The Basics of Water Pollution in Pennsylvania

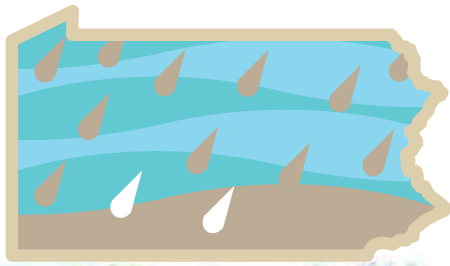


photo-Russ Gettig

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.

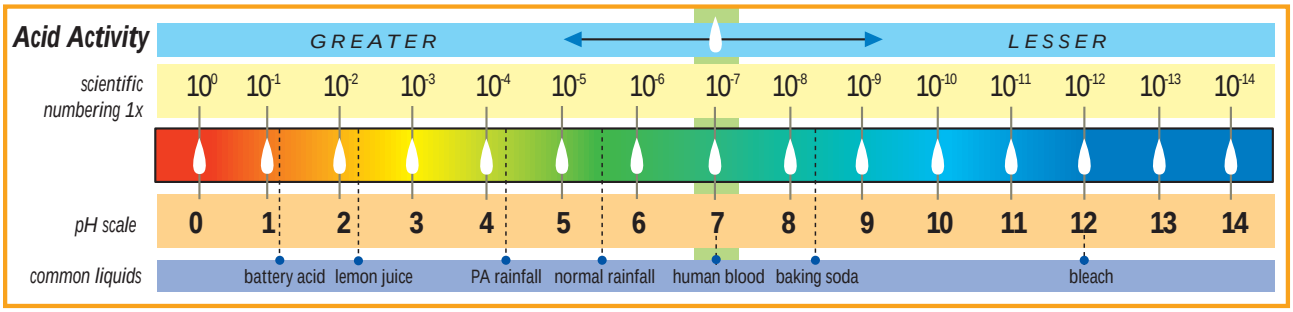
Requirements for life

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

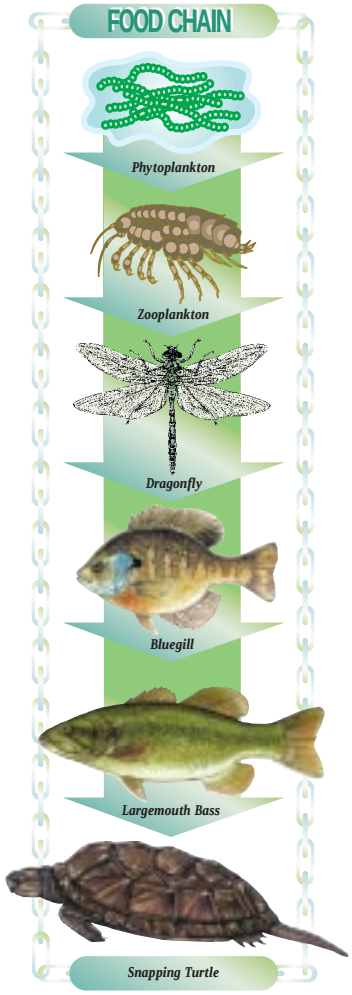
*to convert Fahrenheit to Celsius: [(F-32) x 5]/9=C

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

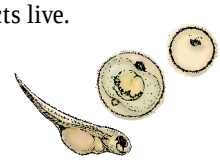
Little Sewickley Creek, Westmoreland County. The yellowish-orange stream-bottom staining of "yellow boy" is caused by acid mine drainage.

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.

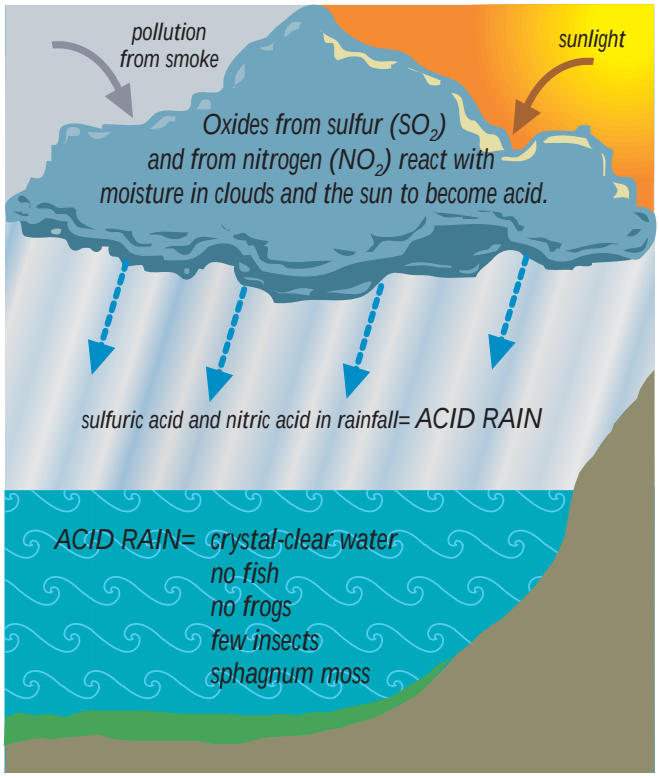
Acid rain



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

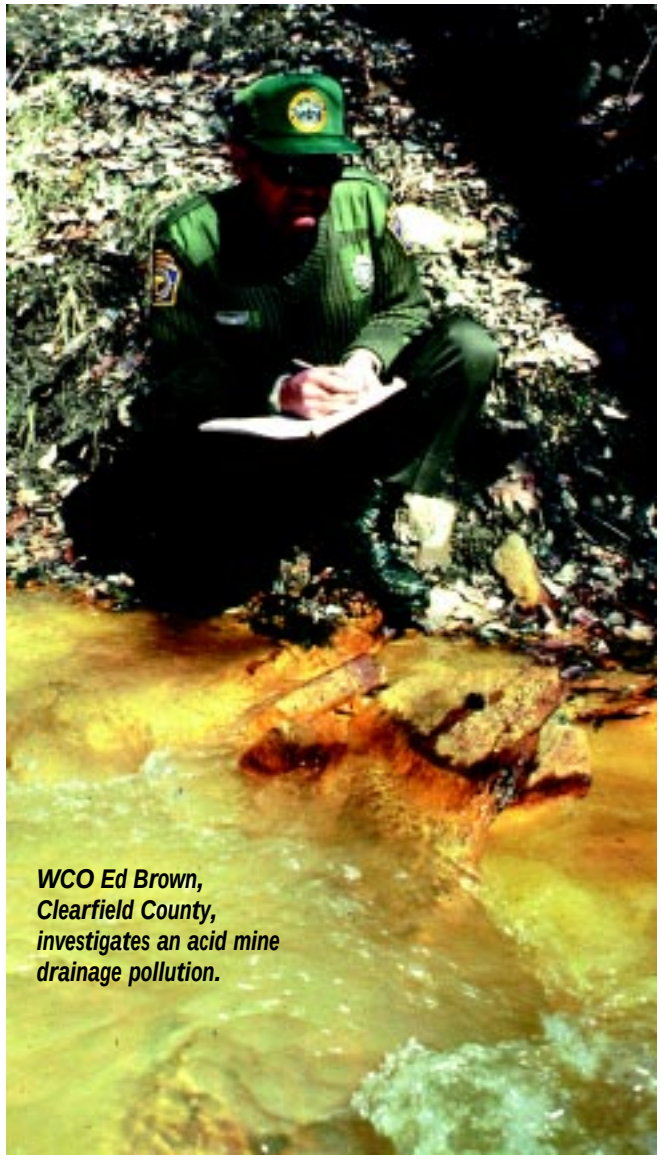
Permits and Regulations. The best way to address pollution is to prevent it. The Commonwealth of Pennsylvania has laws in place protecting water quality. The PA DEP regulates the things industries release into the air or water. DEP also has regulations in place protecting banks and channels in rivers, 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.

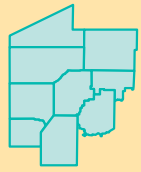
Second, you can become part of the solution. Evaluate your own use of fertilizers and pesticides at home in your yard. If you don't purchase a fishing license, consider doing so. Fishing license dollars help the Fish & Boat Commission do its job protecting Pennsylvania's fish and aquatic life. The Fish & 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.

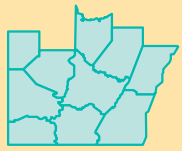
"The people have a right to clean air, pure water, and to the preservation of the natural, scenic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee for these resources, the Commonwealth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

PFBC Regional Law Enforcement

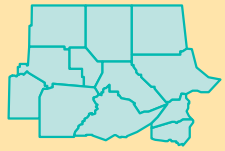
Northwest Region. 11528 SH 98, Meadville, PA 16335; 814-337-0444. Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango and Warren counties.



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

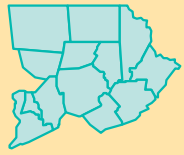


Northcentral Region. 450 Robinson Lane, Bellefonte, PA 16823; 814-359-5250. Cameron, Centre, Clearfield, Clinton, Elk, Jefferson, Lycoming, McKean, Northumberland (west of Rt. 147), Potter, Snyder, Tioga and Union counties.



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.

SPORT FISH RESTORATION
Your purchase of fishing equipment and motor boat fuels supports Sport Fish Restoration and boating access facilities