, quiet streams of lowlands, ponds and ditches.

Information about our state's other crayfish can be found at the Pennsylvania Crayfish Reference Collection link under the Web Resources section.

## Collecting

Crayfish are easy to catch. Look for them in any pond, lake, river or stream. Roll rocks over in shallow water and grab behind the pincers (thorax), or use a dip net. Or have one angler hold a minnow seine while another angler lifts rocks and swooshes crayfish downstream toward the net.

## Storing

Crayfish are also easy to store. Use a cooler with wet grass or aquatic plants instead of a bait bucket with water. They'll keep for days if you store them in a cool shady spot and keep the grass wet. Wrap softshells in wet newspaper, cheesecloth or cotton material. Store them in the refrigerator and they will stay soft for a week.

## It's the LAW!

- A fishing license is required of those 16 and older to collect crayfish and other fishbait or baitfish.
- No closed season or minimum size for crayfish. Pennsylvania law allows a daily limit of 50 combined fishbait species.

## Fishing Tips

Use live crayfish for bass, trout, perch, carp and catfish. Softshells are deadly! Hook them through the tail or break them apart and use the body parts. Rig with a splitshot, slip or swivel sinker. Or try a jighead. Move your line occasionally to pull live crayfish from their rocky hiding spots.

## Web Resources

**Association of Astacology**
www.uku.fi/english/organizations/IAA/

**Crayfish World**
www.crayfishworld.com

**Crayfish Corner**
www.mackers.com/crayfish/

**Invasive Species**
www.protectyourwaters.net

**Pennsylvania Crayfish Reference Collection**
www.lhup.edu/~tnuttall
pennsylvania_crayfish_reference_.htm

# The Basics of Water Pollution in Pennsylvania

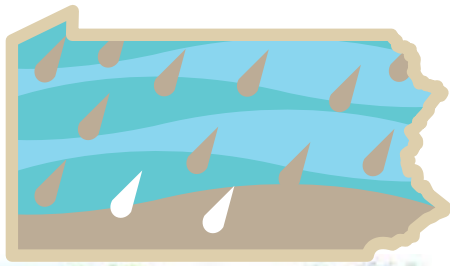


*photo-Russ Gettig*

Pennsylvania has more than 83,000 miles of streams and rivers. There are also some 4,000 lakes and impoundments providing 160,000 acres of recreation. These waters are home to more than 120 different species of fish, nearly 1,000 different species of aquatic insects and 38 species of clams and mussels. It's no surprise, then, that anglers and boaters spend more than 25 million days on the water in Pennsylvania. The total economic benefit to the Commonwealth of this water-based recreation exceeds $1.34 billion each year. Add to this benefit the large number of people depending on our surface water for drinking or industry, and it's easy to see that water is one of our state's greatest resources. It is also easy to see that protecting these resources is not something to be taken lightly. In the 1970s, Pennsylvania was a national leader by adopting strict water quality regulations to protect these aquatic resources. Pennsylvania has maintained its leadership by enforcing more stringest regulations than those set forth under the Federal Clean Water Act.

CATCH US ON THE WEB! PENNSYLVANIA FISH & BOAT COMMISSION www.fish.state.pa.us

**For the complete water quality assessment report from the PA DEP, visit www.dep.state.pa.us.**

# The Basics of Water Pollution in Pennsylvania

Some 43 percent of our streams and rivers have been surveyed to assess water quality. About one-quarter of our lakes and reservoirs have also been assessed. Waters that are unable to support the fish and other aquatic life that they once did or should are considered to be impaired, or degraded. According to a PA Department of Environmental Protection (DEP) water quality assessment report, one-fifth of our surveyed streams and half of our surveyed lakes (13 percent of the total) are impaired or polluted. Even though some of these waters still hold fish, many no longer sustain aquatic communities that should be present. This is a result of pollution. But how does pollution affect our aquatic resources? Read on to understand the effects of pollution on fish and other aquatic life.

Healthy habitats

Before we can repair unhealthy or polluted aquatic systems, we must understand how healthy ones function. All organisms have specific requirements to survive, including adequate amounts of food, water and shelter. When these requirements are met, the organism can survive. That is, a polar bear can survive only where its needs are met, whether that's in a zoo or in the Hudson Bay region of Canada. Aquatic organisms, like our state fish, the brook trout, are no different. The brook trout is found in waters where its needs are met.

Aquatic organisms survive under a range of conditions. If a condition like water temperature is outside that range, the organism can die. Biologists call this "tolerance." The brook trout can tolerate temperatures within a range of 32 degrees to about 75 degrees. Within the range of tolerance is a narrower range. Our brook trout can live a healthy existence and grow in this narrow water temperature range. The ideas of tolerances and ranges may seem complicated, but they're really this simple—an organism will do best in its ideal habitat. In addition, each kind of organism has a specific ideal habitat.

The combination of the ideal ranges of temperature, pH and dissolved oxygen (DO), and other water quality conditions, combined with an adequate amount of food and shelter, are needed for our brook trout to thrive. This is a healthy brook trout habitat. If the water temperature is less than 70 degrees and the DO is high, things are looking good. Add a pH between 6.5 and 7.5 (ideal), plenty of food, and places to seek shelter from the current or predators, and you have ideal brook trout habitat. Other fish, including other species of trout, and aquatic organisms have requirements similar to those of the brook trout. These organisms and the way they interact are called a "community." Some members of a fish community provide important food for the fish we want to catch.

Like our brook trout, smallmouth bass have specific habitat requirements. They are part of a community of fish found in our warmer streams and rivers. These waters provide the right conditions for this fish community to live. The same holds true for largemouth bass, muskies, northern pike, walleyes, panfish and other fish that anglers seek. These fish are found where their requirements for life are met. Water pollution can change all that. Pollution can alter one or many important components of a habitat. When that occurs, the health of individual organisms, and often the entire community, is at risk.

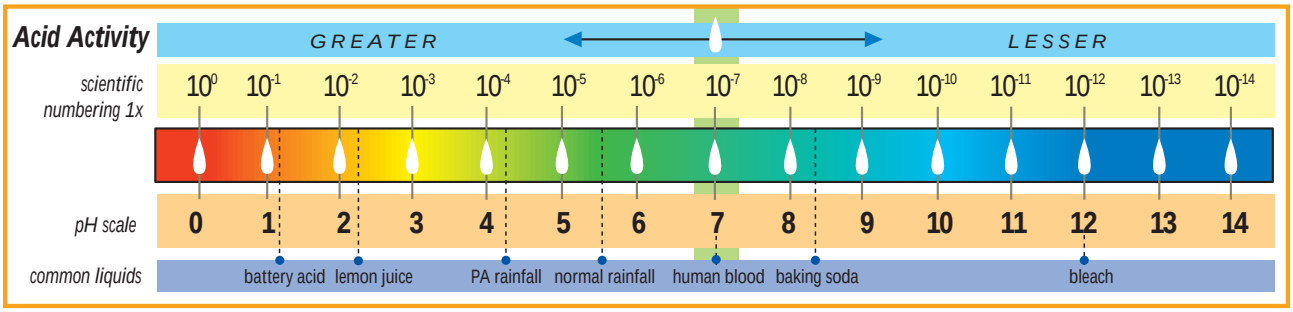
## Requirements for life

Let's look at some important water quality factors, and how they may influence the fish community.

The measure of hydrogen ions or acidity in a solution like water is called pH. The pH scale ranges from 0 (most acidic) to 14 (most basic). A pH of 7 is considered neutral. The pH scale is logarithmic–it changes by tens. That is, a change of one whole number in the pH equals a tenfold change in the amount of acidity. Changes of two whole numbers indicate a 100-fold change in acidity. The pH of a solution also influences the amount of substances like heavy metals dissolved in it.

In aquatic habitats, pH has a strong effect on which fish, amphibians, invertebrates and plants can live in a community. The pH of a stream or lake depends on the water source and the kinds of rocks and soil that water contacts. Proper pH is an important life requirement for

*photo-Barry & Cathy Beck*




all aquatic organisms. Developing eggs and larvae also have specific, more narrow pH requirements. Adult brook trout can tolerate a pH of between 5.0 to 9.5 and remain relatively healthy. However, even at the high and low ends of this pH tolerance level, fish become stressed. Aquatic invertebrates, with external skeletons or shells made of calcium, are extremely sensitive to pH below neutral. These organsisms are important members of aquatic food chain.

At the low end of this range, naturally occurring metals will dissolve into the water. This hits the aquatic life with a double whammy–low pH and high metals concentration. A fish that could tolerate water with a pH less than 5 will die at a pH of 5.5 if the water contains as little as 1.0 parts per million (ppm) of iron. One ppm is equivalent to a drop of chocolate in 16 gallons of milk. Biologists call these relationships synergism–where two substances combine to have effects much worse than just their sum. Water with low pH (less than 6.0) coming in contact with naturally occurring low concentrations of iron, lead, aluminum, magnesium or mercury creates a toxic cocktail. Therefore, pH is a critical factor in aquatic habitats.

These dissolved metals may interfere with body functions. They can also influence developing eggs and larvae. This leads to lower natural reproduction, if any at all. Ultimately the population declines, the food chain collapses and the community suffers.

## Temperature

Fish can't maintain their internal body temperature as do humans. Fish have very specific temperature requirements. Water temperature can influence oxygen concentration, metabolism (body functions), reproduction and growth. Water temperature is influenced by the seasons, the amount of sunlight reaching the water, amount and speed of the water, the source of the water (springs or runoff) and the amount of material suspended in the water. Fish are found where the temperature range is within their tolerance, and better still, within the ideal range. For example, temperatures higher than 75 degrees are usually lethal for brook trout. But fish like the channel catfish and largemouth bass need temperatures that high to survive and reproduce successfully. Rapid changes in temperature can kill fish. But that same change in temperature over the course of a season (say, spring to summer) can have little effect on the aquatic community.

graphic-Ted Walke

## Dissolved Oxygen (DO)

Dissolved oxygen is another important water quality factor for fish and many aquatic invertebrates. DO is the amount of oxygen dissolved in the water. Even though the

### *Solubility of Dissolved Oxygen*

***Solubility: Amount of dissolved oxygen that distilled water can hold at a given temperature.***

| Temperature (C*): | Solubility (mg/l) |
|---|---|
| 0: | 14.6 |
| 1: | 14.2 |
| 2: | 13.8 |
| 3: | 13.5 |
| 4: | 13.1 |
| 5: | 12.8 |
| 6: | 12.5 |
| 7: | 12.2 |
| 8: | 11.9 |
| 9: | 11.6 |
| 10: | 11.3 |
| 11: | 11.1 |
| 12: | 10.9 |
| 13: | 10.6 |
| 14: | 10.4 |
| 15: | 10.2 |
| 16: | 10.0 |
| 17: | 9.8 |
| 18: | 9.6 |
| 19: | 9.4 |
| 20: | 9.2 |
| 21: | 9.0 |
| 22: | 8.9 |
| 23: | 8.7 |
| 24: | 8.6 |
| 25: | 8.4 |
| 26: | 8.2 |
| 27: | 8.1 |
| 28: | 7.9 |
| 29: | 7.8 |
| 30: | 7.7 |

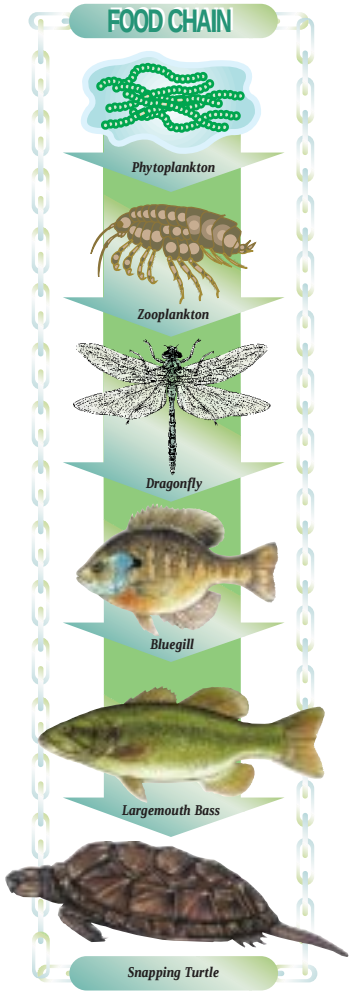
*to convert Fahrenheit to Celsius: [(F-32) x 5]/9=C

chemical formula for water is $H_20$, fish and other aquatic organisms can't remove the oxygen molecules. They depend on oxygen dissolved in the water for respiration. They extract the oxygen dissolved in the water through their gills or across their skin.

Temperature, water velocity, wind, water depth and plant growth influence DO in water. Temperature has great influence on the amount of DO. Warmer water contains less oxygen than colder water. The number of organisms using oxygen can also influence the amount of dissolved oxygen present. If more oxygen is used (respiration) than is being put in, dissolved oxygen levels decrease.

The dissolved oxygen needs for many aquatic insects and fish differ, but some ranges overlap. Fish such as blacknosed dace, brook and brown trout, and certain stoneflies have similar oxygen needs. That's one of the reasons they are found together in the same community. The same holds true for smallmouth bass, certain shiners and hellgrammites. Their dissolved oxygen needs and tolerances overlap.

Channel catfish and carp can tolerate DO as low as 2 mg/l. Generally, dissolved oxygen levels in aquatic habitats must be greater than 6.5 mg/l for fish and aquatic organisms to survive.




## Food

Fish, like humans, need food to survive. When food is abundant at the right time of year, fish grow and stay healthy. But fish can go without food for long periods. Long-term survival of a fish population requires abundant food. That's why biologists study not only the fish we want to catch, but the food they eat. All members of the community—the food chain—are important to the survival of sport fish. The first links in a food chain are plants. In aquatic habitats, these plants may be single-celled phytoplankton, algae or larger submerged plants. Some small streams depend on leaves falling from nearby trees as an energy source. All members of the community have a role in providing food.

These plants are then eaten by smaller aquatic insects and other invertebrates similar to the way cattle may graze a field of grass. These insect grazers are then eaten by other insects and larger fish, which are called "consumers" in the food chain. Finally, large predator fish eat the smaller fish and insects.

## Shelter, or cover

Fish need shelter from predators. They need places to hide from the time they hatch to the time they die of old age. Fish living in moving water also need places to rest from the current. The bottom of a lake, river or stream often provides important shelter. Vegetation, growing in the water or on its shores, also provides important shelter.

***Brine discharge from an oil field production operation on Lewis Run, McKean County.***

All the components for healthy brook trout (or any other fish's) habitat must come together in just the right amounts for it to survive. You can see that if any one of the conditions changes, the resident fish and other members of the community will have a tough time of it. If conditions change too much, the fish community may change. This change may not always be for the best. Water pollution can throw off this delicate balance.

## Pollution

Water that has had the delicate balance upset is called "impaired." In Pennsylvania, two major kinds of pollution impair our waters: Agricultural runoff and abandoned mine drainage (AMD). These pollution sources put excess nutrients, siltation and metals into our waters. Even though there are many other pollution sources, none of the others combined affects as many stream miles or acres of lakes as these three.

## Agricultural runoff

Agricultural runoff occurs when runoff from rain or melting snow carries soil, pesticides and fertilizers from fields into nearby waters. When soil is carried into a stream or river, it can suspend in the water to make it cloudy, or it

*photo-PFBC file photo, graphic-Ted Walke*

photo-PFBC file photo

*This stream flows through an unfenced pasture. The stream has no cover and its stream banks are eroded and unstable. The effects of livestock here include increased plant growth, decreasing amounts of dissolved oxygen (as manure breaks down), and elimination of important stream-bottom habitat.*

settles to the bottom as silt. Silt in the water can damage some fish's gills and make breathing difficult. Cloudy water also absorbs more sunlight than clear water. This may raise the water temperature. A temperature that's too high can stress or kill aquatic organisms. It may also account for the reason why some fish have left a community where they have lived for years.

Silt that settles to the stream bottom is known as "sediment." Fish find some of the food they require on stream bottoms. An increase in a waterway's amount of sediment can kill invertebrates by suffocating them. Sediment can also smother fish eggs and alter natural repopulation patterns. It can also fill in the living spaces and destroy habitat.

photo-Ted Walke

*A redeveloped riparian (stream bank) zone has plenty of cover, shading and stable stream banks.*

Nutrients like nitrogen and phosphorus also enter our waters from farms. Manure and other fertilizers are used to increase crop production. When these nutrients reach our streams and rivers, they have the same effect on aquatic plants. Aquatic plant and algae growth can reach nuisance levels. Decomposing plants also consume dissolved oxygen. When less oxygen and warmer temperatures are combined, things change. Our brook trout, and mayflies, caddisflies and stoneflies, will move or die. In their place may be smallmouth bass, rock bass and catfish, which tolerate warmer water and require less DO. The community has been changed by pollution.

Livestock can also affect aquatic communities. Stream banks erode where livestock enter the water to drink or cross to reach other pastures. This increases the amount of silt. Manure is also deposited directly into the stream. The effects of livestock include increased plant growth, decreasing dissolved oxygen (as manure breaks down) and eliminating important stream bottom habitat.

To protect their crops, farmers use pesticides to remove pests. Most pesticides are designed to kill insects and are poisonous to aquatic life when they enter a waterway. In high concentrations pesticides can kill all aquatic life in a community. In low concentrations they can alter food chains by killing or injuring the most sensitive organisms.

## Abandoned mine drainage (AMD)

AMD pollutes almost half of Pennsylvania's impaired waters. AMD is one of our waterway's worst pollutants. AMD occurs when water enters abandoned coal mines. Runoff from mine lands and refuse piles may also form AMD. Water reacts with iron pyrite in the coal and surrounding rocks and forms acids. These acids are then transported into our waters. Most of the sources of AMD today are long-abandoned mine sites. These mines were in their heyday at the turn of the century or from a time when regulations were less strict.

photo-PFBC file photo

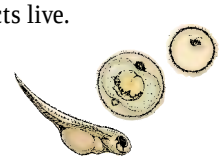
*Little Sewickley Creek, Westmoreland County. The yellowish-orange stream-bottom staining of "yellow boy" is caused by acid mine drainage.*

The most immediate effect of AMD is lowering the water's pH level. When pH decreases below 6.0, algae and rooted aquatic plants can die. The food supply for aquatic organisms is reduced. Healthy aquatic communities are then replaced by those more acid-tolerant.

Acidity can also stress a fish's body function. Another problem is gill damage and a decrease in sodium in the fish's blood. Fish eggs and fry (young fish) are also affected. The young born for an entire year can die. This leaves only older, more resistant fish left in a community. Eventually, without the fry, the community will be void of fish. Often, however, the pH of AMD is so low that the entire community is wiped out.

Metal toxicity caused by AMD is another common stream killer. Aluminum, iron and manganese enter our waters from abandoned mines. These metals are toxic to the brook trout and other aquatic life. Small amounts of these metals can stress fish or even cause death, especially in young, developing fish. Large amounts can settle on a stream bottom. This settling can make the stream water and bottom appear yellow (iron), white (aluminum) or black (manganese). The covering smothers the few invertebrates that may be left. It also eliminates shelter important to spawning and places where aquatic insects live.

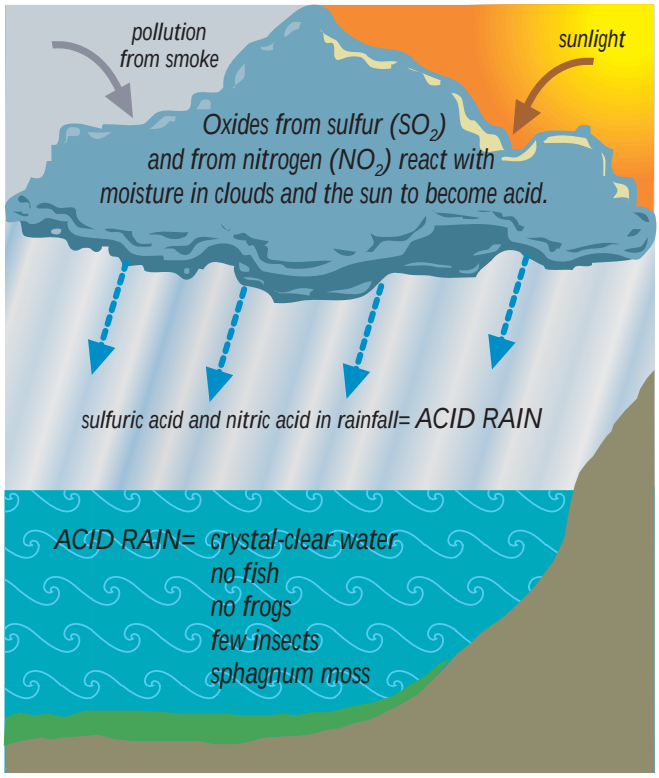

## Acid rain



Acid rain is formed when moisture in the clouds mixes with sulfur or nitrogen in the air. Acid rain includes rain, sleet or snow with a pH level that falls below 5.6 (normal rainwater). The sulfur and nitrogen get into the air by the burning of fossil fuels such as coal and gasoline. The average pH of rainfall in Pennsylvania is 4.3. This level is some of the most acidic rain in the country. The effects of acid rain are often worse in the spring, following snowmelts. Large quantities of low pH snow melts and enters our streams.

The effects of acid rain on stream and lake communities are similar to those of AMD. Low pH combined with dissolved metals influences natural reproduction as well as day to day survival. Acid rain is such a problem in some Pennsylvania streams, especially in the spring, that the Commission changes its trout stocking schedules. These streams are stocked only after the "slug" of low pH snowmelt has moved through. The low pH of spring snowmelt may also have an effect on developing trout and aquatic insects, from eggs laid the previous year. Young developing organisms are more sensitive to lower pH and even small concentrations of metals than they are as adults.

photo-Russ Gettig, graphic-Ted Walke




## What the Fish and Boat Commission is Doing

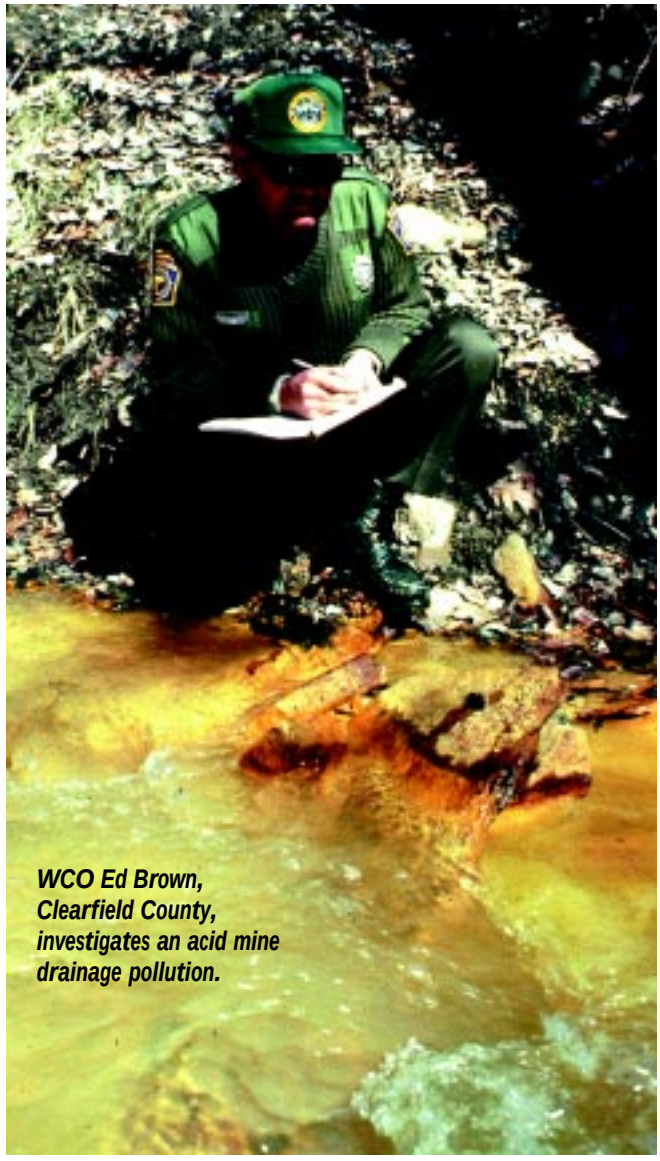
**Permits and Regulations.** The best way to address pollution is to prevent it. The Commonwealth of Pennsylvania has laws in place protecting water quality. The PA DEP regulates the things industries release into the air or water. DEP also has regulations in place protecting banks and channels in rivers, lakes and streams. Before any activity can be done on the shoreline or to the stream or river bottom, a permit must be obtained. Before any substances can be discharged into a stream or lake, a permit must be obtained. The regulations contain standards for many water quality factors. Among them are pH, dissolved oxygen and temperature. The discharges must meet these standards or they are not allowed. In addition, the discharges and activities can't alter the aquatic community that lives downstream.

The Fish & Boat Commission plays an important role in the review of these permit applications and compliance with the permit. The Commission utilizes its technical expertise to ensure that fish communities are not harmed by the proposed activities. Commission staff reviews more than 1,500 permit applications each year. Permits for activities that have the potential to harm aquatic communities are often recommended for denial. The permit applicant and DEP negotiate to change the activity to reduce or eliminate the potential effect.

Other state, regional and local agencies may also be involved in the review of these permit applications. Local conservation districts and water authorities also have a vested interest in protecting water quality and aquatic life.

**Monitoring, law enforcement.** Discharges are most often required to exceed specific standards, based on the chemicals discharged and the water receiving the discharge. Monitoring is achieved through routine sampling of elements such as pH, dissolved oxygen, metals and other chemicals. The results of these samples are reported to DEP, and often to the Fish & Boat Commission. Waters receiving a discharge are routinely surveyed by the Fish & Boat Commission or DEP biologists to assess water quality above and below the discharge. Data is also often compared to that collected before the discharge was approved.

If the quality of the water, or composition of the fish community, shows signs of impairment, the polluter may be fined by both DEP and the Fish & Boat Commission.



*WCO Ed Brown, Clearfield County, investigates an acid mine drainage pollution.*

Just as anglers are given a citation and a fine when violating fishing regulations, so are polluters fined for violating those regulations. Pollution fines are based on the damage done to the resource. Much of the money collected in fines is used to stop the effects of pollution. The Fish & Boat Commission collected more than $300,000 in fines in 1999.

The Commission's waterways conservation officers play important roles in enforcing water quality laws and regulations. They investigate pollution violations, collect evidence and often prosecute the cases in court. WCOs and the Fish & Boat Commission Division of Environmental Services staff also play an important role in reviewing permit applications.

## So what can I do?

First, Pennsylvanians are truly blessed with high-quality aquatic resources, and it's important to understand and appreciate the abundant aquatic resources of our state. Often positive environmental qualities are overshadowed by the gloom and doom of pollution. Currently, some one-fifth of the waterways we have studied (13 percent of the total) are impaired, but we are making significant progress in reversing hundreds of years of abuse and neglect.

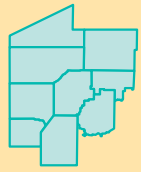
Second, you can become part of the solution. Evaluate your own use of fertilizers and pesticides at home in your yard. If you don't purchase a fishing license, consider doing so. Fishing license dollars help the Fish & Boat Commission do its job protecting Pennsylvania's fish and aquatic life. The Fish & Boat and PA DEP also offer several opportunities for people or groups that want to volunteer their time and services. For more information, visit our web site: **www.fish.state.pa.us.**

**To report water pollution or disturbances to streams, lakes or watersheds, contact the Fish & Boat Commission Regional Law Enforcement office for your region or the Pennsylvania Department of Environmental Protection (DEP) at 1-800-541-2050.**

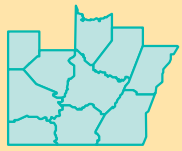
***"The people have a right to clean air, pure water, and to the preservation of the natural, scenic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee for these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."***
**Article 1, Section 27, Pennsylvania Constitution**


## PFBC Regional Law Enforcement

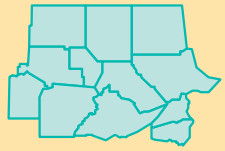
**Northwest Region.** 11528 SH 98, Meadville, PA 16335; 814-337-0444. Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren counties.



**Southwest Region.** 236 Lake Road, Somerset, PA 15501; 814-445-8974. Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland counties.

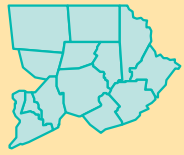


**Northcentral Region.** 450 Robinson Lane, Bellefonte, PA 16823; 814-359-5250. Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland (west of Rt. 147), Potter, Snyder, Tioga and Union counties.



**Southcentral Region.** 1704 Pine Road, Newville, PA 17241; 717-486-7087. Adams, Bedford, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lebanon, Mifflin, Perry and York counties.

**Northeast Region.** P.O. Box 88, Main Road, Sweet Valley, PA 18656; 570-477-5717. Bradford, Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Northumberland (east of Rt. 147), Pike, Sullivan, Susquehanna, Wayne and Wyoming counties.



**Southeast Region.** P.O. Box 8, Brubaker Valley Road, Elm, PA 17521; 717-626-0228. Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia and Schuylkill counties.

**For answers to technical questions about the effects of pollution on fish and aquatic life:**
**Fish & Boat Commission**
**Division of Environmental Services,**
**450 Robinson Lane, Bellefonte, PA 16823; 814-359-5147.**

# SMART Angler's Notebook

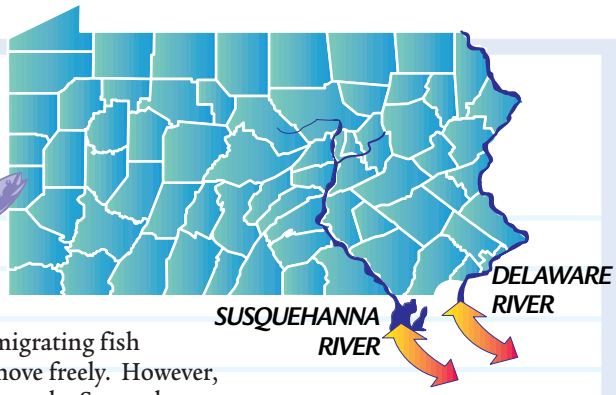
by Carl Richardson

*illustrated by Ted Walke*


## DIADROMY

**No, it's not the Greek god of fishing.** Diadromy might not be a Greek god, but it is from a Greek word, *dromos*–which means "running." Fish that migrate between salt and fresh waters are called diadromous.

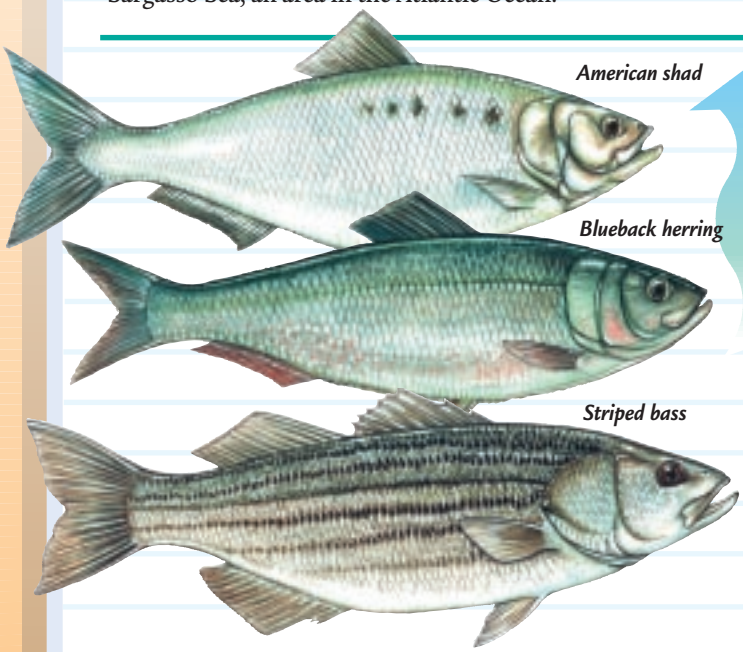
There are two kinds of diadromous fish found in Pennsylvania. They are anadromous and catadromous. The Susquehanna and Delaware rivers have runs of diadromous fish because they lead directly to salt water. The Delaware remains free of obstacles and migrating fish can move freely. However, dams on the Susquehanna are barriers to diadromous fish migrations. Soon, though, migrating fish will be provided safe passage at all the major barriers on the Susquehanna.




## Catadromous fish

The Greek word for "down" is *cat*, so catadromous fish must "run down." They run from fresh water to salt water to spawn. The American eel is catadromous. Eels are native to the Delaware and Susquehanna rivers. Only the female eel migrates up into the river system. The males remain in the estuary, or lower river. When mature, the females migrate down the river and join up with the males. Mature eels then make their way to the Sargasso Sea, an area in the Atlantic Ocean.


*American eel*


*American shad*

*Blueback herring*

*Striped bass*

## Anadromous fish

Anadromous fish run up. Anadromous fish found in Pennsylvania include American shad, herring, striped bass, and shortnose and Atlantic sturgeons. These fish also run both the Delaware and Susquehanna rivers.

After three to five years at sea, mature **American shad** return to fresh water. They make their spawning run in the spring, to the rivers where they were born. They spawn, and hang out in fresh water for a short period. Because they are adapted to eat the larger saltwater plankton, some starve to death. Some survive and return to the sea. In the fall, as water temperatures drop, the young shad head to the ocean. There they migrate up and down the coast each spring until they are three to five years old.

**Striped bass** mature in about two to four years. Mature stripers spawn in the lower reaches of the river systems. There, submerged grasses provide hiding places for the young stripers. After spawning, many adults migrate far up the river system. Anglers fishing the upper Delaware report catching stripers as far up as Port Jervis, New York.

Not much is known about **sturgeon** and their habits. However, it takes many years for a sturgeon to mature. Male Atlantic sturgeon mature at about age 12, females at 18 or 19. They spawn just above the saltwater and freshwater line. The young sturgeon remain in fresh water until their second to sixth years. Then they migrate out to sea.

*Shortnose sturgeon*

SMART Angler's Notebook

by Laurel Garlicki


# A River Flows Through It

If you were asked to imagine a stream, what would come to mind? Each person asked would probably picture something a little different. Some would imagine a bubbling mountain brook. Others would dream of a warm, lazy creek teeming with rock bass or trophy smallmouth bass. Each of us would be right. Pennsylvania has more moving water than any other state—more than 83,000 miles. This water flows through Pennsylvania in one of six major watersheds, or basins: Lake Erie, Ohio, Susquehanna, Genesee, Potomac and Delaware. If you are familiar with the rivers after which the watersheds are named, you know that they differ greatly. They have been shaped by climate and thousands of years of geologic activity, including glaciers in some cases. These differences are the reasons why Pennsylvania has so many different kinds of fishing and boating opportunities.

Even in a watershed, though, one can find habitat differences. The babbling brooks, runs, streams, creeks and the major waterway in each watershed offer a variety of habitat types. These diverse waterways are home to nearly 160 species of fish and hundreds of invertebrate species. What follows is a simple explanation of why the differences occur within a watershed.

The boundaries of most major watersheds are found high in Pennsylvania's mountains. From there, the topography changes to more gradual slopes and often to very flat land. That is why the headwaters of a river, the Allegheny River, for example, are very different from the lower river near Pittsburgh. Even though they have the same name, they are very different waters, with different critters calling these waters home. That is why it is important to understand the changes that occur within a watershed. The transition from headwaters to larger rivers may be referred to as the **river continuum**.

The interactions of climate, moving water, surrounding geology and land topography affect the physical characteristics of the stream. The shape of the stream channel, the composition of the bottom, water temperature, and the water's chemistry (pH, alkalinity, hardness) are defined by this interaction.

These variables, especially temperature, bottom type and water chemistry, influence the type and number of organisms inhabiting the stream. Aquatic macroinvertebrates and other organisms have specialized **adaptations** (characteristics that help them survive). Some of these organisms are so specialized that they may be found only in specific sections of the watershed. Riffle beetle larvae, also called water pennies, are examples of this specialization. They have streamlined bodies and suction cups on their feet to help them cling to rocks in a swift headwater riffle. They feed on the film of algae growing on the surface of rocks.

Farther down the watershed, caddisfly larvae build elaborate tube-shaped nets to filter their food from slow-moving rivers. Some of these larvae are free-living. Others build shelters of sand and gravel on rocks. These specialized adaptations let these organisms live in particular spots in a watershed. That is, they may not be found in the entire watershed—only in those places where their needs are met.

The predators that feed on these and other aquatic invertebrate animals are what SMART Anglers' dreams are made of! Fish are more mobile and often have wider tolerances than the invertebrates they feed on. As a result, they can be found in several different places in the watershed.

The fish community also changes as we move through a watershed. For example, anglers in search of small but feisty brook trout take to cold, fast-moving headwater streams. Brook trout are well-camouflaged for this weedless environment. The rocky stream bottom also provides nooks and crannies where tasty insects like stonefly nymphs and caddisfly larvae live. Record-musky anglers will head to bigger waters such as the warmer, slower currents of a river. The dark vertical bars on the side of the musky help it blend with the aquatic plants it uses for cover. Those same aquatic plants attract prey. Anglers seeking brown trout or smallmouth bass will likely find their quarries in the waters in between.

Stream Order: "Brook," "creek," "run," "stream" and "river" aren't scientific terms for describing a waterway. Streams can be more accurately categorized by their stream order. A first-order stream has no tributaries and flows directly from its source—a spring, lake or melting snow. When two first-order streams join, they make a second-order stream. Two second-order streams join to make a third-order stream, and so on. Stream order increases only when two streams of the same order join. The use of stream order classification lets us make accurate comparisons between two streams.

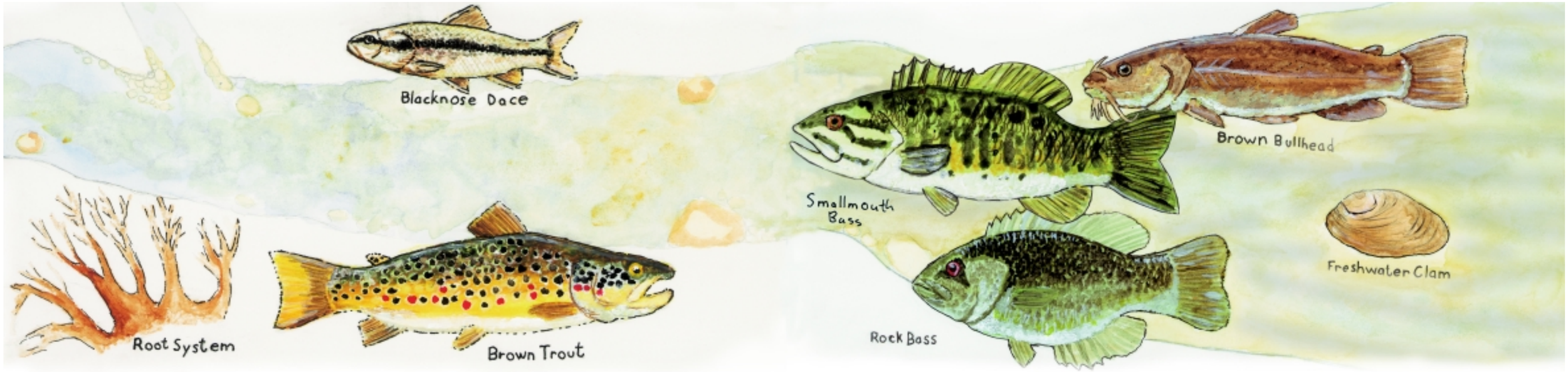
Headwater streams are usually cold, steep and fast-moving. They have steep gradients and high dissolved oxygen content, and they are shaded by the surrounding trees. The aquatic insect community is dominated by shredders and collectors like stonefly nymphs, caddisfly larvae and crane fly larvae. Brook trout, sculpins and dace also thrive in these habitats.

Trees are very important neighbors for moving water.

*Illustration – Ron Kuhn*

A river flows through it

This graphic highlights the changes that occur as we move down through a "typical" watershed. Typically, the amount of flowing water in a stream increases as you move down through the watershed. Often the speed at which this water moves and its temperature increase farther down in the watershed. The amount of dissolved nutrients also generally increases from the headwaters to the lower reaches of a waterway. Take note of the changes in the fish community from the headwaters to the lower reaches.




They shade the stream and help keep water temperatures cool. Tree roots stabilize the streambank and prevent soil from washing into the stream. The overhanging tree branches provide important shelter for fish and other organisms living in the water. One of the trees' most important contributions to first- and second-order streams is energy. The energy that drives the food chain in a headwater stream comes from *outside* the stream. Some species of stonefly and mayfly nymphs shred leaves and twigs that fall into the stream. Their wastes and smaller pieces of leaves and twigs are washed downstream.

Temperature is one of the biggest determining factors of fish populations. Each fish species has a preferred temperature range in which it can live, grow and reproduce. Biologists group fish into three preferred temperature categories: Coldwater (50 degrees to 65 degrees), coolwater (65 degrees to 70 degrees) and warmwater (70 degrees to 85 degrees). Temperature preferences among groups can overlap, creating "transition waters." Coldwater transition waters often hold brown trout, blacknose dace and longnose dace.

As the stream's gradient declines farther down in the watershed, the current slows in medium-sized creeks and rivers. Water temperature increases and the channel is wider. Bankside vegetation can shade only the edges of the water. Riffles and pools with cobble, gravel and sand become more abundant and provide ideal habitat for a variety of mayfly nymphs that act as collectors and grazers. More predatory insects are found here, compared to headwaters. In addition, the rocks are often covered with algae and other types of vegetation. If the water is cool enough in these streams—less than 70 degrees in the heat of summer, brown trout will be found here. If the water is warmer, smallmouth bass, rock bass and shiners call this habitat home.

Wider and deeper channels that meander through the river valley characterize the lower reaches of a river. Fine sediment drops out and accumulates on the bottom as the current slows. Bottom-dwelling collectors like clams, midge larvae, snails and burrowing insects make a living in the sediment and among the rooted aquatic plants. Hunters and searchers such as the predaceous diving beetle and dragonfly nymph move about in the water column in search of their next meal. Warmer water temperatures and lower dissolved oxygen are the preferred conditions for the largemouth bass, pumpkinseeds and brown bullheads that live here.

Energy to fuel the food chain can now be found *within* the river. Wastes that were generated upstream accumulate in the slow waters of the lower river. These nutrients act as fertilizer. A variety of rooted aquatic plants, algae and phytoplankton thrives here, creating the basis of the food chain.

## "We all live downstream"

This phrase is more than a catchy slogan. It is a fact of life within a watershed. The waste from insects breaking down leaves in headwaters provides nutrients and food for others downstream. The amount and quality of water in a headwater stream influences the water quality downstream. Removing streamside trees in a headwater may affect other waters many miles away, farther down the watershed.

The word "watershed" is more than a buzzword or a technical term. Watersheds are complex systems in which many factors interact. The physical characteristics of a stream section in a watershed influence the biological community found there. The physical characteristics are the result of the interaction between moving water and the land it drains.

Differences between the major watersheds are more obvious. But even within watersheds there are differences. Those physical changes create unique habitats for organisms equipped with special adaptations suited for that habitat. It is the same water flowing down the same waterway that creates different habitat often miles away. A better understanding of this important but complex concept will likely lead to more enjoyable (and maybe more successful) days on the water.

*Illustration – Ron Kuhn*

## References, more information

There are many excellent resources for information on this concept. They provide more information than we can cover in these four pages.

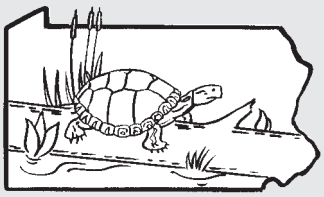

- *Pond and Brook*, by Michael J. Caduto, ISBN 0-87451-509-2.
- *Rivers and Streams*, by Patricia A. Fink Martin, ISBN 0-531-11523-2.
- *Stream Ecology—Structure and Function of Running Waters*, by J. David Allan, ISBN 0-412-29430-3.
- *Aquatic Entomology*, by W. Patrick McCafferty, ISBN 0-86720-017-0.
- *Pennsylvania Fishes*, published by the PA Fish & Boat Commission (also available online) ISBN 1-930369-01-8.


## Web resources:

DCNR's Watershed Education program – www.watersheded.dcnr.state.pa.us/what/components.html
Stroud Water Research Center – www.stroudcenter.org/research
Portland State University – www.oaa.pdx.edu/cae/programs/sti/pratt/rcc.html
Michigan State University – www.kbs.msu.edu
PA Fish & Boat Commission web site – www.fish.state.pa.us

# "Herp" Sweet Home

Adapted from "Water, Water Everywhere," in *Living in Water*, Edition 1 (Baltimore, Md.: National Aquarium, 1987).



- **GRADE LEVELS:** 6 – 12
- **SUBJECT AREAS:** Environmental Studies, Science
- **DURATION:** 2 sessions
- **SETTING:** Classroom
- **SKILLS:** Classifying, comparing, concluding, describing, developing vocabulary, following directions, interpreting, reading, reasoning
- **VOCABULARY:** Biome, bog, deciduous forest, dichotomous key, habitat, marsh, swamp, vernal pool, wetland, wet meadow
- **CHARTING THE COURSE:** Class Field Guide; Herpetology Field Trip; "Herp" Habitat Haggle; Park It Here!; Before the Well Runs Dry; Carry On!; What Every "Herp" Needs; Froggy Swamp; What Do You Know About "Herps?"; Oh "Herps!"; Isn't That Special?
- **"HERP" HAPPENINGS:** A Tiny Turtle in Danger of Disappearing; Leave No Stone Unturned; Sandstone and Salamanders; Swamp Rattlers


## Summary

Students use a dichotomous key and a flow chart to classify common Pennsylvania habitats. Each of these habitats is a potential home to many species of amphibians and reptiles.


## Objectives

Students in grades 6 through 8 will
- define habitat.
- use a flow chart and a dichotomous key.
- name and describe three different Pennsylvania habitats.

Students in grades 9 through 12 will
- analyze the usefulness of dichotomous keys to scientific investigation.
- describe several habitats, listing the typical vegetation and other defining properties.
- given a habitat type, name two amphibians or reptiles that live in that habitat.

## Materials

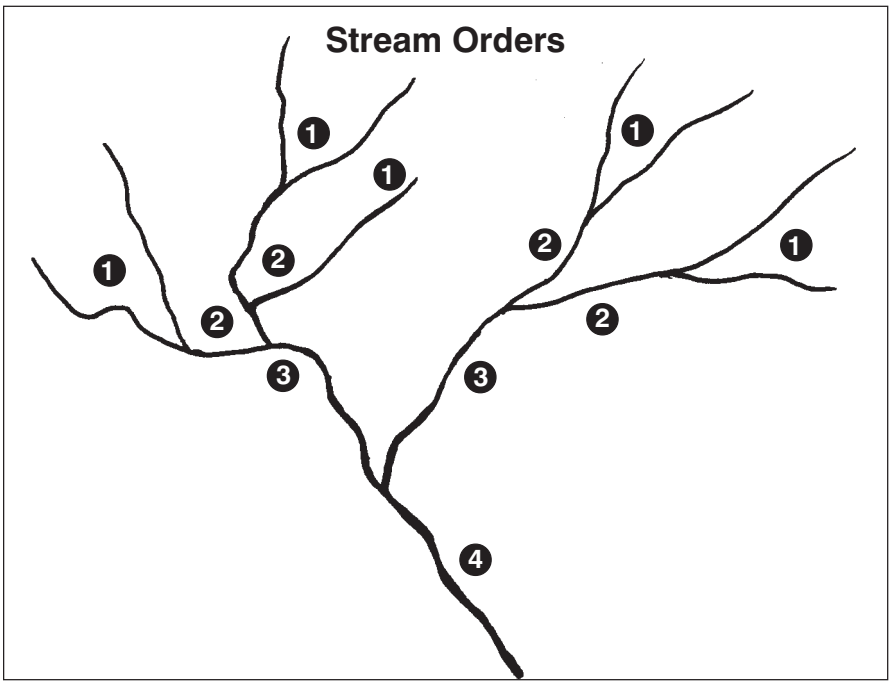
Copies of Key to Pennsylvania Habitats (page 147); copies of Pennsylvania Habitat Flow Charts (pages 149–151); copies of habitat cards (pages 153–167), one per student.

## Background

**Dichotomous keys** are used in science to classify many types of things, usually living organisms. The user is offered two choices at each step, and by choosing between the two the user is led to an answer or to another choice. These keys can seem daunting at first due to their minute detail. Introducing students to a simple key allows them to become accustomed to the concept without being overwhelmed. A flow chart offering two choices at each step is essentially the same as a key, but the layout of the flow chart can help children visualize how a dichotomous key works.

The entire state of Pennsylvania is part of a temperate **deciduous forest biome**, a biome characterized by mid-range temperatures and high levels of precipitation. The final stage of *ecological succession* in Pennsylvania is a deciduous forest dominated by large hardwood trees such as oak, maple, and beech. Before the European settlement of this state, about 98 percent of it was covered by forest. Today, only small, inaccessible patches of old growth forest remain, notably in Cook Forest State Park, Susquehannock State Forest, and Bald Eagle State Forest. Second and third growth forests now cover approximately 60 percent of the state. A major part of Pennsylvania has been cleared for agriculture, the number one industry in the Commonwealth. As the population grows, more and more land is becoming residential, and wildlife and humans must share backyard **habitats**. In rural areas, and even in some suburbs, small stands of second growth trees dot the landscape. These woodlots are home to many species, including several amphibians and reptiles.

The forest was not the only habitat found in Pennsylvania before colonial times. There were naturally occurring meadows or prairies (the result of pond or lake succession), and the mountainous regions of the state contained rocky outcrops that still exist today. Aquatic habitats abounded, including over 50,000 miles of flowing water. (In fact, Alaska is the only place in the United States that has more miles of rivers and streams than Pennsylvania.) Unfortunately, some of this flowing water has been degraded by human activities like farming, industry, and mining. Abandoned mine drainage is the primary pollutant, impacting more than 3,000 miles of Pennsylvania streams. It may come as a surprise that there were far fewer lakes and ponds in Pennsylvania prior to the




immigration of Europeans, but most of the lakes and ponds we have today are artificial. Of course, Lake Erie existed, holding a wealth of species before an influx of sewage and agricultural fertilizer led to it being declared biologically dead in the 1960s. (Today, Lake Erie is recovering and is once again home to many species, although some, such as the blue pike, are now extinct.) Excluding Lake Erie, Pennsylvania's two largest lakes — Raystown Lake and Lake Wallenpaupack — are both artificially created. In addition, Pennsylvania once had an abundance of **wetlands**, including **swamps**, **bogs**, **marshes**, **wet meadows**, and **vernal pools**. Today, 56 percent of those wetlands have been eradicated by human activities like filling and flooding, and we are still losing wetlands each year.

The dichotomous key and flow chart used in this activity distinguish between different habitats by using distinctive characteristics like the amount of water or the type of vegetation. Also, since some habitats are created by human activity, human impact and the proximity of homes and other buildings are also considered.

Terrestrial habitats are those which are not covered with water for a significant amount of time, although they may be covered with water immediately after a rainfall or when snow melts. These include forests, both old growth and second growth; woodlots, which are small wooded areas surrounded by other, usually human habitats; rocky outcrops that have occurred naturally in mountainous areas or have been exposed by human activities; meadows, or open areas of land that have been cleared of trees by fire or other natural occurrences; farmland that may be cultivated for crops or cleared for pasture; and backyards, those areas immediately surrounding residences.

Pennsylvania has a diversity of aquatic habitats that are covered by water for all or part of the year. This water can be flowing, as in a river or stream. Rivers and streams are formed by the runoff of precipitation or by water coming up from underground. When groundwater reaches the surface, it forms a spring. Streams and rivers are classified by order. A first-order stream has no tributaries; it is formed directly from runoff or a spring at its headwaters. When two first-order streams join, they form a second-order stream. It remains a second-order stream, even when other first-order streams converge with it. However, when it meets with another second-order stream, it becomes a third-order stream. The designation "river" is somewhat arbitrary and is based primarily on the size of the body of water. However, most flowing bodies of water with an order of five or above are considered rivers. It is very rare for a river to reach the tenth order, but the Mississippi River is twelfth order. (See diagram.)

Size is the only real difference between lakes and ponds, and these two habitats share many characteristics. They have open water and are not dominated by emergent vegetation, although plants may grow around the periphery. Algae, duckweed, and lilies may, however, appear throughout a lake or pond. Lakes and ponds in temperate climates will also have a temperature gradient. In general, the surface water will be coldest in winter and in fact may be frozen, while the water at the bottom will be 4° Celsius. (Water is densest at 4° Celsius, and therefore this heavier water will sink to the bottom.) In warm months, the top layer will be warmest due to the sun, the bottom layer will be coldest, and the area in

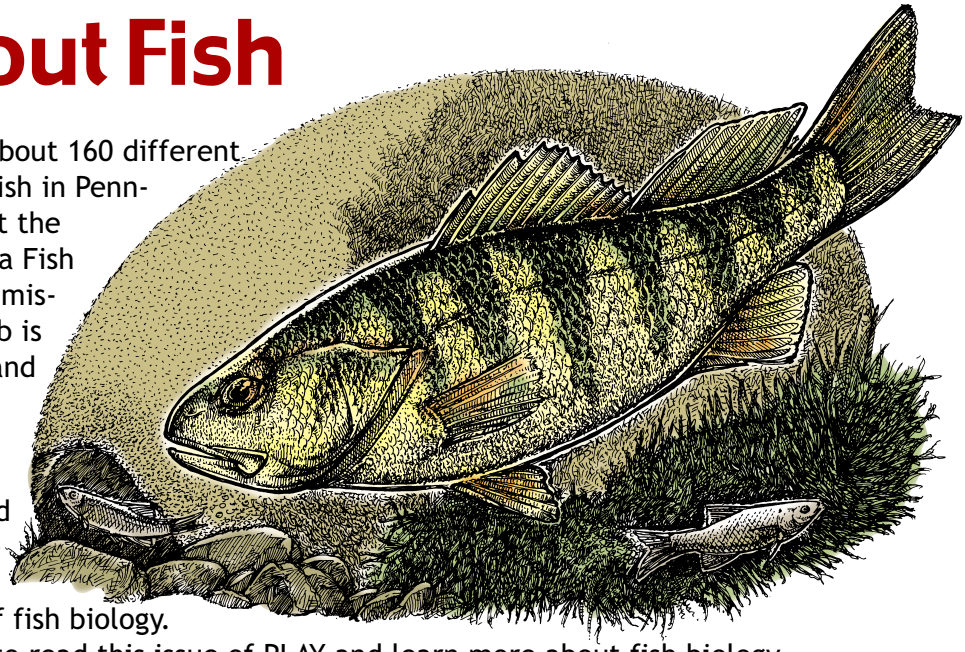
Dedicated to the Memory of Commissioner Enoch S. "Inky" Moore Jr.

# PLAY

Pennsylvania ○ League ○ of ○ Angling ○ Youth

FALL 2002

## All About Fish



There are about 160 different species of fish in Pennsylvania. At the Pennsylvania Fish & Boat Commission, our job is to protect and manage these fish. Ichthyology (pronounced *ick-thee-o'-lo-gee*) is the study of fish biology. Your job is to read this issue of PLAY and learn more about fish biology.

***Can you list the characteristics all fish have in common? How do they differ from other animals? Can you explain how a fish swims? Do you know how the fish in Pennsylvania are classified and organized into families?*** After reading this issue, you will know the answer to these questions. You will be on your way to becoming a junior ichthyologist.

Fish are important to Pennsylvania. More than one million people fish in Pennsylvania. Maybe you are one of them. Anglers spend millions of dollars each year on fishing here. That helps Pennsylvania's economy.

The employees of the Fish & Boat Commission work hard to give anglers fishing opportunities. A big part of that job is protecting all fish from pollution and habitat loss. Maybe someday you will join the Commission as an ichthyologist or fisheries manager!

Want to learn more about fish in Pennsylvania? Check out the Pennsylvania Fish & Boat Commission web site at: www.fish.state.pa.us. There are printable color illustrations of many fish found in Pennsylvania. These illustrations are from the Commission's book *Pennsylvania Fishes*. You'll find an online version of this book on our web site. You can buy a copy online by clicking on "The Outdoor Shop."

*When you are done with this issue of PLAY, pass it on.* Remember that subscriptions to the PLAY newsletter are free to other kids ages 8 to 12. Teachers and youth group leaders can also get PLAY newsletters. Contact the Fish & Boat Commission for more details on this program.

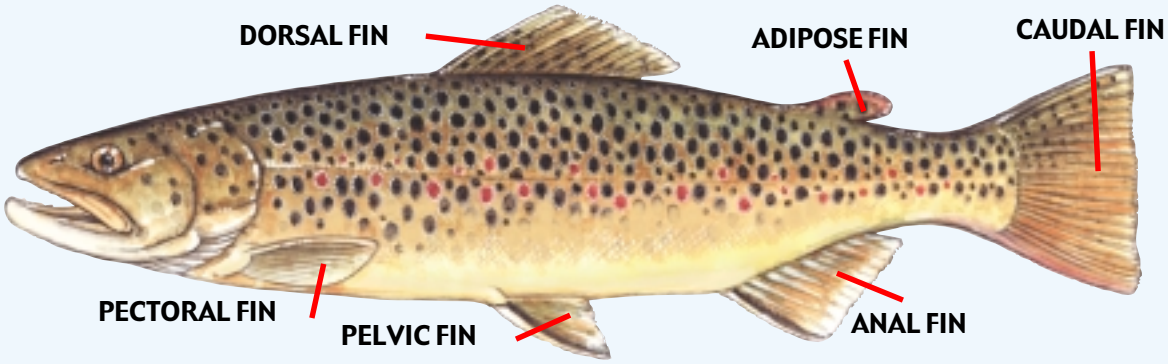
Don't forget to check out the Commission's web site: www.fish.state.pa.us. The site is loaded with information on reptiles, amphibians, fish, fishing, boating and water safety.

CATCH US ON THE WEB! www.fish.state.pa.us

# How Fish Swim

***Fish swim to breathe, eat and move in the water.***

Fish muscles look like sideways W's, called myomeres (pronounced *my'-oh-mears*). The muscles contract from side to side and front to back. The fish's body pushes against the water and moves the fish forward.



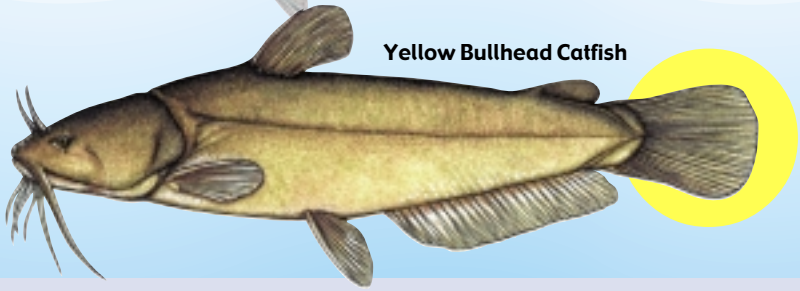

Fins help fine-tune swimming. The caudal fin, or tail fin, increases speed. The pectoral and pelvic fins steer up or down. They also help fish turn and stop. The dorsal fin and anal fin keep the fish upright in the water—as the keel on the bottom of a sailboat keeps it upright.

## Fish Tails

The caudal, or tail, fin adds an extra forward kick to the fish's swimming. Tail shapes vary depending on how the fish swims or where it lives.


**Crescent-shaped tails** are suited for swimming fast for long distances.


**Fork-shaped tails** are also suited for fast swimming, but they are helpful in making quick turns.




**Rounded tails** are built for swimming slowly.

PLAY

*Written by:* Carl Richardson, Laurel Garlicki, Keith Edwards, Dennis Tubbs, Steve Whinham, Walt Dietz and Carl Haensel
*Edited by:* Art Michaels

*Layout, design and illustration:* Ted Walke
*PLAY subscriptions:* Linda Covage and Patti Copp

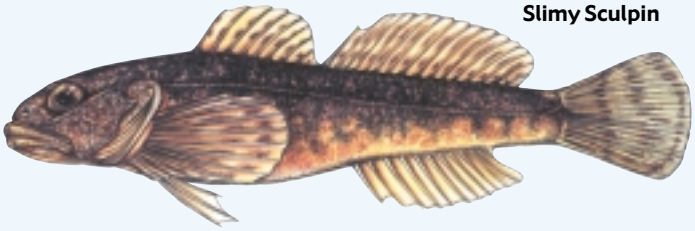
## *Fish swim using their muscles, tail, fins and body shape.*

**Body shapes vary depending on how fish swim or where they live. Understanding this idea can give you clues to where a fish lives in the water.**

Green Sunfish

**Flattened disks:** Fish like sunfish and perch are shaped like a flattened disk on their sides. This shape makes them hard to see (if you are a predator).

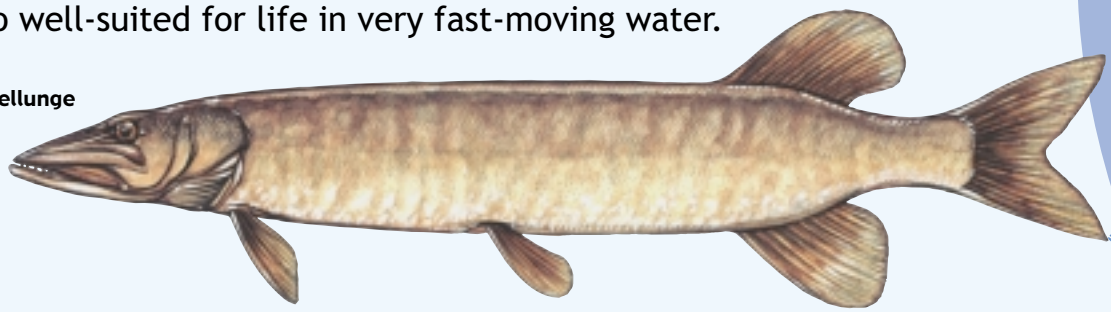
Slimy Sculpin



**Horizontal disks:** Catfish and sculpins are also flattened, but from top to bottom. This shape helps them stay on the bottom.

**Torpedo:** Muskies and trout have streamlined bodies. This shape helps them move quickly. Torpedo-shaped fish are also well-suited for life in very fast-moving water.

Muskellunge



**Snakelike:** Fish like eels have snakelike body shapes. Fish with these shapes slither, just like a snake! They swim quickly and are able to move quickly in different directions.

American Eel

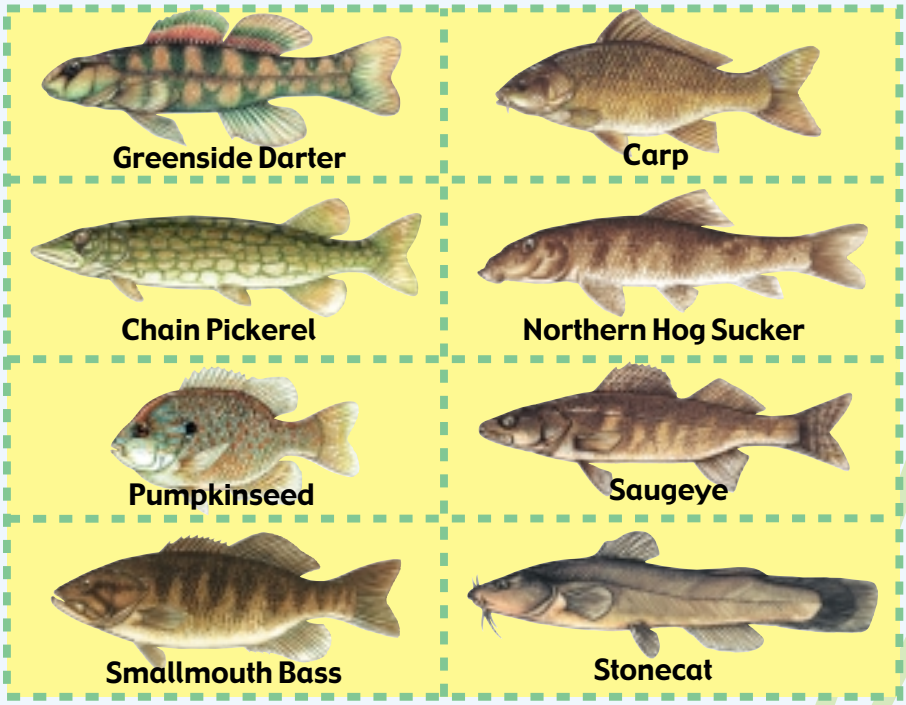

## Want to know more about Pennsylvania fishes?

*Pennsylvania Fishes* is a 170-page full-color book that contains information and identification details on Pennsylvania's fishes. The book sells for $9.43 plus 57 cents PA state sales tax and $3.00 shipping and handling (total of $13).

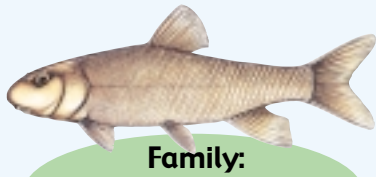
*Please send orders to:* PA Fish & Boat Commission, Educational Media Services, P.O. Box 67000, Harrisburg, PA 17106-7000.

# Pennsylvania

Fish are just as different from one another as we are different from other mammals. There are three different types, or classes, of fish. Cartilaginous fish (Chondrichthyes) have skeletons of cartilage and include the sharks, rays and skates that live in the ocean. Jawless fishes (Agnatha) also have skeletons of cartilage, but they lack jaws. Bony fishes (Osteichthyes) have skeletons of bone. Scientists place different groups of fish in these classes into "orders"




*Which families do the fish above belong to?*



Family: Catostomidae (suckers)

Family: Cyprinidae (minnows)

Family: Lepisosteidae (gars)

Family: Petromyzontidae (lampreys)

Class: Agnatha (jawless fishes)

Class: Chondrichthyes (cartilaginous fishes)

*Not found in Pennsylvania*

Family: Polyodontidae (paddlefish)

Class: Osteichthyes (bony fishes)

Family: Acipenseridae (sturgeons)

Phylum: Chordata: (spinal cord)

Kingdom: Animalia (animals)

**HOLD THIS SECTION UP TO A MIRROR TO REVEAL THE ANSWERS:**

GREENSIDE DARTER– Family: Percidae, CHAIN PICKEREL – Family: Esocidae, PUMPKINSEED – Family: Centrarchidae, SMALLMOUTH BASS – Family: Centrarchidae, CARP – Family: Cyprinidae, NORTHERN HOG SUCKER – Family: Catostomidae, SAUGEYE– Family: Percidae, STONECAT– Family: Ictaluridae

# Fish Family Tree

and then into "families." The easiest grouping of fish to learn is the fish family. That's because members of a fish family share very similar features or life cycles.

There are over 400 fish families throughout the world. Pennsylvania has more than 20 families. Some fish in these families are common. Others are rare. Some are just plain weird-looking. **For now, here is a "big picture" look at those families you might encounter while fishing in Pennsylvania:**

Family: Salmonidae (trout and salmon)

Family: Moronidae (temperate basses)

Family: Sciaenidae (drums)

Family: Cottidae (sculpins)

Family: Percidae (perches)

Family: Osmeridae (smelts)

Family: Gasterosteidae (sticklebacks)

Family: Amiidae (bowfins)

Family: Esocidae (pikes)

Family: Cyprinodontidae (killifishes)

Family: Centrarchidae (sunfishes)

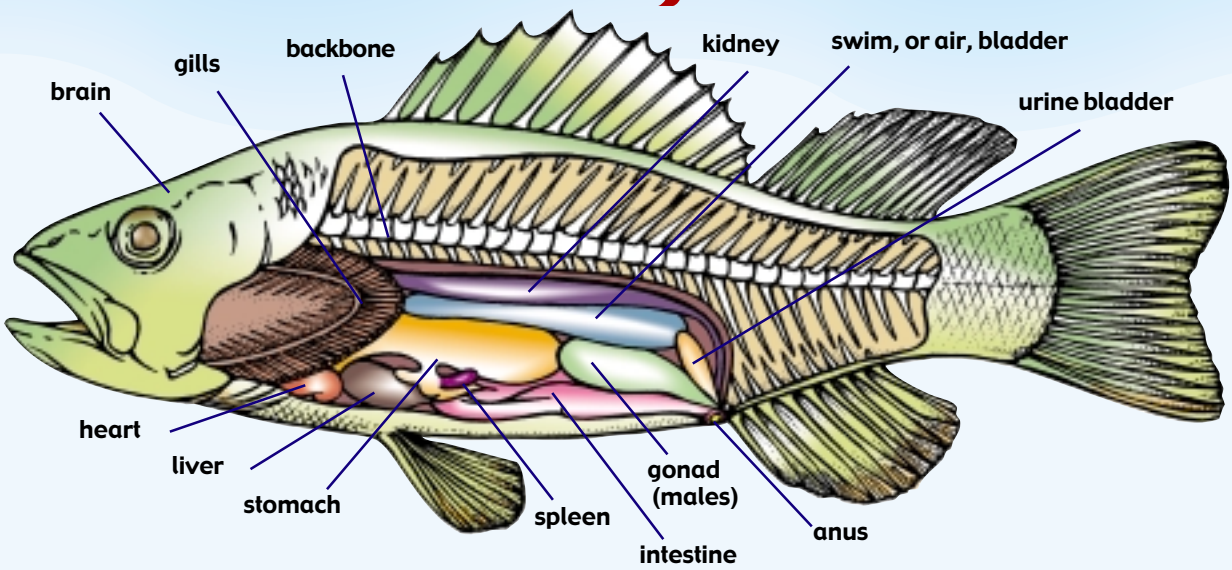
Family: Gadidae (burbots)

Family: Ictaluridae (catfishes)

Family: Clupeidae (herrings)

Family: Anguillidae (eels)

# Internal Anatomy




**Head:** Fish have a bony skull that protects the brain and gills.

**Backbone:** Fish have backbones. The backbone goes from the skull through the body to the tail. Since fish live in water, bones don't have to support the entire body weight. Bones support muscles and give the fish its shape.

**Brain:** Fish brains are small, compared to their body shape. The brain of a trout you catch is about the size of a large pea. The brain of a fish is very different from a human brain. Fish brains have large lobes for smell, and, depending on the species, sight. Human brains have lobes for those things, but other parts, like where we think and reason, are much larger.

**Spinal cord:** The spinal cord is inside the backbone and connects the brain to the organs, muscles and other nerves.

**Ribs:** Attached to the backbone are rows of thin ribs. These ribs protect the fish's internal organs.

**Heart:** Fish have a two-chambered heart. Human hearts are four-chambered. Blood is pumped by the heart into the gills. Blood returns to the heart after going through the organs and muscles.

**Gills:** Fish have gills instead of lungs. A fish takes in water by opening its mouth. Fish "pump" water across their gills by moving the gill covers (operculum). Along the way, the blood takes in oxygen and gives off carbon dioxide through the gills. Bones called gill arches support the gills. Gill arches are the curved, white bony structures you see when you look at the gills.

## *Give Me Some Air!*

Some fish require more oxygen than others. Trout need lots of oxygen. Trout live in colder water because more oxygen is found there. Other fish, like carp and largemouth bass, don't need as much oxygen. They can live in warmer water.

**Stomach and intestines:** As in humans and other animals, these organs help digest food. Nutrients are removed and wastes are passed "down the line" to the fish's anus.

**Liver:** Fish livers are large. The liver filters blood, removing toxins taken in from the environment.

**Kidney and urine bladder:** As in other animals, these organs collect salts and eliminate waste from the fish.

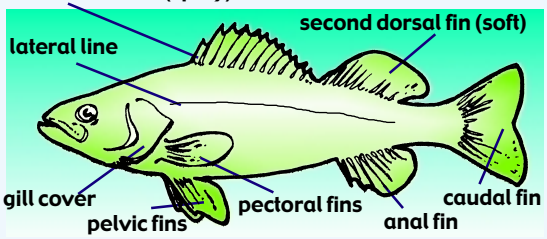
**Air bladder:** Why don't fish sink to the bottom? It's because they have an air bladder. This air bladder helps the fish float upright, in one place, without sinking. The air bladder also magnifies sounds and helps them hear. Some fish species use the air bladder in the same way that we use our lungs: They can gulp air when they stick their heads out of the water.

# Living in Water: Fish Anatomy

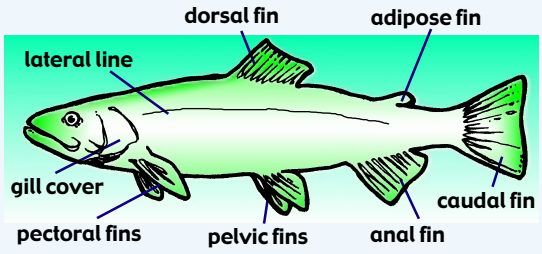
**Fish are adapted for life in water. Even though there are many different shapes and sizes of fish, they have many characteristics in common.**

Pennsylvania's fish can be grouped according to two different body types: Spiny-rayed and soft-rayed. Rays are found in fish fins. They support the fin. Muscles move the rays, which, in turn, move the fin.

**Spiny-rayed fish** have hard, and sometimes sharp, spines in one of the two dorsal fins. The other dorsal fin has soft rays. Yellow perch are spiny-rayed fish.



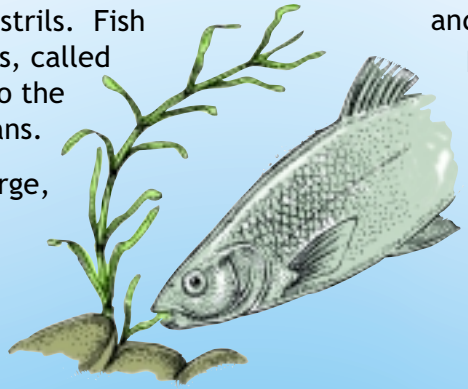

**Soft-rayed fish** don't have stiff, hard spines. They also have only one dorsal fin. Soft-rayed fish also have a small, fatty fin on the back, called an adipose fin. Trout are soft-rayed fish.

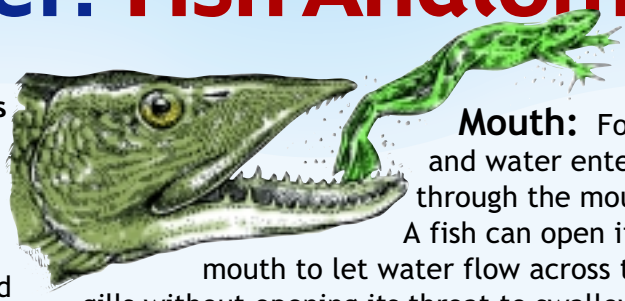



**Fins:** While their dorsal fins may be different, soft-rayed and spiny-rayed fish do have similarities in their other fins.

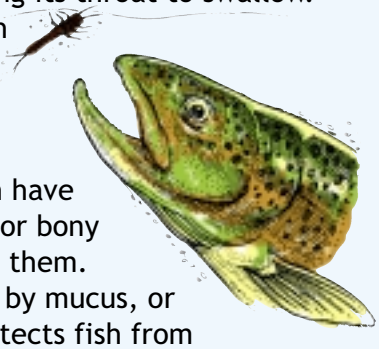
**Head:** A fish's head has a mouth and openings for eyes and nostrils. Fish have two pairs of nostrils, called nares. The nares lead to the olfactory, or smell, organs.

**Eyes:** All fish have large, round eyes. This gives them a wide field of vision.



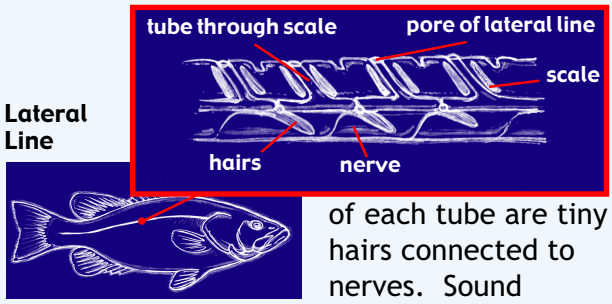


**Mouth:** Food and water enter through the mouth. A fish can open its mouth to let water flow across the gills without opening its throat to swallow. The mouth of a fish is adapted to what it eats and where that food is found.

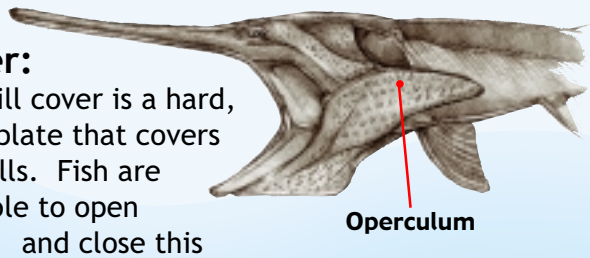


**Scales:** Most fish have overlapping scales or bony plates that protect them. Scales are covered by mucus, or "slime," which protects fish from infection and helps them swim faster.

**Lateral line:** On both sides of nearly all fish is a line of pores called the lateral line. These pores are openings of tiny tubes that go through the scales into the body. At the ends of each tube are tiny hairs connected to nerves. Sound waves (like those from your lure) enter the tubes and make the hairs dance.




**Gill cover:** The gill cover is a hard, bony plate that covers the gills. Fish are able to open and close this plate, pumping water across the gills. This plate also protects the gills, in the same way that your ribs protect your lungs. Another name for this cover is the "operculum."



# Rivers

**Rivers** come in all shapes and sizes. Some are small and flow fast. Others are much larger and flow slowly. One thing that they have in common is that many lower-order tributaries eventually feed them. Some well-known rivers in Pennsylvania include the Allegheny, Susquehanna and Delaware. The lower reaches of these rivers are often much wider, deeper and warmer than their upstream tributaries. The fish that live in them are different because of these conditions.


## Focus on Fishing

Smallmouth bass are a great fish to focus on when fishing in rivers. They are more tolerant of warmer waters than are other fish like trout. They also like living around large rocks, downed trees and debris that can be found in the river environment. You can fish for smallmouth bass from the shore or from a boat. You'll want a fast-action spinning or baitcasting outfit.

Use hellgrammites, minnows and crayfish if you prefer live bait. No smallmouth can resist those tasty treats. Try a crayfish plug, jointed minnow or large spinner if you prefer tossing lures.

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# 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.

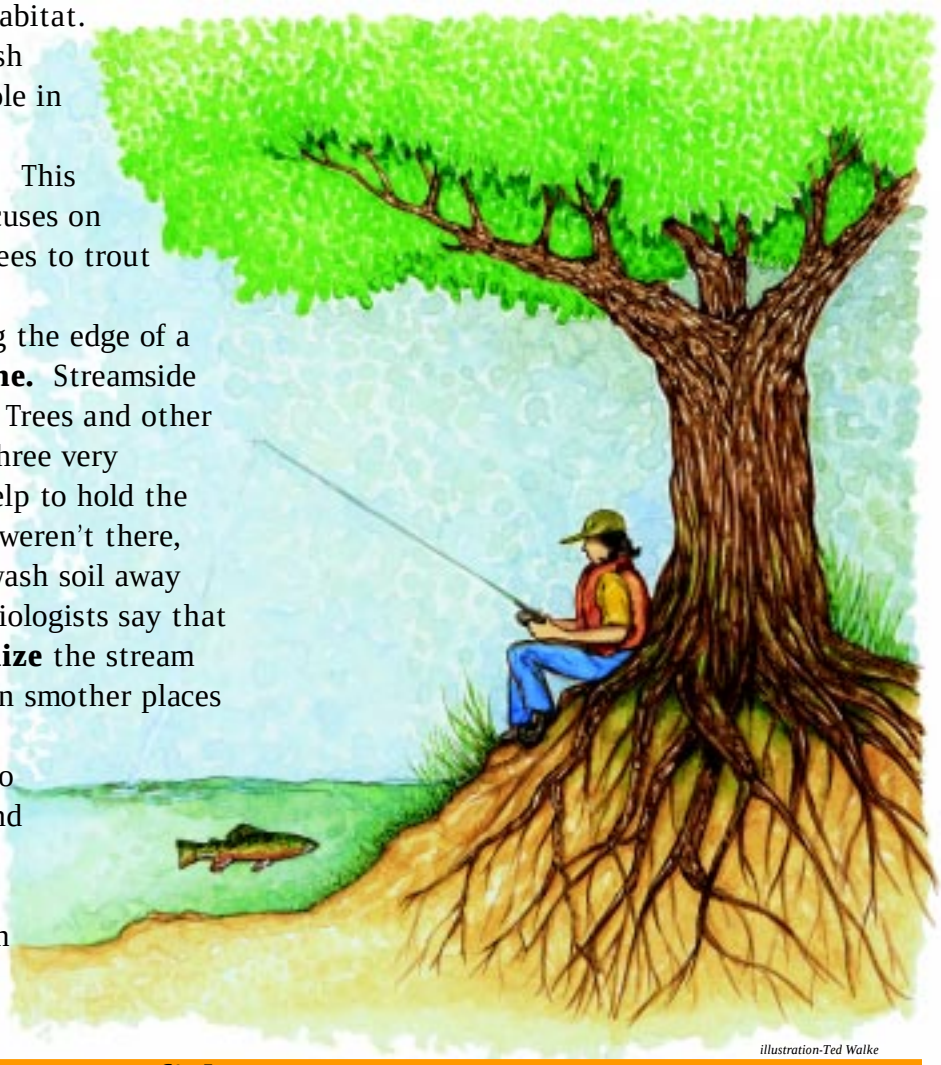


illustration-Ted Walke

# 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.

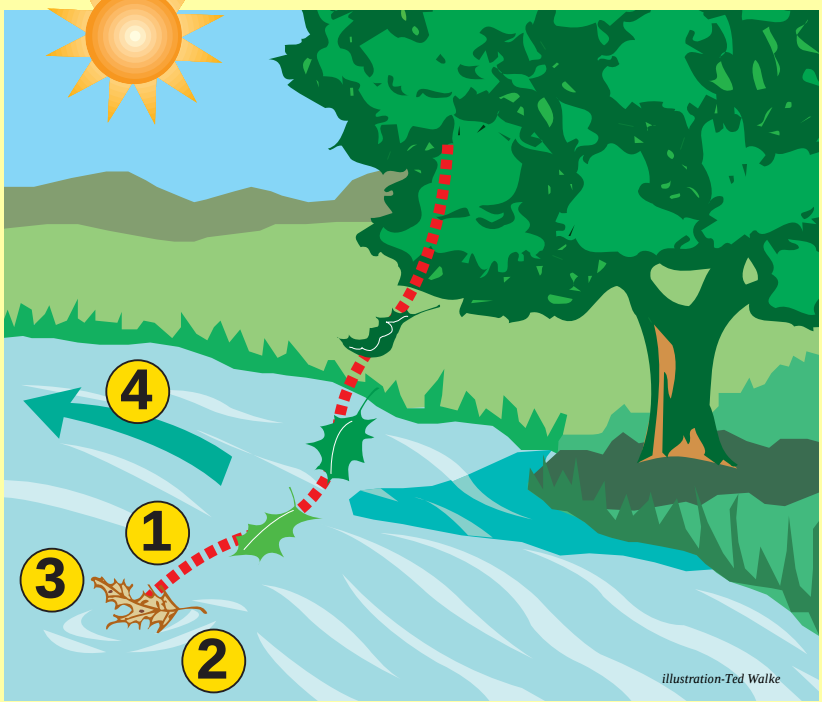
But some of the most important plants in some ecosystems are found outside of the water. This is true for small streams. Plant-eating insects depend on leaves and other material from streamside plants. Biologists call this stuff falling into the stream from plants "**litter.**" Bugs then feed on this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



Dedicated to the Memory of Commissioner Enoch S. "Inky" Moore Jr.

# PDAY

SUMMER 2005

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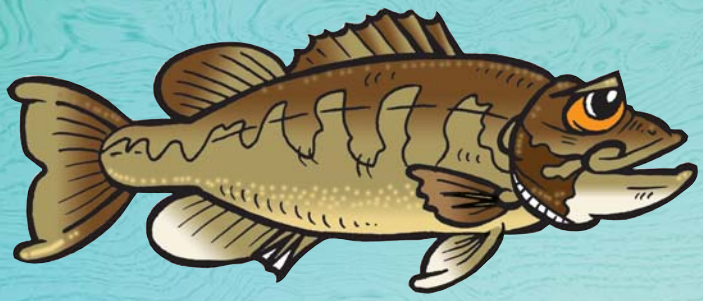
# PA's Most Mighty Migratory Fish

*by Walt Dietz*

**Which fish would you think of if you were asked to imagine one of Pennsylvania's most important and interesting fishes?**

Maybe even the mighty **muskellunge**? What about the state's official fish, the **brook trout**?



Would the popular **smallmouth bass** come to mind?

***Here's a hint:*** This fish once had a significant effect on our state and nation's economy. It still does. And it's had its share of obstacles over the years. How about the **American shad**?

The American shad is one of our state's most important fishes. It was once caught and eaten by Native Americans. Later, an entire fishing industry thrived around it and it fed many people. Is there any wonder why its scientific name is *Alosa sapidissima*, which is Latin for "shad, good to eat"? It's also important in the ecosystem as predator and prey. Today it serves as a great sportfish for many anglers. And it's even good for our state's outdoor recreation economy.

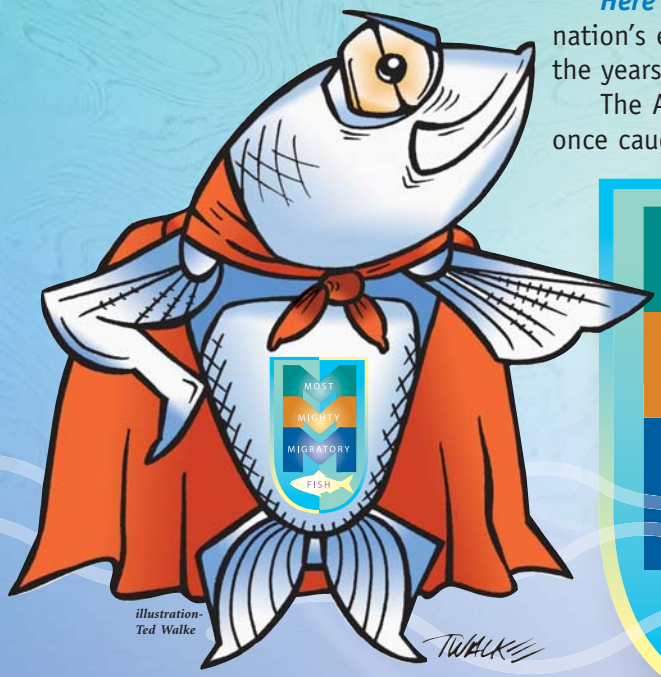



*illustration-Ted Walke*

**The American shad may not have been your first guess to the question about Pennsylvania's most important and interesting fishes. But you might change your mind once you take a closer look at this great fish. Read on to learn more about the story of the American shad!**

www.fish.state.pa.us

PA's Most Mighty Migratory Fish

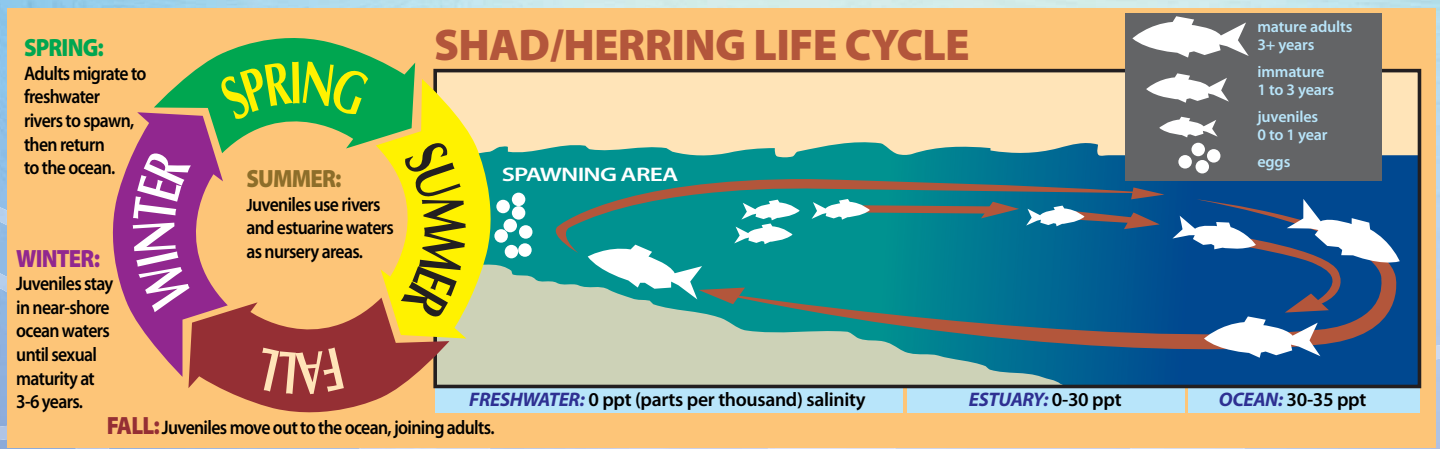
# The Life Cycle of American Shad

The **American shad** belongs to the herring family (Genus: Alosa). It is the largest herring in North America and can grow up to about 24 inches and 6 pounds. It ranges along the Atlantic Coast from Florida all the way to Canada. It likes to eat zooplankton, microcrustaceans and small fish.

This fish is quite a traveler and has a very interesting life cycle. It is anadromous (a-'nad-dro-mus), which in Greek means "up-running." In other words, the "anadromous" shad migrates upstream from salt water to fresh water to spawn. The shad enters two rivers in our state by way of the Chesapeake Bay or Delaware Bay. Can you guess which two rivers? See the map of the shad's migration route to find your answer.


Shad make their journey to the rivers in late spring. They spawn at night in shallow areas where the water is moving. One shad can release up to 300,000 eggs! Most shad die after spawning, but some may survive to spawn another day.

After hatching, the little shad fry live in their river nurseries until the next fall, when they start their journey back to the Atlantic Ocean. Check out the life cycle of the shad, **if you think you can keep up!**




*graphics and illustration-Ted Walke*

PA's Most Mighty Migratory Fish

# Where Have ALL the Fish GONE?

American shad and other migratory fishes have had their share of obstacles over the years. These fish were once plentiful in our waterways.

*Susquehanna Flats, MD 1900*

*archival photos courtesy of U.S. Fish & Wildlife Service*

The Native Americans relied on them as a food source. Fish later became an important food source for European settlers who came to America. Our taste for their meat and caviar (eggs) led to over-fishing, which led to population declines.

Our waterways also became polluted as our nation grew. Sewage, industrial discharges, pollution from cities, runoff from timber harvesting and siltation from farms made it hard for migratory fish to survive their journey.

## American Shad Timeline

*(Susquehanna and Delaware Rivers)*

**1820**
Small mill dams eliminate shad runs on the Susquehanna to Binghamton, NY.

**1830- 1835**
Construction of canal feeder dams on Susquehanna River at Columbia, Nanticoke, Shamokin, Clarks Ferry and Duncan's Island.

**1866**
PA's first commissioner of fisheries appointed. Regulations require fish passage at all dams. Start of five fishways constructed at Columbia with no success at passing fish.

**1873**
First shad hatcheries established.

**1874**
Poor shad harvest results on the Susquehanna and even worse on the Delaware.

**1878**
Construction of Columbia Dam on Susquehanna River.

**1885**
2.5 million pounds of shad commercially caught on Susquehanna River Flats (below dams).

# PA's Most Mighty Migratory Fish

One of the biggest obstacles to migratory fish was building dams. Dams once provided the power to run mills. Today, they are used to make hydro-electricity or provide recreation.

*Conowingo Dam on the Susquehanna River, 6 miles below the Pennsylvania/ Maryland border.*

*Conowingo Dam photos- PECO Energy*

Dams serve an important purpose in our lives, but they also block migratory fish from reaching their spawning grounds.

Dams such as the Conowingo Dam have constructed permanent fish passage facilities to aid these migratory fish.

## WHICH WAY DO I GO?

Make sure you check out the 2004 Fall PLAY issue on **Fishing & History** to learn about how Native Americans and early settlers caught migratory fish.

*illustration-Ted Walke; photo-Vic Attardo*

**1889** Fish baskets and weirs eliminated from Delaware River.

**1891** Shad catches on Delaware show some recovery.

**1904** Construction of York Haven Dam on Susquehanna.

**1910** Construction of Holtwood Dam on Susquehanna (fishways included with no success at passing shad).

**1915** Last commercial harvest of American shad on Susquehanna.

**1926** Construction of Conowingo Dam on Susquehanna.

**1932** Construction of Safe Harbor Dam on Susquehanna.

**1947-1963** Restoration studies began.

**1970** PA Fish Commission, electric utilities and federal government agree on restoration plan.

PA's Most Mighty Migratory Fish

# a SUCCESSFUL SHAD STORY


Shad fry

photo-Russ Gettig


UP

UP

UP

and

We can probably thank the American shad for the Fish & Boat Commission's existence today. Our agency was started in 1866 to address the declines of shad populations. There wasn't much success in the early years. But shad restoration is much different today. And it works, thanks to the efforts of the Commission, electric utilities and other groups.

We are able to help American shad in several different ways. One is the agreement that state and federal agencies have on regulations. These regulations restrict the harvest of American shad and other migratory fish in the rivers, bays and ocean.

We have programs in place to restore stream and river habitat and remove dams that block fish passage.

AWAY

*The fish lift at Safe Harbor Dam began operation in 1997. This fish lift, like Conowingo Dam's lift, passes migrating fish directly into the pool above the dam.*


*At left, water from above the dam attracts fish into the fish lift. A gate closes and crowds the fish over a bucket, which lifts the fish, in water, and releases them into the channel at a level above the dam.*

*Safe Harbor Dam photos-Ted Walke*

## American Shad Timeline

(Susquehanna and Delaware Rivers) *continued*

**1972**
Construction of Conowingo fish lift completed.

**1971-1974**
124 million shad eggs transplanted.

**1976**
Susquehanna River Anadromous Fish Restoration Committee (SRAFRC) formed.

**1972-1980**
7 million shad fry stocked in Juniata River.

**1980**
Shad fishing closed on all Maryland waters of the Chesapeake Bay.

**1981**
750 American shad counted at Conowingo Dam.

**1985-1994**
150,000 adult shad released to spawn above dams on Susquehanna. 100,000 shad fry released into Susquehanna.

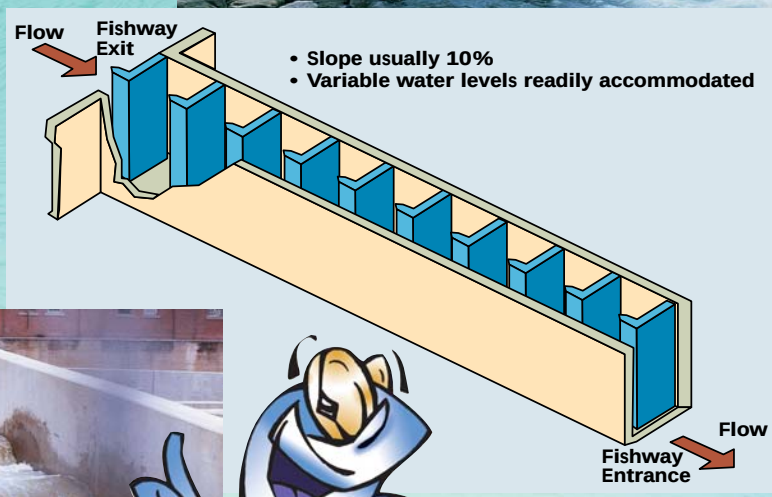
# PA's Most Mighty Migratory Fish

photo-Mike Hendricks

*Fish & Boat Commission personnel release 21-day-old inch-long shad fry into the Juniata River at Millerstown, Perry County. The Commission raises 10 million to 20 million shad fry annually for stocking. Raising shad and stocking them above blockages is currently a major part of restoration.*

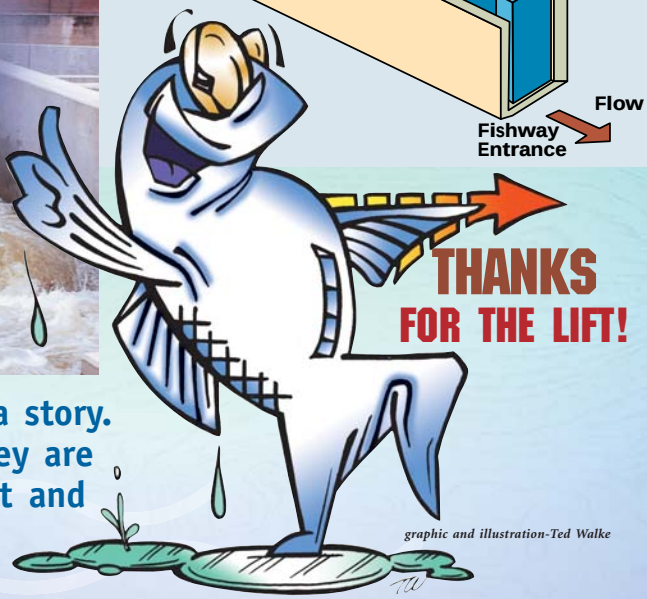
Regulations also require utilities (the dam owners) to provide fish passage at each dam that cannot be removed. These utilities have built fishways, elevators or lifts that help transport fish over the dam so they can continue their upstream migration. All four of the big hydroelectric dams on the lower Susquehanna River have fish elevators or lifts.

Finally, the Commission restocks fry and migrating adults to areas above the dams so that they can reach their spawning areas. The shad fry come from eggs that are taken from adult shad and raised in a hatchery.




*Fishways constructed on barriers (see graphic) are called ladders. Migrating fish swim up the ladders at their own pace to reach upstream spawning habitat.*

photo-U.S. Fish & Wildlife Service




graphic and illustration-Ted Walke

**American shad have quite a story. Now you might agree that they are Pennsylvania's most important and interesting fishes.**

**1990**
15,000 American shad counted at Conowingo Dam.

**1995**
Holtwood fish passage completed.

**1997**
Safe Harbor fish passage completed.

**2000**
York Haven fish passage completed.

**2001**
193,574 American shad counted at Conowingo dam, a new record!

**2001**

DCNR agrees to provide fish passage at inflatable dam in Sunbury.

**2003**
125,135 American shad counted at Conowingo dam.

PA's Most Mighty Migratory Fish

# Many More Migratory Fish

illustration-Ted Walke

**American shad aren't the only fish that migrate up and down Pennsylvania's waterways. You might be surprised to learn how many fish move between the Atlantic Ocean and our state's waterways. One fish even does it in reverse!**

**Gizzard shad** (*Dorosoma cepedianum*). This herring is a bit different from the others. It has a muscular gizzardlike stomach to process plankton and plant food that it strains from the water.

**Striped bass** (*Morone saxatilis*). This fish can live up to 30 years and reach sizes of 4 feet long and 50 pounds! It spawns near tidal tributaries. Small stripers may move up rivers to feed during the summer. Landlocked stripers can be found in some of our state's bigger lakes.

**Hickory shad** (*Alosa mediocris*). This endangered shad is slightly smaller than the American shad, reaching lengths of around 15 inches. This shad prefers to eat small fish.

**Atlantic sturgeon** (*Acipenser oxyrhynchus*). This prehistoric fish is endangered. It can reach huge sizes up to 14 feet long! It migrates to the lower reaches of the Delaware River to spawn.

**Alewife** (*Alosa pseudoharengus*). This shad prefers to spawn in smaller tributaries and slack water. A "landlocked" form of the alewife has been stocked into lakes across the state as forage for gamefish.

**American eel** (*Anguilla rostrata*). The eel does things in reverse. It is catadromous (cat-'tad-dro-mus), which means "down-running." It spends most of its life in fresh water and then migrates to the Atlantic Ocean's Sargasso Sea to spawn.

**Blueback herring** (*Alosa aestivalis*). This herring looks like the alewife, but it's slightly bigger. It migrates to the lower Delaware River and Delaware estuary.

**Paddlefish** (*Polyodon spatula*). This bizarre-looking critter migrates up and down the Allegheny and Ohio rivers in search of plankton to eat.

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