Field Guide to South Carolina's Streams, Lakes and Wetlands

Governor's Division of Energy, Agriculture and Natural Resources

WATER WATCH FIELD GUIDE TO SOUTH CAROLINA'S STREAMS, LAKES AND WETLANDS

WATER WATCH

A Program of the Governor's Office
Division of Energy, Agriculture and Natural Resources

Carroll A. Campbell, Jr., Governor

July 1988

State of South Carolina

Office of the Governor

Dear Friends:

I want to invite you to become part of a unique experience known as Water Watch. Water Watch is a public participation program that encourages citizens to adopt a stream, lake or wetland so they can gain hands-on experience in protecting and promoting stewardship of South Carolina's water resources.

This field guide was specially developed for Water Watch. It provides an illustrated guide with information for aiding field observation, monitoring and analysis of South Carolina's aquatic resources. I hope it will provide your group with an enjoyable learning experience that will ultimately lead to a greater appreciation for our natural environment and greater public participation in protecting it.

Please join my Water Watch program and use this guide in conjunction with the SC Water Watch Program Manual to get your group started. Conservation groups, civic organizations, school groups, scout troops, property owners -- anyone interested in guarding and protecting the health of our aquatic environment is welcome.

I commend and encourage you in your efforts to protect our highly valued natural resources and clean environment.

Sincerely,

Carroll A. Campbell, Jr.
Governor

ACKNOWLEDGEMENTS

This publication was compiled and edited by William D. Marshall who wishes to acknowledge the contributions and editorial assistance of Tom Poland, Nancy Ann Coleman, Mina Harrington, Jim Bulak, Steve de Koslowski, and Virginia Beach. Others who provided review and comments include: Barry Beasley, Ronny Rentz, Doug Baughman, Charles Logan, Malcolm Leaphart, and Mary Lynn Batson. Thanks to John Gelinas for his assistance in the layout of this guide and to Pat Cockrell for typing support.

A Field Guide to South Carolina's Streams, Lakes and Wetlands is an adaptation of publications produced by the following:

The Kentucky Water Watch Program, Kentucky Natural Resources and Environmental Cabinet, Division of Water;

The North Carolina Stream Watch Program, North Carolina Department of Natural Resources and Community Development, Division of Environmental Management; and

The Maryland Save Our Streams Program, Maryland Department of Natural Resources, Tidewater Administration.

We gratefully acknowledge these agencies for their permission to adapt text and illustrations from their program materials.

Funds for publishing this field guide were provided by:

The Harry Hampton Memorial Wildlife Fund,

The Governor's Task Force on Litter,

The Sierra Club, South Carolina Chapter, and

The Saluda River Chapter of Trout Unlimited.

Figures presented in this guide were adapted from the following publications:

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Chapter 1: Ecology

Ecology is the study of the relationships between living things and their environment. Understanding ecology helps us appreciate water as a vital resource. This chapter discusses these relationships and how the natural lay of the land and man's activities affect river, lake, wetland and stream ecosystems.

Lakes and wetlands make up that part of South Carolina's water bodies commonly referred to as standing water. A **lake** can generally be defined as a body of standing water occupying a definite basin. A small lake shallow enough to allow growth of rooted plants from one shore to the other is commonly referred to as a **pond**. Areas not deep enough to be called a lake but covered with water or featuring saturated soil at least part of the year are **wetlands.** A wetland that supports shrubs and/or relatively large trees such as cypress and gum is classified as a **swamp.** A treeless wetland area occupied by grasses, rushes and sedges is referred to as a **marsh**. Almost one quarter of South Carolina's total land area can be classified as wetland. Over 11,000 miles of **rivers and streams** make up South Carolina's flowing waters. All of these water bodies serve many purposes. They are necessary and valuable elements of our state's natural resources.

Lakes

Life Groups and Zones

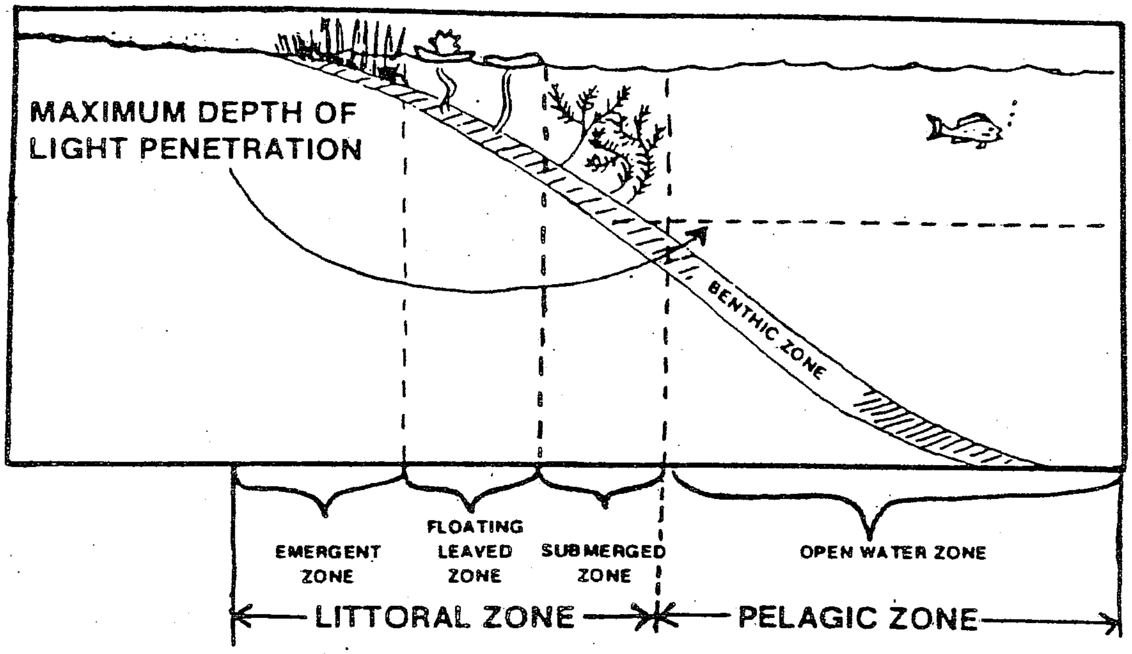
A glance at a lake might lead you to believe it's just a large body of water, pretty much the same throughout. Lakes, however, can be divided into a number of regions (See Figure 1-1). Each region has its own features and characteristic life forms. The region of free, open water is the **pelagic zone** where tiny organisms known as plankton live. Animal components of the plankton are referred to as zooplankton; plant components are known as phytoplankton.

The animals that live on or in the bottom of the lake are called the **benthos** or **benthic organisms.** Benthic animals large enough to be seen with the unaided eye such as freshwater clams and crayfish are called **macrobenthic** organisms. Fish and other free-swimming animals are sometimes referred to as the **nekton.**

The shallow region around the edge of a lake, from the highest seasonal water level to the depth where light cannot reach the bottom, is called the **littoral zone.** This is the major zone of large plants **(macrophytes)** in a lake. This zone is an area of great productivity and any fishing enthusiast will tell you this area provides cover and breeding habitat for many species of fish. Protection of the littoral zone is critical to the life of the entire lake ecosystem.

Closest to shore (0 to 5 feet deep) grows a band of **emergent** plants that rise above the water surface. Cattails are a good example. Going away from the shore (2 to 10 feet deep) is a band of **floating-leaved** plants such as water lilies. Extended farther outward to the depth of maximum light penetration is a band of **submerged** plants that do not reach the surface. The depths of these zones vary with the nature of individual lakes, and plants characteristic of one zone are often found in other zones.

Figure 1-1. The life zones of a lake.



The Seasonal Cycle of Lakes

The internal structure of most lakes changes with the seasons. A cycle occurs whereby a lake becomes **stratified**, or layered, based on the temperatures of the various layers. The cycle begins in spring/early summer and proceeds as follows. Before the lake begins to warm, it is almost uniform in temperature from top to bottom. Gradually, as the days grow longer and the sun climbs higher in the sky, the water at the surface grows warmer. This creates a **density difference** between the warmer, lighter surface water and the heavier, colder deep water. As the temperature difference between surface and deeper waters increase, so does the density difference until a **density discontinuity** (a barrier) is produced. The densities of the surface and deeper water masses become so different they no longer easily mix.

As a result, three layers form in a lake during the summer... an upper warm layer called the **epilimnion;** a lower cold layer called the **hypolimnion;** and a narrow layer of rapid temperature change in between, the **thermocline.** This process is referred to as the **thermal stratification** of a lake. This temperature difference can be felt when you dive into a lake in the summertime.

Stratification holds important consequences for the lake and its life. Since the upper and lower layers are separated, the only circulation that can occur is in the surface layer as winds move it. Oxygen enters the water through contact with air and from phytoplankton production as well. The deep layer is effectively cut off from a supply of oxygen during the **period of summer stagnation.** If some process uses up the oxygen left in the hypolimnion, most animal life there will die. As you'll see later, this does, in fact, happen.

In autumn, as the air cools, the epilimnion also cools, eventually reaching a temperature equal to that of the hypolimnion. The density difference disappears. At this point, winds mix the waters from top to bottom. Top waters circulate to the bottom and bottom waters to the top. The lake, in essence, turns over, and this period is referred to as the **period of fall turnover.** Then winter arrives and further cools the surface water and it becomes more dense (heavier). Water is most dense and heaviest at 39 degrees F. The colder water, between 39 and 32 degrees F, is lighter. The result is another stratified situation with the top layer now being colder but still lighter than the water below. Since our lakes seldom freeze over, their waters remain in circulation all winter, generally skipping the **period of winter stagnation**.

With spring's arrival, surface waters warm up. Now, winds can circulate the waters from top to bottom again causing the **period of spring turnover**, thus completing the cycle.

Figure 1-2. Thermal stratification of a lake during the period of summer stagnation.

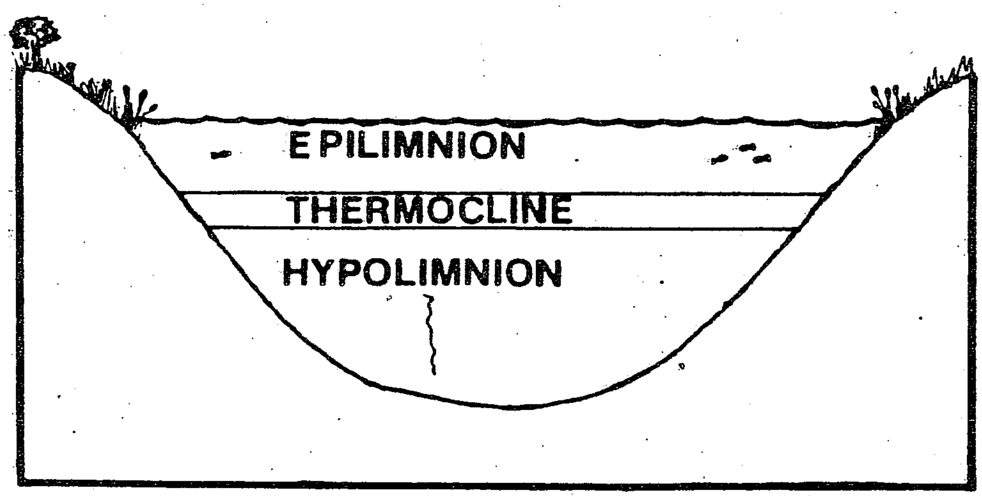
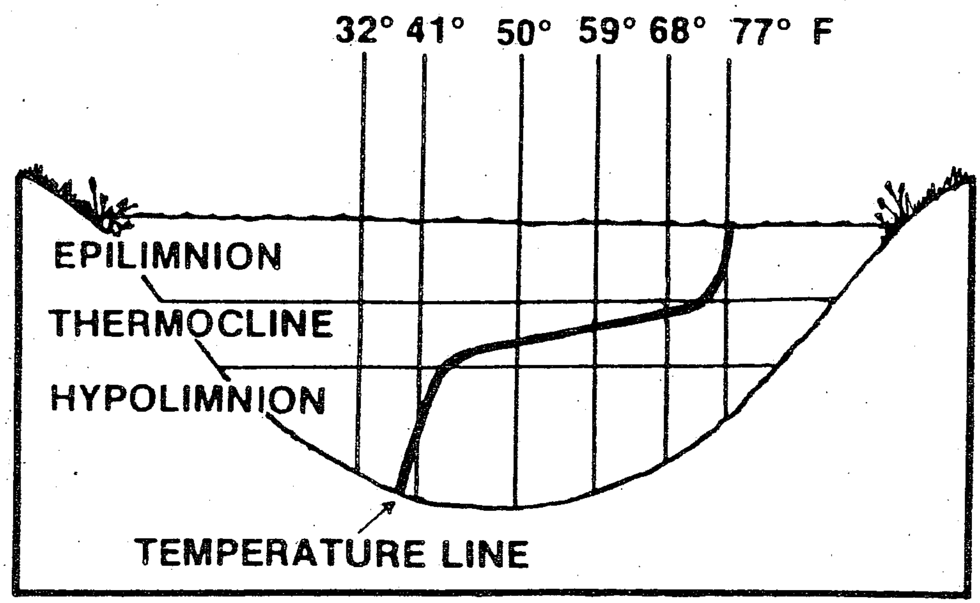


Figure 1-3. Temperature profile of a stratified lake during period of summer stagnation. Note rapid temperature decline passing down through the thermocline.



Cultural Eutrophication

A major problem affecting lakes today is **cultural eutrophication**, a process whereby lakes receive excessive amounts of nutrients such as nitrogen and phosphorous. It may sound good, but it isn't. Excess nutrients combined with a lake's plant life and the cycle of stratification can lead to drastic changes in the lake's habitat.

The phytoplankton of a lake consist of algae that can reproduce very quickly when given enough food. When the warmer waters of late spring combine with nutrients brought up from deep waters during the spring turnover, conditions become ideal for algal growth. Normally, the algae quickly use up their food supply making algal blooms short-lived. This process is referred to as natural eutrophication.

The problem of **cultural eutrophication** arises when nutrients from sewage, agricultural runoff and other sources join natural food supplies producing an essentially limitless supply of food for the algae. Capitalizing on a continuous source of food, the algal population continues to grow in the epilimnion as the summer stagnation occurs. Individual algae are short-lived. As more are produced, more die and sink through the thermocline and on into the hypolimnion which is now cut off from a oxygen supply. The decaying algal organisms sinking down from the surface layers consume large amounts of oxygen.

A chain reaction can now occur leading to serious impairment of the lake as an enjoyable, productive resource. The lake is in a mess. An unsightly scum of algae covers the surface. Gases such as hydrogen sulfide bubble to the surface creating a characteristic rotten egg odor. Fish and other animal life die. When the fall turnover takes place, dead and decaying organisms arise to the surface. This entire process is referred to as cultural eutrophication since it is caused by man's cultural activities.

Wetlands

Types of Wetlands

Wetlands are areas covered with shallow water (usually less than six feet) or with saturated soil at least part of the year. Wetlands represent some of the least understood and unappreciated environments in South Carolina. This is unfortunate because wetlands without a doubt are some of the most valuable and productive areas in the state.

Wetland areas include "wet" habitats commonly called marshes, swamps, bogs, sloughs, potholes, backwaters and mud flats. Technically, wetlands are lands between dry land and aquatic systems where the water table is at or near the surface most of the time or the land is covered by shallow water. In wetland environments, water saturation is the most important factor in determining the nature of the soil and the kinds of plants and animals growing there. Most wetland plants, for instance, are referred to as **hydrophytes**, plants adapted to living in the low-oxygen conditions of saturated soils.

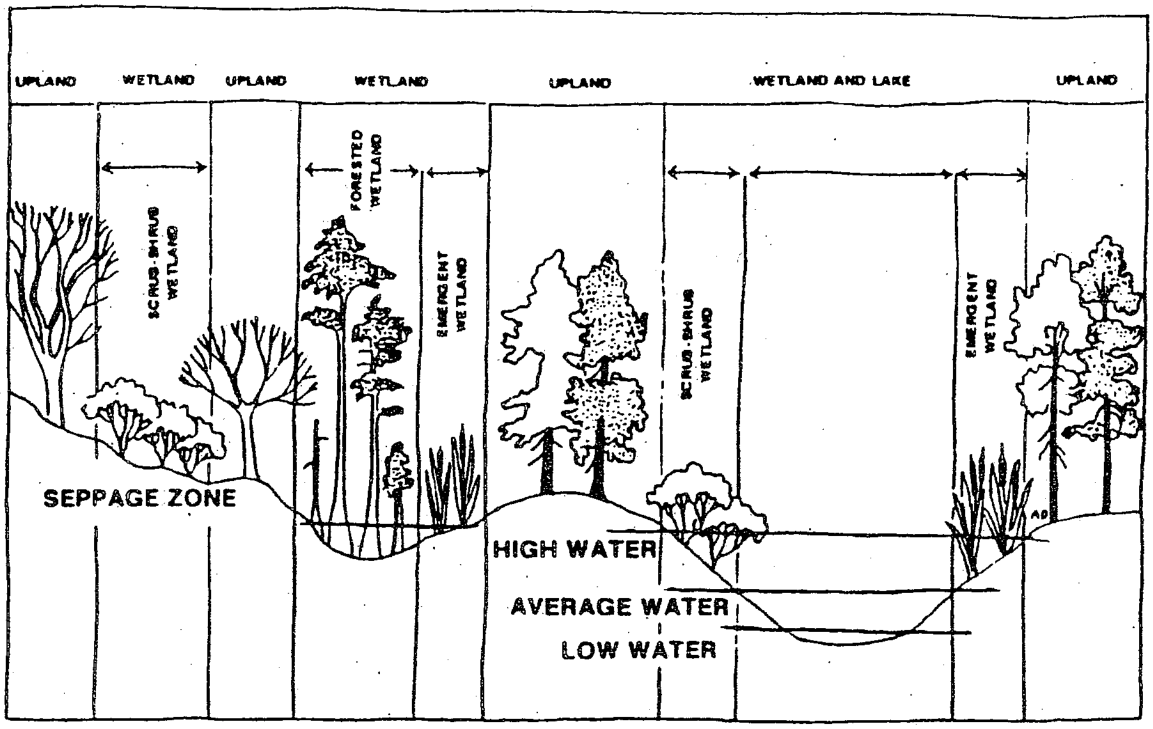
A marsh is a treeless wetland occupied by grasses, rushes and sedges. These **emergent wetlands** are similar to the emergent zone around lakes. They support the same types of emergent plants... cattails, bulrush and floating-leaved and submerged plants as well.

The **swamp** is a wetland with trees. Actually, the common name "swamp" covers two types of wetland. The **scrub/shrub wetland** is a swamp dominated by small trees and brushes less than twenty feet in height, such as buttonbush and willow. The **forested wetland** is similar but is dominated by trees over twenty feet in height, such as cypress and gum. **Bottomland hardwoods** are a type of forested wetland occurring along the floodplains of rivers and their tributaries.

The Importance of Wetlands

For hundreds of years, wetlands have been falsely viewed as wasted land that should be drained or filled and put to more "productive" use. Only after losing over half of our country's wetlands have we come to realize that such areas occupy an important place in the overall "natural scheme of things." In fact, the more we learn about wetlands, the more we discover about the positive roles they have played and continue to play in the wise management of our water, fish and wildlife resources.

Figure 1-4. Examples of wetland habitats in South Carolina.



Modified from Cowardin 1979

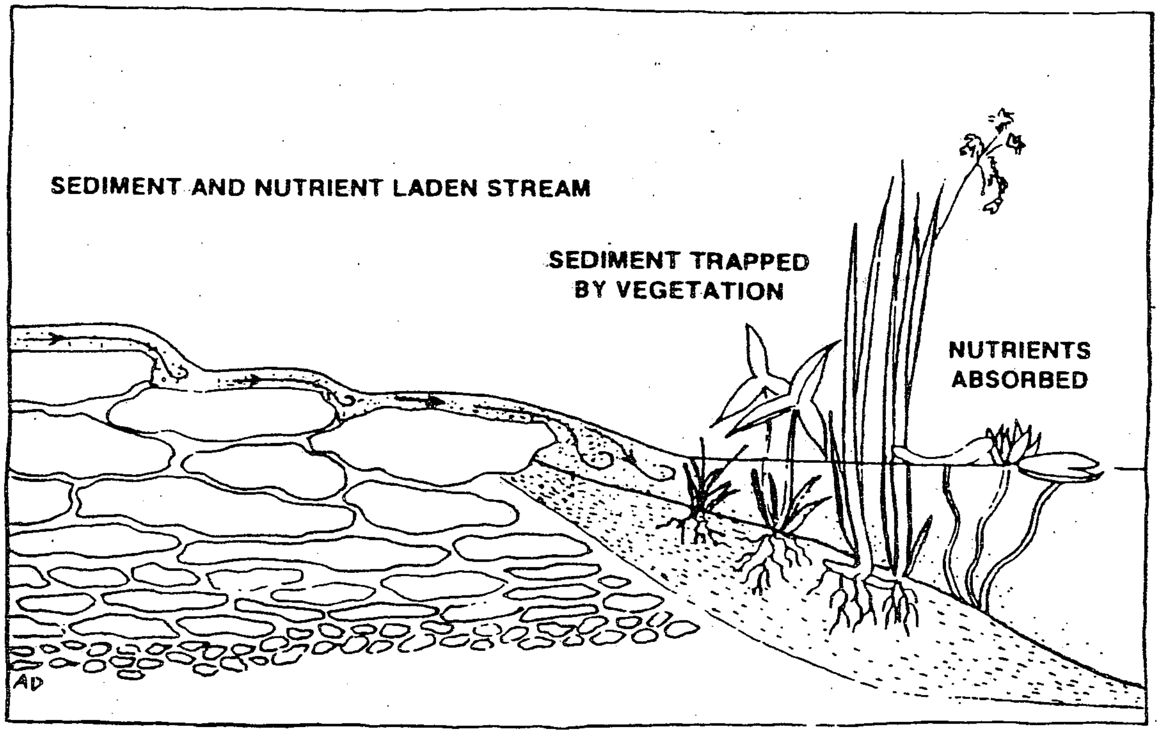
The following are a list of ecological functions or beneficial services provided by wetlands.

Filtering Pollutants

Wetlands help prevent problems associated with cultural eutrophication by absorbing nutrients, especially nitrogen and phosphorous essential to plant growth. As with all types of ecosystems, however, a limit exists as to the amount of nutrients that can be absorbed. Though wetlands can be of great help in reducing eutrophication, the sources of excess nutrients still need to be controlled. The same is true for other pollutants such as farmland pesticides and industrial pollutants. Wetlands can remove some of these pollutants by filtering them out, chemically breaking them down and absorbing them through root systems... as long as the amounts aren't excessive.

As water passes through a wetland, dense vegetation slows down the rate of flow, and many sediments carried along by the faster water settle out. Thus, wetlands help reduce the **turbidity**, i.e. cloudy appearance of water, and help retard the filling of lakes and reservoirs through siltation. A study in Wisconsin determined that wetlands, under ideal conditions, can remove 90 percent of the sediments from water.

Figure 1-5. Wetlands Purify Water.



Flood and Erosion Control

It's very clear now that the draining and filling of floodplain wetlands has been partly responsible for some of our country's recent major flood disasters. Wetlands store water during flooding and then gradually release the waters. This reduces flood crests and slows the rate of flood waters, thus lessening downstream flood damage. The U.S. Army Corps of Engineers determined that the best way to prevent flooding in the Charles River watershed near Boston was to protect the area's naturally occurring wetlands. Acquiring the wetlands was more economical than building dams and dikes and provided the same level of protection. Wetlands also reduce shoreline erosion by absorbing the force of water along the river banks and the force of wave action around lakes, thereby protecting homes along their fronts.

Water Supply and Groundwater Recharge

Waters that end up in wetlands would otherwise flow downstream and be lost as a resource to the upstream area. Retention of these waters makes them available for domestic or municipal water supply, livestock watering and irrigation. Thus, by protecting wetlands, we reduce downstream flood damage and assure future water supplies. On the other hand, dredging and filling wetlands increase flood and erosion damage and allow the loss of water resources of upstream regions. Furthermore, many wetlands retain water and allow it to seep into the ground to replenish groundwater supplies, a process called **groundwater recharge.**

Biological Productivity

Some of the most productive natural systems in the world are wetlands -- a far cry from the traditional view of a "wasteland." Freshwater wetlands share a productivity level that competes with tropical rain forests and salt marshes. Such a high level of productivity results from many factors... nutrient-laden water and wetland plants' high efficiency rates of converting solar energy into organic material. These same plants, of course, add large amounts of oxygen to the air and water.

Animals such as muskrats feed directly on marsh plants, but most plant material settles on the bottom and breaks apart to form **detritus** (partially decomposed organic material). Detritus is eaten by aquatic insects and other macrobenthic animals that, in turn, are eaten by fish, waterbirds, and still other animals. Vitamin-rich detritus and nutrients from its decay drift downstream to increase the productivity of other areas. Wetlands, therefore, function as the "prime farmland" of the aquatic world. Many, many lifeforms depend on this food source.

Fish and Wildlife Habitat

Wetland areas along rivers and lakes provide food and spawning and nursery grounds for such species as largemouth bass, bluegill, other sunfishes, catfish, minnows, carp and still other fish species. Bottomland hardwood wetlands are especially important areas as spawning and nursery grounds for warmouth sunfish and largemouth bass. River wetlands in Georgia have been known to produce up to 1,300 pounds of fish per acre.

Providing year-round habitat for resident birds as well as breeding grounds, wetlands are nearly as important to birds as to fish. Wetlands also provide overwintering habitat and feeding grounds for migratory species. Waterfowl, such as ducks and geese, and wading birds, such as herons, egrets, sandpipers, are familiar wetland inhabitants. The largest of game birds, the wild turkey, also nests in bottomland hardwood forests.

Wetlands are also home to a diverse array of reptiles, amphibians and mammals. The list of common residents is a long one that includes muskrats, mink, otter, raccoons, skunks, weasels, many rodents, various turtles, toads, frogs and numerous salamanders. The number of amphibians alone that can occur in wetlands (especially in the spring) is nothing short of a minor miracle. One small, forested pond in Georgia less than 100 feet wide revealed 1,600 salamanders and 3,800 frogs/toads to one diligent investigator.

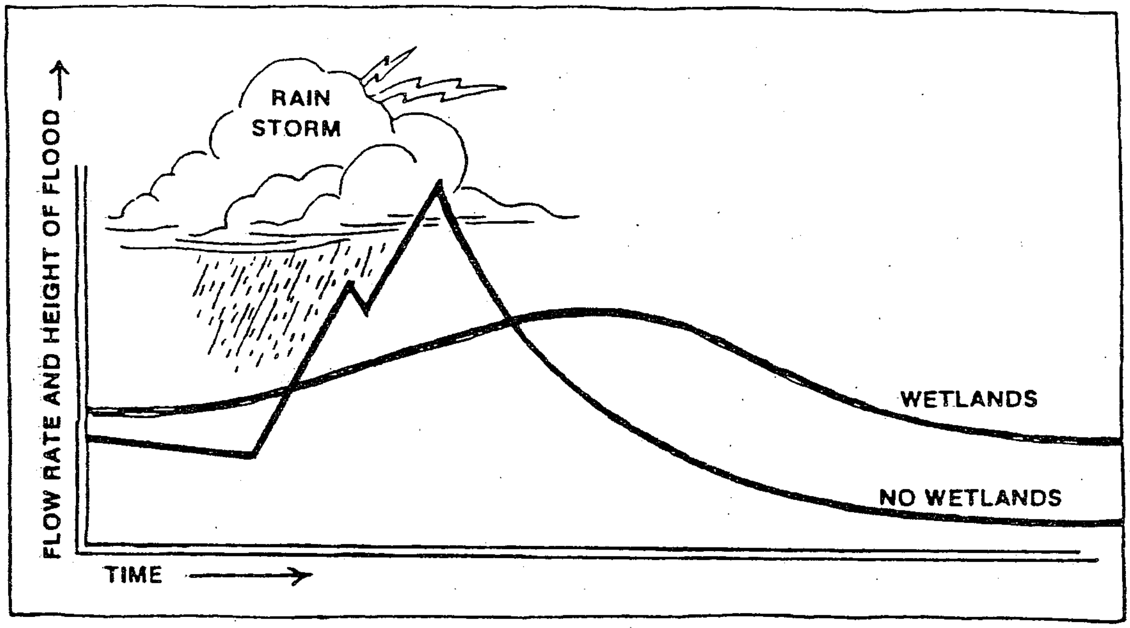
Endangered and Threatened Species

South Carolina defines a **threatened species** as one which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in the state. Similarly, an **endangered species** is in danger of extirpation and/or extinction throughout all or a significant portion of its range in the state. Many threatened and endangered species depend on wetlands during at least one part of their lifetime. Moreover, many endangered plants require wetlands for their survival. A major reason plants are endangered or threatened is that the habitat upon which their existence depends is itself approaching an endangered condition.

Examples of threatened or endangered species associated with wetlands in South Carolina include: Shortnose Sturgeon (fish), Swallow-tailed

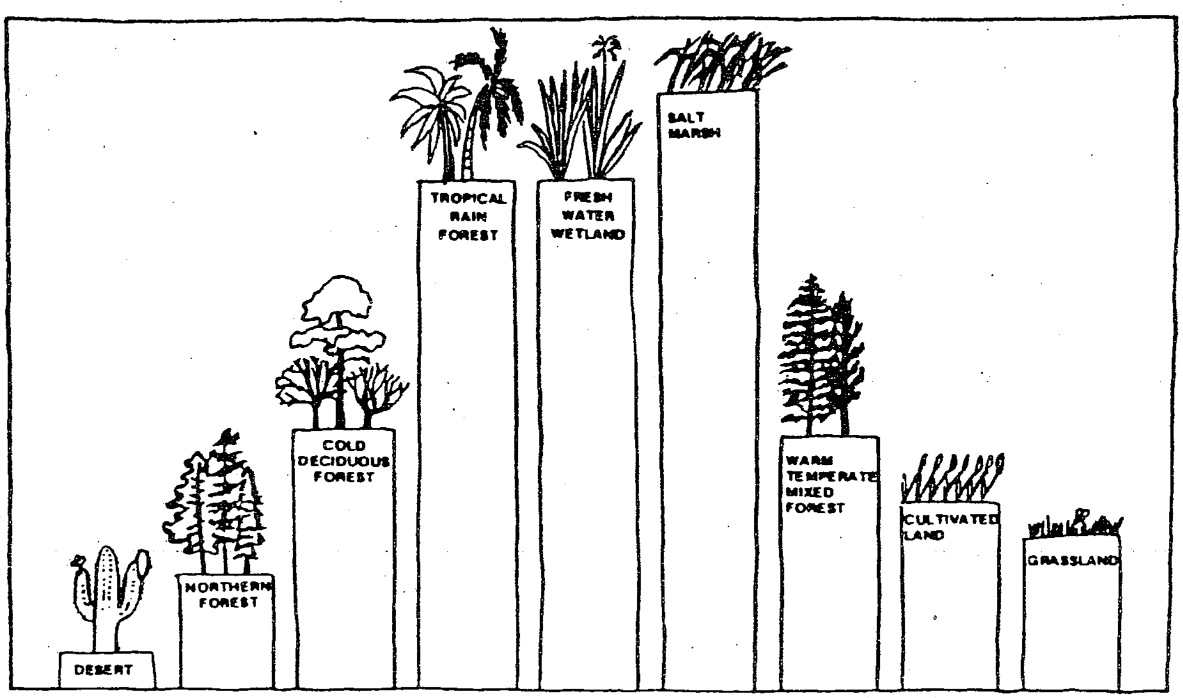
Kite, Wood Stork, Bald Eagle, Bachman's Warbler, Ivory-billed Woodpecker (birds), Canby's Dropwort (plant), and the American Alligator.

Figure 1-6. Wetlands reduce peak flows and heights of floods.



Modified from Kiesler 1983

Figure 1-7. The relative productivity of wetlands in comparison to other selected environments.



1984 From Newton 1981

Recreation

Perhaps the greatest recreational use of wetlands is represented by hunting and fishing. Waterfowl hunting is a major wetland activity, and big game hunting is an important activity in some areas. Much of our freshwater fishing depends on wetlands since many game fish species require wetland areas for spawning and raising their young. Wetlands are important as well to those who enjoy bird watching and wildlife observation.

Education and Research

Wetlands are interesting ecosystems for research. Wetlands provide an understanding of many ecological processes: productivity, nutrient cycling with natural water pollution control and numerous other areas of study including the relationships of plants and animals in a habitat which supports great abundance and diversity. Wetlands serve as outstanding outdoor classrooms for nature study not only by researchers but by schools and conservation groups as well.

The Status of Wetlands Today

The National Wetlands Inventory in 1985 estimated that there are approximately 4,660,000 acres of wetlands in South Carolina. This accounts for about 23% of the state's total land area. In 1986 the National Oceanic and Atmospheric Administration determined that South Carolina had 434,000 acres of coastal wetlands, 85% salt marsh and 15% fresh marsh. The remainder of our wetlands, about 4.2 million acres, is inland wetlands such as Carolina Bays and bottomland hardwood forests.

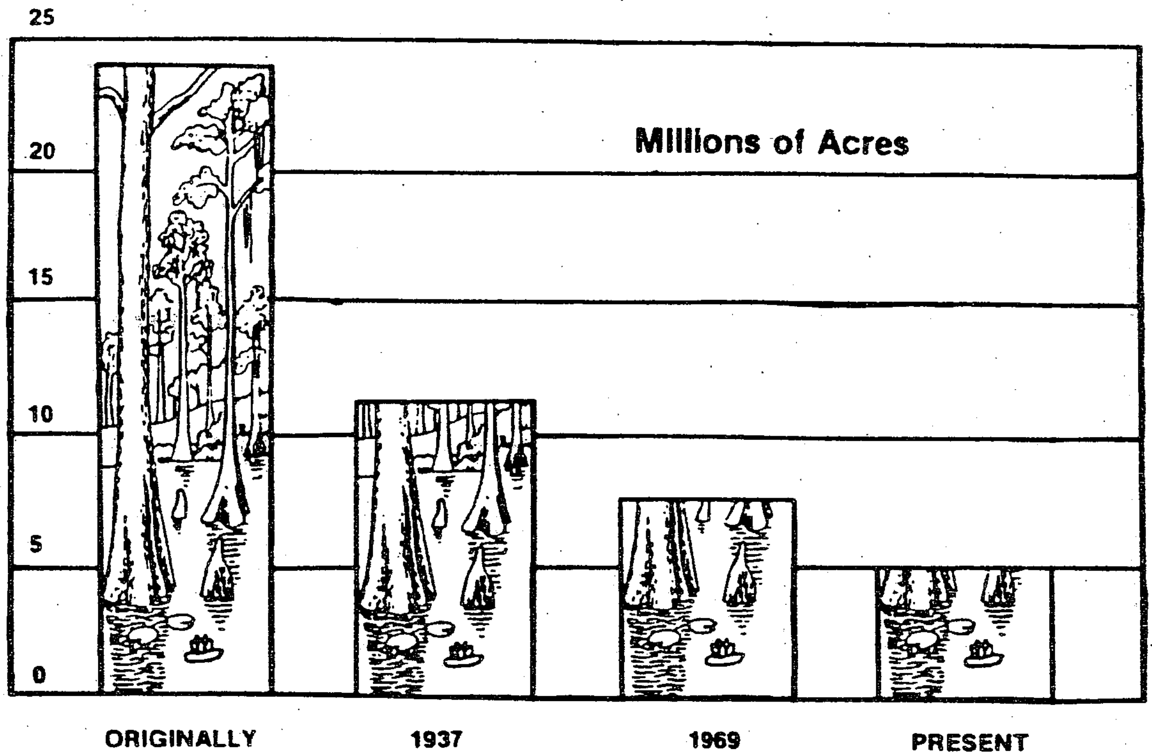
There have been no studies or surveys performed to accurately determine the loss of wetlands specific to South Carolina. However, the average loss of wetlands in the lower forty-eight states from the mid-'50s to the mid-'70s, as estimated by the U.S. Fish and Wildlife Service, was over half a million acres per year. About 300,000 acres per year were lost from scrub/shrub and forested wetlands, with emergent wetlands losing over 200,000 acres per year. Such a loss equals an area as large as Massachusetts, Connecticut and Rhode Island combined.

Wetland Loss and Degradation

Many wetlands have been drained so the land could be converted to agricultural uses. Urban, residential and commercial development also takes its toll. Bottomland hardwoods have been especially hard hit since they harbor the potential to provide timber before being converted to cropland. Much of our prime agricultural land is being developed for non-agricultural uses, and federal agricultural subsidies created incentives for farmers to convert marginal wetland areas to farmland. Many of these incentives were abolished with the 1985 Farm Bill "Swamp Buster" provisions. Steadily, the value of natural wetlands are becoming known and public pressure is leading politicians to develop wetland conservation policies to keep development out of wetlands.

Positive options exist and economic activity within wetlands does not have to cease. With regard to timber production, for instance, selective cutting of bottomland hardwoods can yield valuable returns for hundreds of years and still maintain the ecological functions and benefits derived from this type of forested wetland.

Figure 1-8. The extent of loss of bottomland hardwoods in the United States



Below are other common activities which significantly alter or destroy wetlands and their functions.

Dredging and Stream Channelization

These destructive practices unfortunately have long been an accepted means of flood control. Ironically, such practices have led in many cases to increased flood damage further downstream. Channelization destroys the natural function of stream meanders and floodplains to hold and slowly release flood waters to downstream areas. Channelization only "relocates" a flooding problem to another area and results in the loss of the natural flood control system, the wetland.

Filling

Wetlands are often filled as solid waste disposal sites, for roads and highways, and commercial, industrial and residential development. When wetlands are filled, however, their water retention qualities are lost and the former wetland area becomes subject to periodic flooding.

The filling of wetlands is prohibited by law without a permit from the United States Army Corps of Engineers, the South Carolina Water Resources Commission or the South Carolina Coastal Council.

As mentioned earlier, wetlands help purify polluted water, but only to a certain extent. Excessive discharges of pesticides and other toxic substances, effluent nutrients, agricultural runoff and siltation from erosion can and do degrade wetlands. Wetlands can become overloaded the same as any other habitat.

Streams And Rivers

The stream/river system includes the surrounding **watershed**, the **stream channel, instream habitats and stream banks.** Because of the influence each has on stream organisms, it's important to consider the entire system.

The **watershed or river basin** is the total area that contributes runoff to a stream. Land uses in the watershed affect the water quality. Agriculture and urban area activities, for instance, contribute sediments, organic wastes, nutrients, toxic substances, bacteria and other pollutants to streams. Such disturbances affect whatever lives in the water.

The **stream channel** is created as runoff from the watershed seeks the path of least resistance. If the watershed has very steep terrain, the resulting swift water may cut a deep stream channel and keep the stream bed flushed of sediments. Flat topography permits a stream to be shallow and to meander above a substrate comprised primarily of sediments. In South Carolina we have both kinds of topography with many variations in between. In its natural condition, the channel provides a variety of aquatic habitats for many species of plants and animals. A stable stream channel habitat provides living creatures areas for feeding, resting and reproducing and generally supports a great diversity of life.

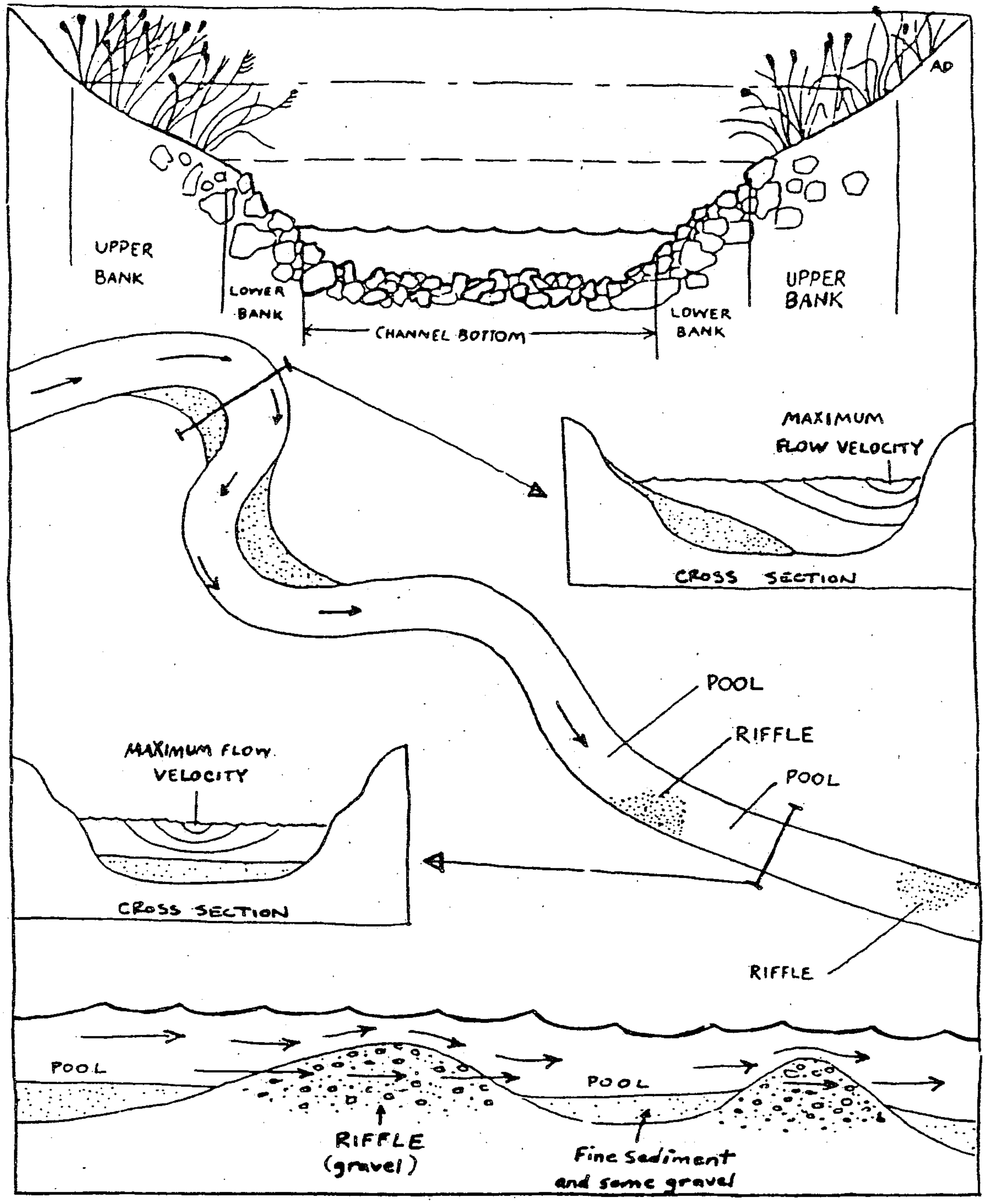
Instream **habitats** include pools, riffles, root mats, plants, undercut banks and a wide variety of substrate materials. These, along with the depth and flow of the water, usually determine the type of aquatic organisms present in streams.

Stream banks and other riparian zones serve many functions other than keeping the water in the channel. They provide homes to many plants and animals, and under natural conditions help protect the stream from human influences. When banks are covered with trees, shrubs and herbaceous (non-woody) plants, they shade the stream, retard erosion, collect or trap sediments and absorb nutrients--all of which improve water quality.

Stream Pollution

Streams, like any natural system, possess a great diversity of plants and animals. A decline in the diversity of organisms occurs when the system is disturbed in some way, pollution for instance. Although some natural pollutants can create problems for streams and rivers, most problems result from human activities. Water pollutants are generally grouped into the following categories: sediment, organic wastes, nutrients and toxic substances.

Figure 1-9. The stream system.



Sedimentation

One of the major sources of water pollution in South Carolina is **sediment**, small particles of "dirt" swept along by water running off the land. Most sediment comes from the accelerated erosion of agricultural and construction sites. Waters heavily polluted with sediment are very obvious because of their "muddy" appearance. This appearance is especially evident in rivers where the force of moving water keeps the sediment suspended. Such rivers often run red. The Pee Dee, for instance, carries a heavy silt load.

As a river reaches a lake or reservoir, the water loses speed and the sediment drops to the bottom, a process called **siltation.** Although the water may appear clear some distance from the point where the river enters, this doesn't mean that sediment is not a problem in lakes. As sediment settles, it covers the bottom smothering the macrobenthic organisms that live there and changing the nature of the lake bottom in the process. A sandy or clay bottom can turn to "muck" in which few organisms can live. An abundance of sediment in water can clog fish gills, cover their breeding areas and smother their eggs. If heavy sediment loads are carried into a lake or reservoir over a period of years, they can actually fill the basin and eventually turn it into a wetland, and ultimately, dry land. This process is occurring right now even as you read this.

Throughout South Carolina, erosion is creating water quality problems. Erosion produces stream sediment loads which exceed natural conditions, and the potential for erosion is high when any land-disturbing activity causes soil to be washed into the water. Lands denuded of vegetation by agriculture, unpaved roads, unvegetated roadsides, construction, urban areas, forestry and mining operations contribute **sediment** to creeks, rivers, lakes and wetlands. Agricultural practices contribute most of the sediment because of the extensive cropland acreage in the state, but generally the highest erosion activities are associated with construction activities.

Excessive sediment causes many problems in stream systems. Sediment may fill in the spaces between boulders, rocks and other obstacles producing poor riffle habitats and smothering aquatic organisms. Insects, a prime food supply for game fish, can be wiped out, adversely affecting the fish population. Game fish may give way to nongame species or fish whose existence doesn't depend on insects, thus altering the species balance of the water body.

Sediment overloads also fill in the stream bed, thus reducing channel capacity and creating the potential for flooding. In the past, attempts have been made to reduce flooding by channelization. The most commonly employed methods of channelization were straightening the channel by eliminating meanders, dredging the stream and removing vegetation from the banks. Such practices affect both the immediate stream area as well as downstream areas. Other effects include the loss of available habitat for fish and other aquatic animals and an increase in temperature in the now-unshaded portions of the stream.

Organic Wastes

Oxygen is as essential to aquatic life as it is to life on land. The amount of oxygen in water, the **dissolved oxygen** (DO) concentration, is dependent on water temperature since colder water can hold more oxygen. Oxygen is absorbed directly from the air, especially in turbulent areas such as waterfalls and riffles. Oxygen is also contributed by photosynthesis from aquatic plants and algae. On the other hand, aquatic organisms' respiration and the decomposition of wastes, dead plants and animals remove oxygen from water. Generally, daily addition and removal of oxygen in normal, healthy streams is balanced and the average DO remains high enough to support aquatic life.

Organic material, such as that found in wastewater, uses oxygen for decomposition. The amount of oxygen required to decompose waste is called the **biochemical oxygen demand (BOD)**. When the BOD exceeds the available oxygen supply, the DO in the stream is reduced or depleted and is unavailable for fish and invertebrates. Very low DO levels can cause fish kills.

Sluggish streams are especially vulnerable to DO reduction since DO levels are normally lower than in faster, more turbulent streams which mix with air. Streams with extremely low DO levels may feature "bloodworms" (midge larvae), and air-breathing snails may be the only invertebrates present. High amounts of organic material in a stream may result in extensive growths of "sewage fungus" (bacteria) which covers all substrates and thus prevents other aquatic organisms from living in the stream.

Characteristics of a Polluted Stream

Because they flow, most rivers and streams can recover fairly fast from some forms of pollution, especially oxygen demanding wastes and heat. The entry of pollutants into a flowing stream sets off a progressive series of physical, chemical and biological events in downstream waters. The nature of these changes depends on the kind and amount of the polluting substance. The changes can adversely affect stream life either directly by toxic action or indirectly by altering the water quality or the stream bed.

Observing the plants and animals in a stream can provide clues to understanding stream conditions. Some species are tolerant to different degrees of pollution while others are intolerant. In a polluted stream, intolerant species die or are driven out, and tolerant species increase their population enormously. The presence of tolerant species in moderate or few numbers cannot be considered an indication of pollution, however, since they are a part of every natural stream community. But the absence of intolerant species combined with the presence of high numbers of tolerant species indicates a stream is polluted.

A polluted stream can be divided into **zones**. The extent of each zone depends on many factors including...

(1) the kind and amount of pollutant;
(2) the amount of dilution by the receiving stream;
(3) the ability of the stream to break down the pollutants;
(4) the season of the year.

The stream zones polluted by oxygen demanding, organic wastes may be generally classified as follows:

(1) Clean Water Zone - The area upstream of the pollutant discharge usually contains a community of organisms characterized by many species, tolerant and intolerant, with all levels of the food chain represented. The water is generally clear and fresh with high dissolved oxygen (DO) levels.

(2) Zone of Degradation - In the area immediately downstream of the pollutant discharge, the water may become turbid and darker with DO

levels beginning to decrease as the waste decomposes. Usually only tolerant species of fishes, invertebrates and algae live in this area.

(3) Septic Zone - Further downstream, as the waste continues to decompose, much of the stream's DO is used up. The stream may have a foul or **septic odor** and **sludge beds** may develop on the bottom. Only extremely tolerant invertebrates, bacteria and algae can live in this zone; fishes are generally absent. Sewage fungus may be present, even abundant.

(4) Recovery Zone - Even further downstream, the flow and water turbulence allow more of the organic material to decompose and the DO of the stream begins to increase. In this zone, tolerant fishes, invertebrates and algae will again be found.

(5) Clean Water Zone - Eventually most of the organic material is decomposed and the water is once again clear and fresh with healthy DO levels. The aquatic communities contain a wide variety of both tolerant and intolerant species similar to those found above the source of pollution.

If other sources of pollution are discharged into the stream, the zones may be extended further downstream. The stream, in fact, may have no recovery and clean water zone at all and may remain in a degraded condition to the ocean.

Other types of pollutants, such as toxic chemicals, may affect aquatic communities differently. Toxic substances may completely wipe out aquatic life downstream of the source. Moving downstream of the pollution source, the chemicals are diluted and degraded and a gradual recovery of the biota (a region's plant and animal life) may occur.

Algal Blooms

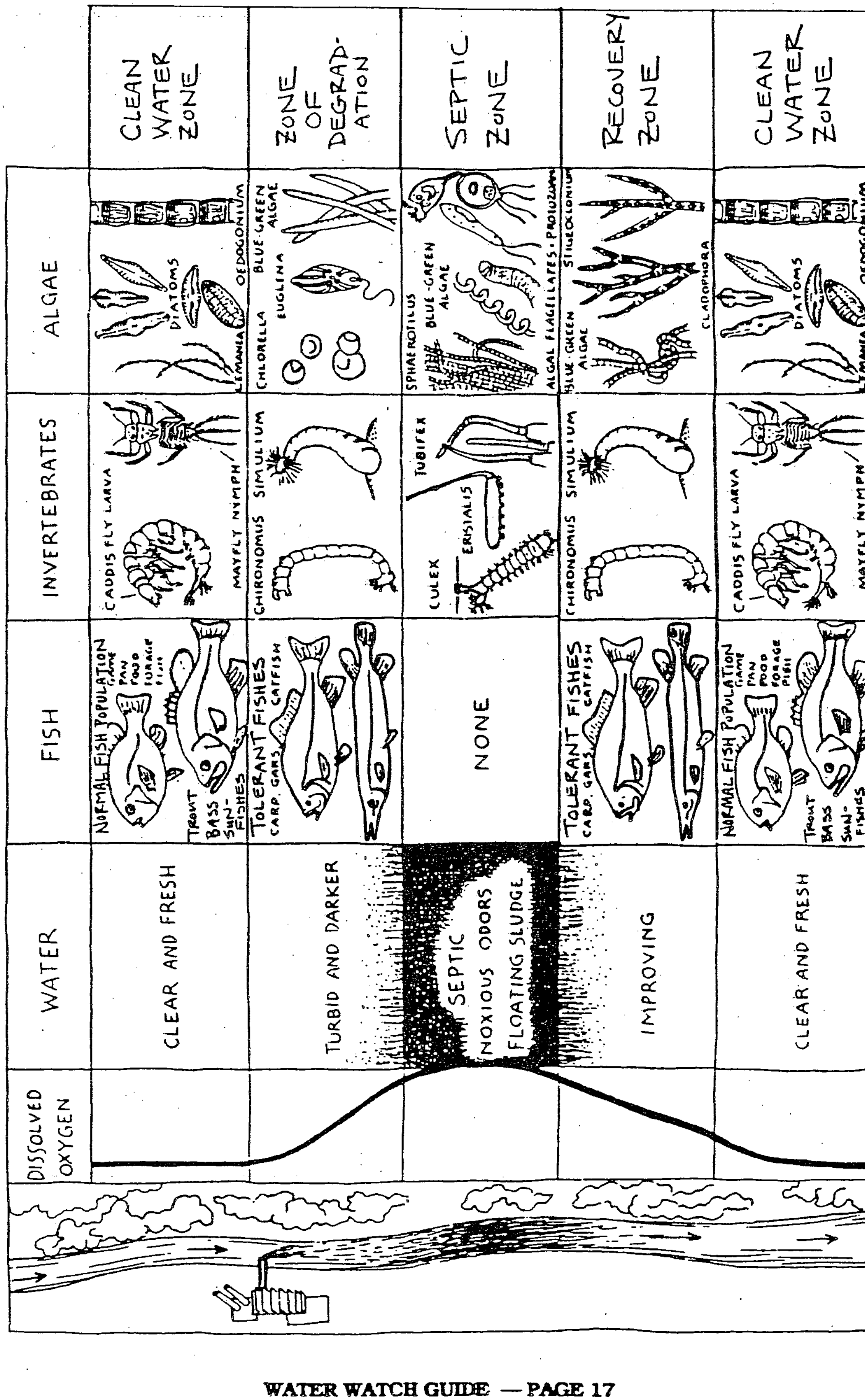
Algae are primary producers that form the base of the aquatic food chain (the lowest **trophic level**). They use sunlight to produce food and oxygen for higher organisms such as aquatic macroinvertebrates and fish. Excessive algal growth, however, can ruin water's appearance and interfere with its intended uses... unpleasant tastes and odors in drinking water, for instance. The die-off and decomposition of large algal populations can severely deplete dissolved oxygen concentrations, resulting in fish kills. Some algal blooms may be toxic to both aquatic and terrestrial animals. Sick and dying livestock, pets and wildlife that drank water containing high concentrations of certain blue-green algae have been reported.

Nutrients

Like land plants, algae, mosses and aquatic plants of streams, rivers, lakes and wetlands require phosphorous and nitrogen to survive. These **nutrients** are necessary to maintain productive floral populations that serve as primary food and habitat producers for grazing insects and fish. Excessive nutrient quantities, however, can lead to algal blooms and nuisance plant growth affecting bodies of water.

As stated earlier, the nutrient enrichment of surface waters, **eutrophication**, is largely caused by domestic, agricultural and industrial activities. Nutrient sources include sewage disposal discharge, septic tank leakage, detergent wastes, fertilizer runoff from lawns, gardens, golf courses and croplands and feedlots, as well as factory effluents.

Figure 1-10. Zones in a polluted stream.



Most of South Carolina's waters contain considerably greater quantities of nitrogen than phosphorous. The extent of algal growth, therefore, is determined largely by the availability of phosphorous. This water quality condition is sometimes referred to as "phosphorous limited."

While many municipal sewage treatment plants efficiently remove solids and other organic wastes, most facilities are not capable of removing much of the phosphorous. The widespread use of laundry detergents containing phosphate brighteners intensifies the problem. Agricultural and residential fertilizer runoff is another significant source of nutrient enrichment. Streams draining agricultural areas generally have about ten times more total phosphorous and five times more nitrogen than streams draining forested watersheds. These quantities of nutrients lead to algal blooms that may adversely affect the uses of bodies of water.

Toxic Substances

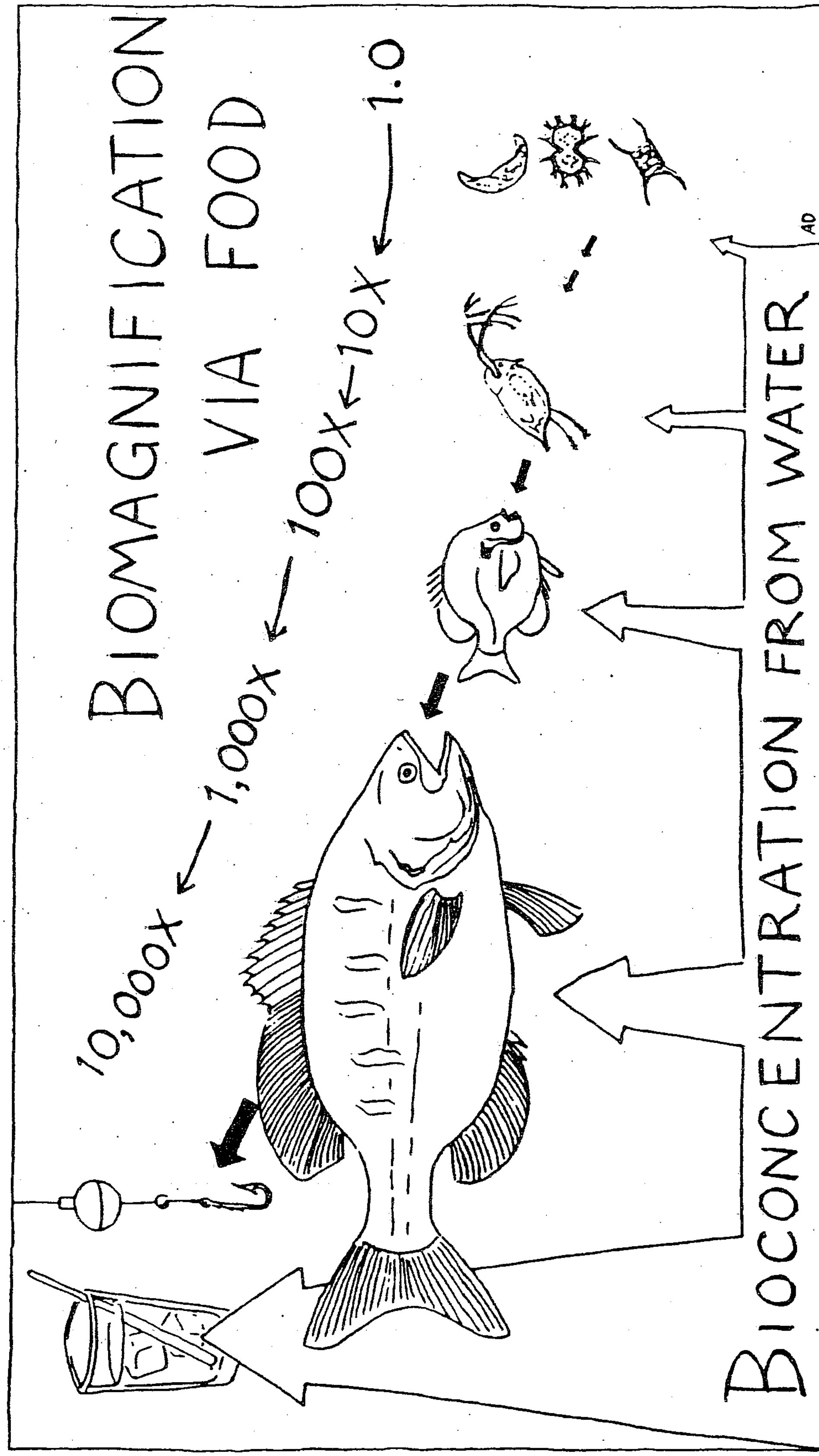
Toxic substances act as poisons. Unfortunately, **toxic substances** in South Carolina's waters have become commonplace. Municipal and industrial wastewater discharges, pesticide and herbicide runoff from agricultural lands, landfill runoff and seepage and urban runoff are the major sources of toxic substances in our lakes, wetlands, rivers and streams.

Toxic substances affect aquatic life and people that drink water or eat fish carrying toxins in one of four ways. First, the substance can cause immediate danger or death. This is called acute toxicity. Second, if the effect is more subtle, producing long-term effects that alter appetite, growth, metabolism or reproduction, it's **chronic toxicity.** Such action can eventually lead to serious illness, death or mutations.

The third effect concerns toxic substances that enter the water in very low concentrations, so low in fact that they pose no apparent risk at that level. Many toxins, organic pesticides and heavy metals bioaccumulate. **Bioaccumulation,** sometimes referred to as **biomagnification,** is a process whereby a substance becomes concentrated by the biological organisms that consume it. A particular toxin, for instance, might be absorbed by a planktonic alga or consumed by a planktonic animal in levels that do not poison them. A minnow, however, may eat thousands of these tiny plants and animals, each with its own small amount of the toxin. A bass will eat hundreds of minnows, each with its amount of toxic substance "accumulated" from thousands of plankton. Traveling up the food chain more toxins accumulate with each consumption, **bioaccumulation** in other words. By the time a person eats the bass, he could be consuming significant quantities of the toxin. In fact, the bioaccumulated PCB levels of lake trout in Lake Michigan prompted officials to advise fishermen not to eat their catch. **Bioconcentration** is another term often used with regard to toxic substances. The movement of a toxicant into an organism from the surrounding water is termed bioconcentration.

The fourth possible effect of toxic substances is the production of behavioral modifications. In this case, the organism isn't killed but its behavior changes. Fish and other animals may move from the affected area, become disoriented, show increased or decreased aggression, or develop unsuccessful reproductive behavior. Toxic chemicals may also result in deformities, cancer, mutations, and growth reductions. Any of these effects may be termed a **toxic response.**

Figure 1-11. Bioaccumulation of toxic substances in organisms.



Bacteria

Bacteria, significant indicators of drinking and recreational water quality, are considered microscopic, but some may be visible in your adopted body of water.

The most widely used "indicator bacteria" are total and fecal coliform bacteria. Commonly found in the small intestines of humans and other warm-blooded animals, fecal coliform bacteria are often associated with harmful bacteria found in various water sources.

Sewage fungus is a sensitive indicator of organic bacterial pollution in flowing waters. Any growth of slimy, cotton-like plumes, usually white, gray, or brown, indicates "sewage fungus," "iron bacteria," or "slime bacteria." These growths usually occur in massive amounts. Streams receiving waste from paper mills, canneries, breweries, refineries, and municipal sewage treatment plants often contain sewage fungus. It is usually observed clinging to twigs, leaves, or even the sides and bed of the stream. Should you find a growth that resembles sewage fungus, continue upstream until you find the source of the organic pollution.

Should a water sample be necessary for coliform analysis, contact the South Carolina Department of Health and Environmental Control for assistance.

Algae

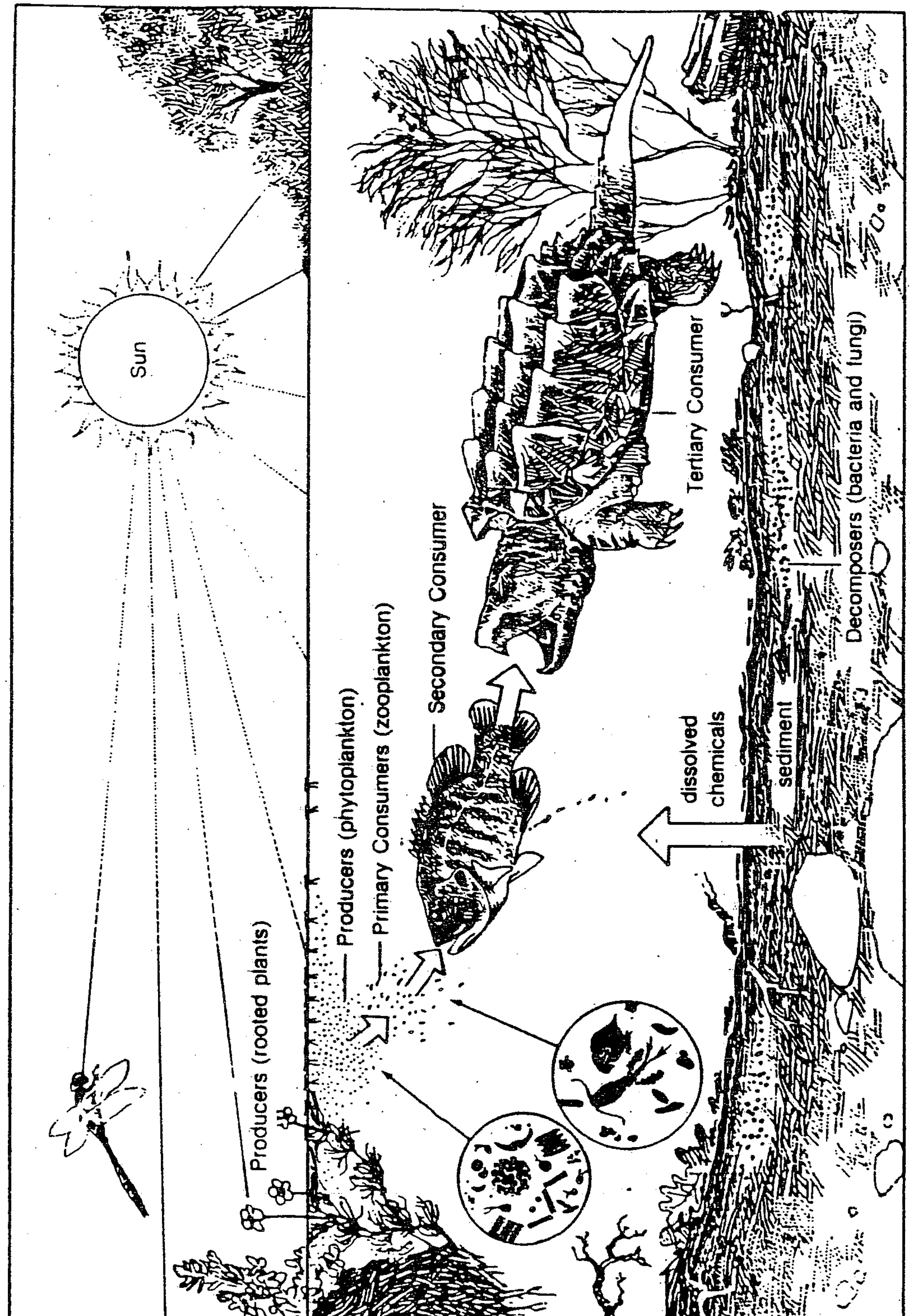
Though most algae is microscopic, the bright colors and rapid growth of "pond moss" or "scum" often catch the eye of water-watchers. Most algae is microscopic, however. Sometimes slick rocks in streams alert one's attention to the presence of algae.

Algae are good indicators of water quality. High-quality streams and lakes contain sparse-to-moderate amounts of algae, assuring an adequate food supply to maintain productive macroinvertebrate and fish communities, but waters with little or no algae may be affected by toxic substances or located in low-nutrient watershed. Waters draining limestone areas have greater algal abundance than those draining shale and sandstone regions.

Plankton and periphyton are the two broad categories of algae. Plankton are free-floating organisms typically found in ponds, lakes, slow-moving rivers, and sometimes stream pools. Periphyton are attached to the bottom, rocks, submerged logs, vegetation, or other surfaces. Dense growths of attached algae--*Cladophora*, for example--often occur downstream from municipal sewage treatment plants or in agricultural areas. Attached algae are typically found in streams, rivers, and around lake margins.

Certain attached algae may be recognized by the unaided eye. The filamentous green *Cladophora* forms coarse, bushy, dark-green to brownish-green masses in streams with strands sometimes three to four feet long. *Lemanea*, a red alga, occurs in swiftly flowing waters and is typically one to eight inches long, olive-green to black, and rather stiff compared to *Cladophora*.

Figure 2-1. The aquatic food chain. Interrelationships among aquatic life forms.



Another red alga, *Batrachospermum*, is commonly found in or below springs. It is dark olive-green to black and forms compact, slimy masses. Fluffy, felt-like masses occurring on rocks or other surfaces are usually diatoms if brown to golden, or blue-green algae if dark green to black.

Two common still-water algae are *Spirogyra* ("pond silk") and *Hydrodictyon* ("water net"). Bright green mats of pond silk frequently contain trapped bubbles of oxygen. Their slimy appearance probably led to the common name "pond scum". Such mats may interfere with irrigation, livestock watering, boating, swimming, and fishing. Natural die-off of the plants may deplete dissolved oxygen in the water, causing fish kills and taste and odor problems in public water supplies. Some species release toxins into the water, thus sickening or killing livestock.

Hydrodictyon is readily recognizable, forming coarse, green, tubular nets, sometimes approaching lengths of six or more inches. Other algae may be identified using sources listed in the reference section.

Aquatic Plants

A diversity of plant types is beneficial to water bodies. Trees and shrubs provide shade and stability and absorb some excess nutrients through their roots. Emergent plants -- those which stand above the water surface, rooted in the shallow water, usually at the water's edge -- trap sediment and stabilize the bank. Floating-leaved plants -- rooted in the bottom of shallow water areas -- help absorb excess nutrients from the water and stabilize bottom areas, as do submerged plants (similarly rooted but with no parts above the water). Free-floating plants also absorb nutrients. All plant types provide food and cover for insects, fish, and wildlife. The plants listed here are a few of the more common members of each of the above types.

Limited populations of aquatic plants can benefit fish and wildlife, enhance water quality, and improve the aesthetic value of a river, stream, lake, or wetland. Non-native species of aquatic plants, however, frequently are not vulnerable to the same natural population controls as are native species, and thus often dominate over native species. Below you will find descriptions of several **Common Aquatic Plants.**

Figure 2-2.
Arrowhead (*Sagittaria latifolia*): An emergent plant, the arrowhead derives its name from the shape of its leaves, which are six to twelve inches long. In July, small white flowers form along a long stalk originating near the base. Arrowhead is common to wetlands and to lake and pond margins throughout South Carolina.

Figure 2-3.
Bulrush (*Scirpus validus*):
This sedge has short leaves and tiny flower clusters on short stalks atop a round, pulpy stem three- to five-feet tall. Bulrushes change from green to brown in colder weather nd typically grow in tight groups, with several stems occurring in a square-foot area.

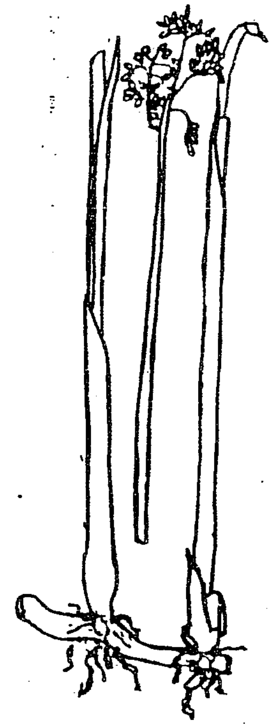


Figure 2-4.
Cattail (*Typha latifolia*):
This common emergent plant can be found growing in most wetlands and around many lakes in South Carolina. The brown "tail" is actually composed of Thousads of tiny flowers, which drop or blow away in autumn. The cattail grows three to six feet with thick, narrow leaves equally as long.

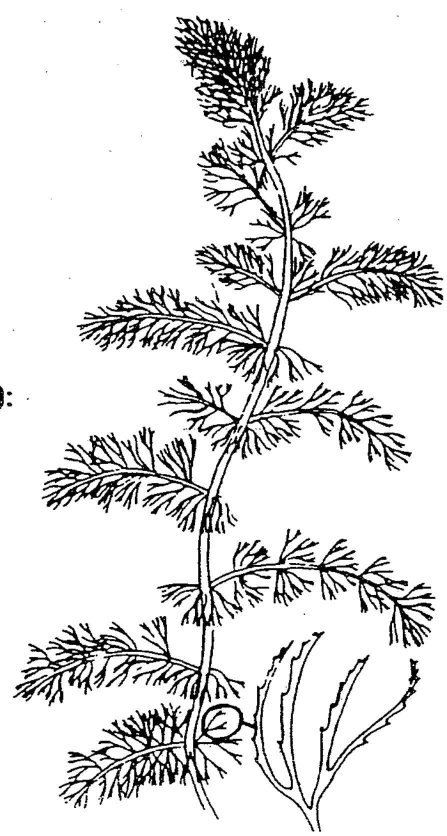


Figure 2-5.
Coontail (*Ceratophyllum demersum*):
The coontail grows entirely under water and commonly occurs in slow-moving streams and other shallow, sluggish waters. Its stems may be seven feet long but less than one inch wide. The narrow, thread-like leaves look more like thin, feathery roots with tiny barbs. Though limp and delicate, coontail may grow in nuisance quantities and is sometimes confused with algae.

Figure 2-6.
Naiad or water nymph (*Najas minor*): Non-native to South Carolina, this slender, limp plant was introduced years ago and can now be found submerged in shallow, sluggish waters all over the state. A favorite duck food, it has linear leaves and long, up to nine feet, many-branched stems well-rooted in the substrate. When found growing in dense mats, it can be a nuisance to swimmers and boaters.

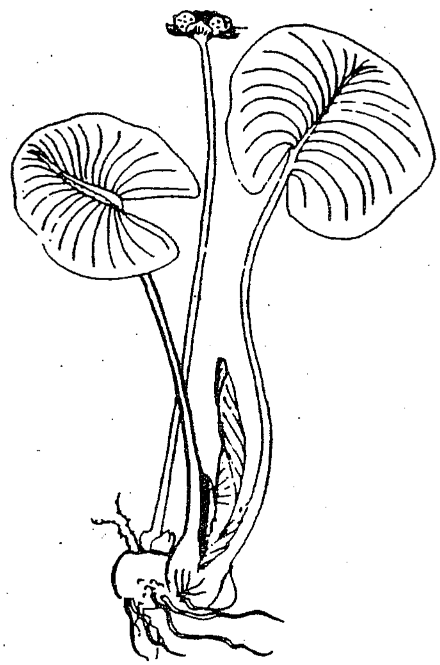


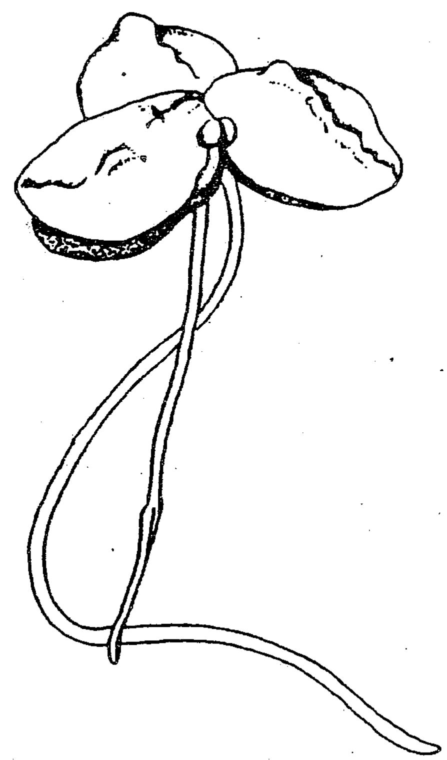
Figure 2-7.
Pond-lily (*Nuphar advena*): The large four- to twelve-inch, waxy leaves of the pond lily can be seen floating in shallow, pooled or sluggish waters in many areas of South Carolina. It has large, one and one-quarter to two-inch yellow flowers on a separate stalk that are generally held up out of the water. A closer look will show that the pond-lily is well-rooted in the substrate.

Figure 2-8.
Pondweed (*Potamogeton*): Many different types of pondweeds exist, but all are rooted in the substrate. Some may be entirely submerged while others feature both floating and submerged leaves. Typically, these plants occur in pooled or sluggish waters throughout the state. They may, in local ponds or lakes, cause problems for swimmers and boaters because of their dense growth. Their slender, limp stems which can grow quite long, feature thin, linear leaves underwater but oval-shaped floating leaves

Figure 2.9.
Sedges (*Cyperaceae* family):
Often mistaken for grass, the sedge is a large group of emergent wetland plants. While grass has a hollow stem, a sedge has a solid stem and may be triangular, its leaves wrapped around the stem at their base. Sedges are great bank stabilizers and erosion fighters. Hundreds of varieties are found along the edges of South Carolina waters, but two common ones are described below: nutsedge and duckweed.

1. Nutsedge (*Cyperus strigosus*):
This sedge has a triangular stem six- to twenty-inches high with grass-like leaves and a cluster of tiny, flat flowers which contain hundreds of minute seeds. Nutsedges are found scattered in wet soils.

2. Duckweed (*Lemna minor*):
About one-fourth-inch wide, these tiny floating plants grow in masses which can cover a pool, preventing sunlight from reaching the bottom, and thus killing other water plants. Without those plants, the water body can support only a low variety of fish and insects. Duckweed got its name because ducks eat it and carry it on their feathers, which helps explain its widespread distribution.



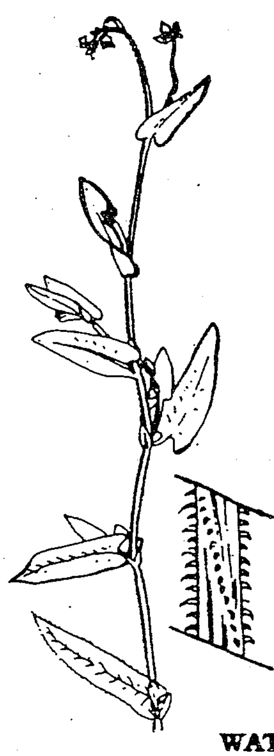
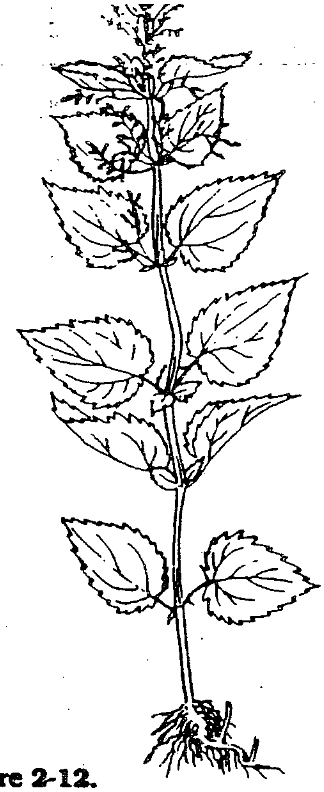


Figure 2-10.
Smartweed (*Polygonum species*):
Sprawling, many-branched plants, smartweeds often form dense growths along stream banks. Their long, narrow leaves and twining stems occasionally possess sharp barbs that are painful when rubbed against the skin. The white or purple flowers appear as clusters on short stalks.

Figure 2-11.
Stinging nettle (*Laportea canadensis*): This common floodplain plant appears harmless, even inconspicuous, but it can cause a burning sensation on contact. It can grow waist high and has large oval leaves. The stem is covered with tiny "hairs" that contain a skin irritant.



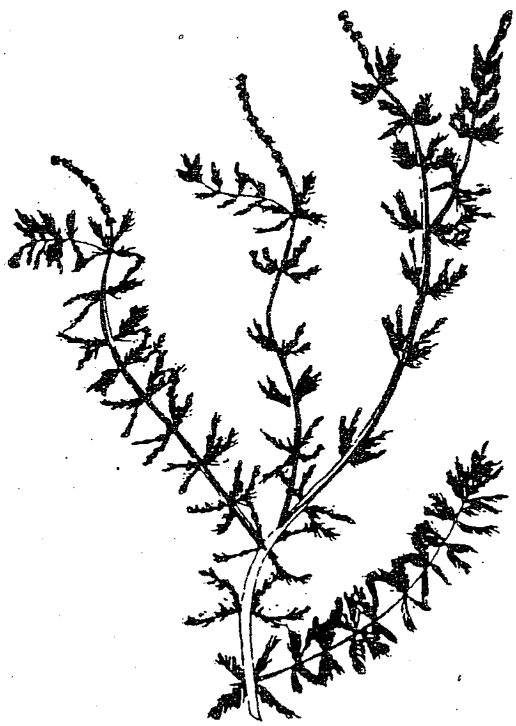
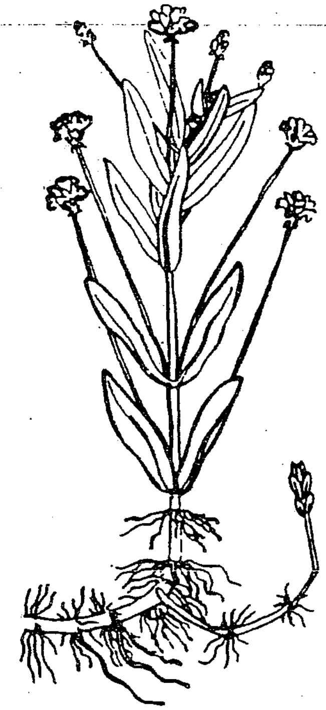


Figure 2-12.
Water-milfoil (*Myriophyllum spicatum*): A slender, submerged plant with many branches, water-milfoil can grow in such dense stands that it chokes out other plants. Although similar to coontail, it does not have any teeth or barbs on the feathery leaves. Another non-native plant, water-milfoil is now fairly common in shallow, sluggish South Carolina waters.

Figure 2-13.
Water primrose (*Jussiaea repens*): Slow-moving streams will often have this plant at the water's edge rooted in the lower banks or mud bars. Water primrose has long stems with floating, lance-shaped leaves and yellow flowers extending into the water.

Figure 2-14.
Water willow (*Justicia Americana*): With leaves resembling those of a willow tree, the water willow has pale violet flowers in head-like clusters on stalks one-and-one-half to three feet tall. It is common on sand and mud and gravel bars of slow-moving streams.



Trees

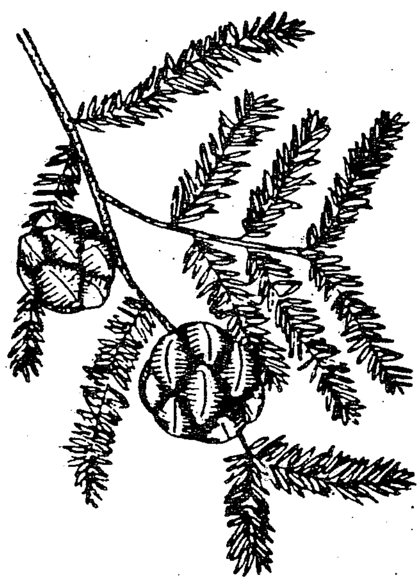


Figure 2-15.
Bald cypress (*Taxodium distichum*): Unlike other cone-bearing trees such as pines, the bald cypress drops its leaves in the fall. It grows up to 125 feet tall in waste-deep water of forested wetlands. With narrow, light- green, feathery leaves, it has fibrous, shredding bark and a trunk that is typically swollen at the base. The roots often have the well-known cypress knees sticking out of the water.

Figure 2-16.
Pin Oak (*Quercus palustris*): The pin oak may grow eighty feet tall from its pyramid-shaped base. Its shiny green leaves are three to six inches long and have five to seven pointed lobes. This oak can be distinguished by the downward angle of its lower limbs. Although it is found growing throughout South Carolina and in virtually all types of habitats, the pin oak's native habitat is poorly drained or wet soils, such as those found in bottomland hardwood forests.

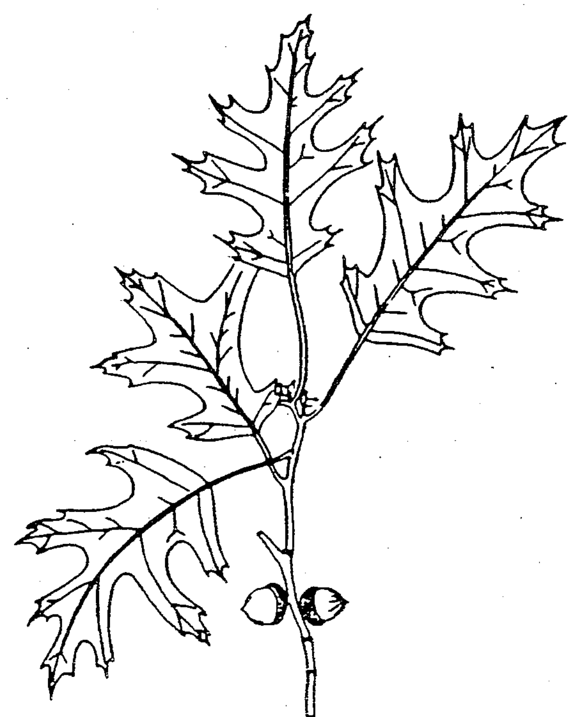


Figure 2-17.
River birch (*Betula nigra*):
Frequently seen along stream edges, the river birch is known for its shaggy, paper-like bark. It may be fifty to seventy-five feet high and have two or three trunks from one base. The leaves are one and one-fourth to three and one-half inches long and wedge-shaped at the base.

Figure 2-18.
Sycamore (*Platanus occidentalis*):
One of the most distinctive streamside trees in the state, the brown and white sycamore can be massive, growing up to 130 feet high with very wide, spreading branches. The leaves are four to seven inches long and have a fuzzy coating on the underside. The small, round fruits seen hanging from limbs and twigs are an obvious feature.

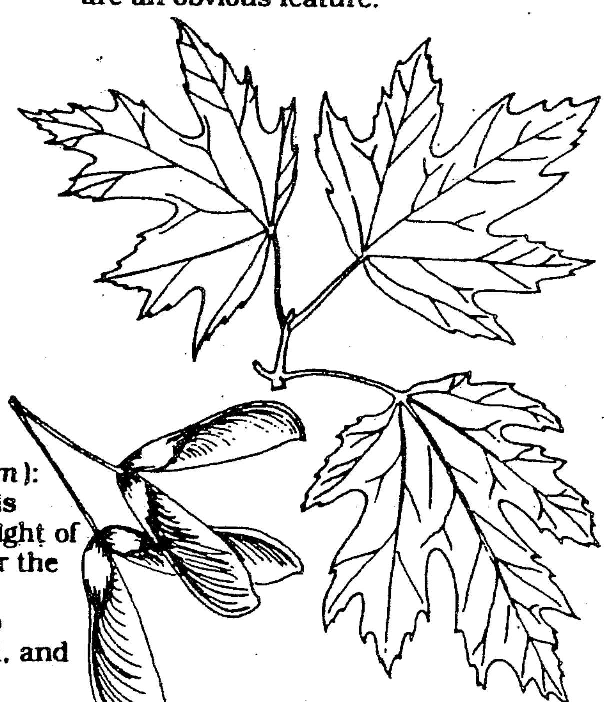
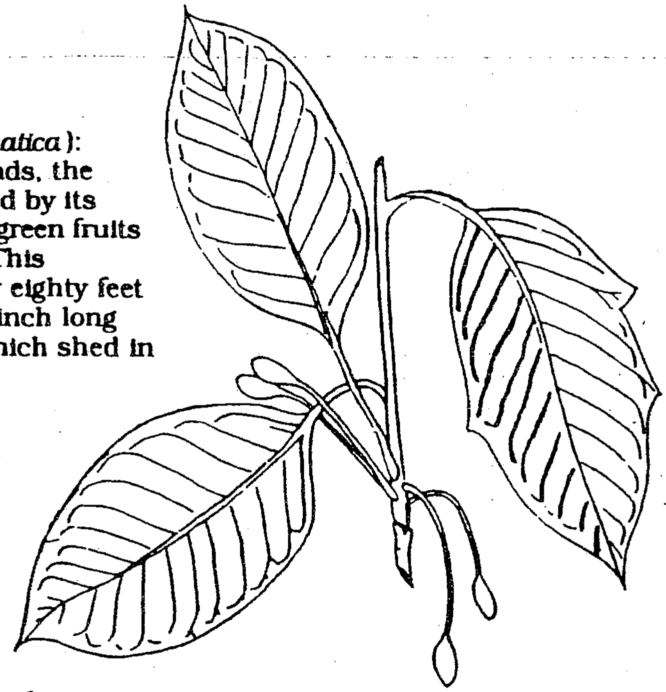


Figure 2-19.
Water maple (*Acer saccharinum*):
Known for its winged seeds, this streamside tree can reach a height of ninety feet and often leans over the water, providing shade for the stream. The leaves are three to seven inches long, deeply lobed, and whitish on the underside.

Figure 2-20.
Water tupelo (*Nyssa aquatica*): Found in forested wetlands, the water tupelo is recognized by its buttressed base and the green fruits found lying beneath it. This hardwood tree may grow eighty feet tall and has five- to six-inch long oval or oblong leaves, which shed in the fall.



Aquatic Macroinvertebrates

The animals in this section are those that spend at least part of their life cycles in water (aquatic), can be seen without a microscope or other instrument (macro), and lack backbones (invertebrate).

A change in an aquatic macroinvertebrate community from high diversity (many species with low numbers per species) to low diversity (few species with large numbers per species) indicates that the waterbody is becoming polluted. See the section on surveying for macroinvertebrates in Chapter 3.

Following are the major aquatic macroinvertebrate groups. For more information on them, refer to the sources listed in the Reference section.

Crustaceans (Class *Crustacea*)

Figure 2-21.
Scuds (Order *Amphipoda*): Also called sideswimmers, scuds are common and widespread. Their crescent-shaped bodies are creamy white to tan-gray. Skittering on their sides, they flex their entire bodies when moving. They can be found hiding in vegetation or under debris in most waters of the state. They are moderately tolerant of organic pollution.

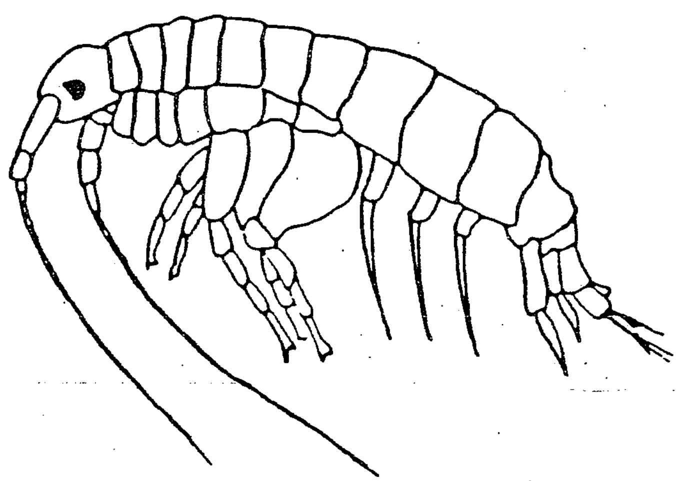


Figure 2-22.
Crayfish and Freshwater Shrimp (Order *Decapoda*): Crayfish, resembling tiny lobsters, hide within the stream banks or under rocks and logs. At night, with a flashlight, you may find them crawling on the bottom. They are brown, orange, black, and sometimes blue, but freshwater shrimp are almost transparent. They may be found in slow areas of most rivers and large streams and are prevalent in lakes and wetlands.

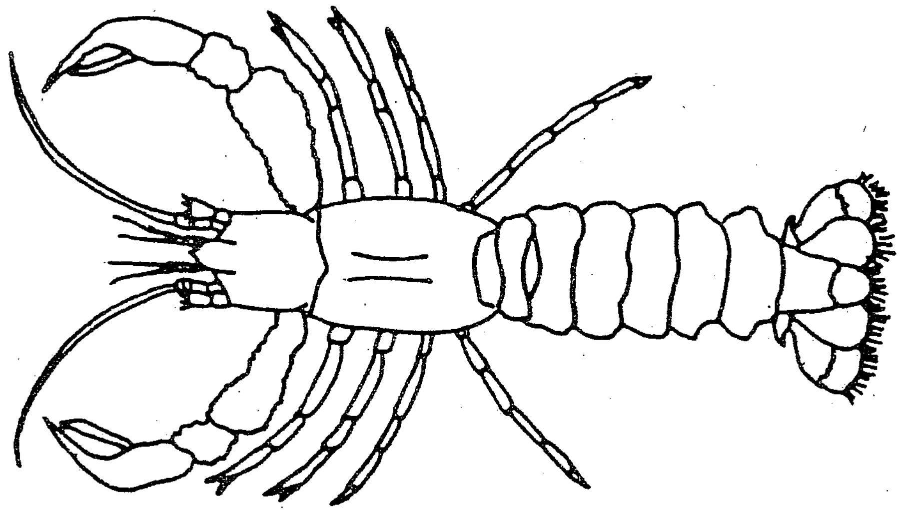


Figure 2-23.
Fairy, Tadpole, and Clam Shrimp (Order *Eubranchiopoda*): Limited to freshwater, these macroinvertebrates are among the most characteristic residents of temporary ponds and pools during spring and early summer, but are usually absent from lakes and running waters. They are also rare in pools where meat-eating insects or predatory fish live. Very graceful animals, they often swim upside down.

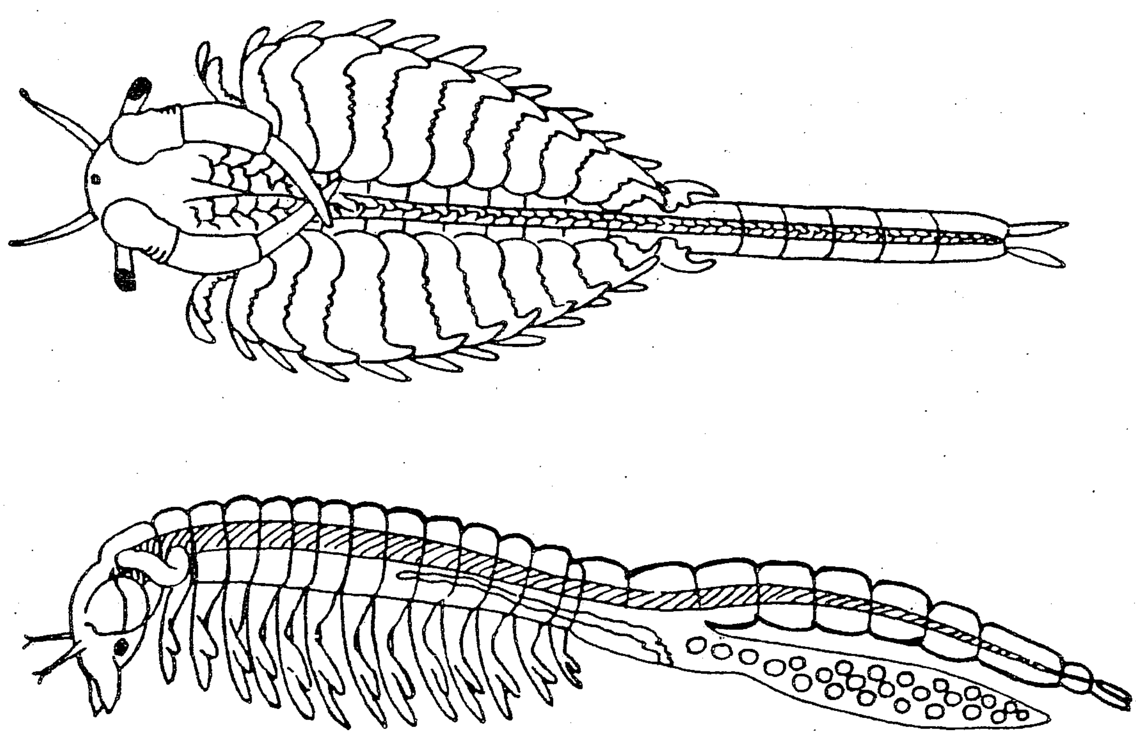
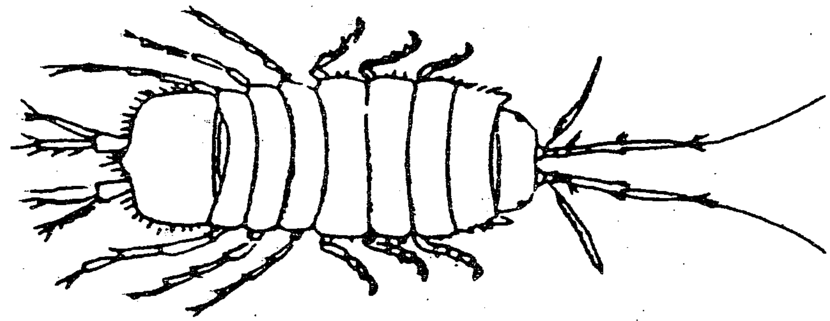


Figure 2-24.
Isopods (Order *Isopod*): Commonly called pill bugs, isopods resemble caterpillars flattened front to back with legs extending on either side. They stay hidden under rocks, vegetation, and debris in small to medium streams or wetlands. They are moderately tolerant of organic pollution.



Insects (Class *Insecta*)

Figure 2-25.
Caddisflies (Order *Trichoptera*): Sensitive to pollution, these flies are soft and often delicately colored. Found in all habitat varieties, many caddisflies build beautiful, intricate cases of stone, leaves, and sticks. Water watchers may see a twig scurrying among their samples. If they look closely, they'll see the dark head of a caddisfly poking out. Some caddisflies with large leaf or twig cases are restricted to calm areas, while those cased in heavy stones live in swiftly flowing waters. A number of species found in flowing waters construct complex nets to trap food from the water. Uncased caddisflies are found clinging to leaves, rocks, and logs.

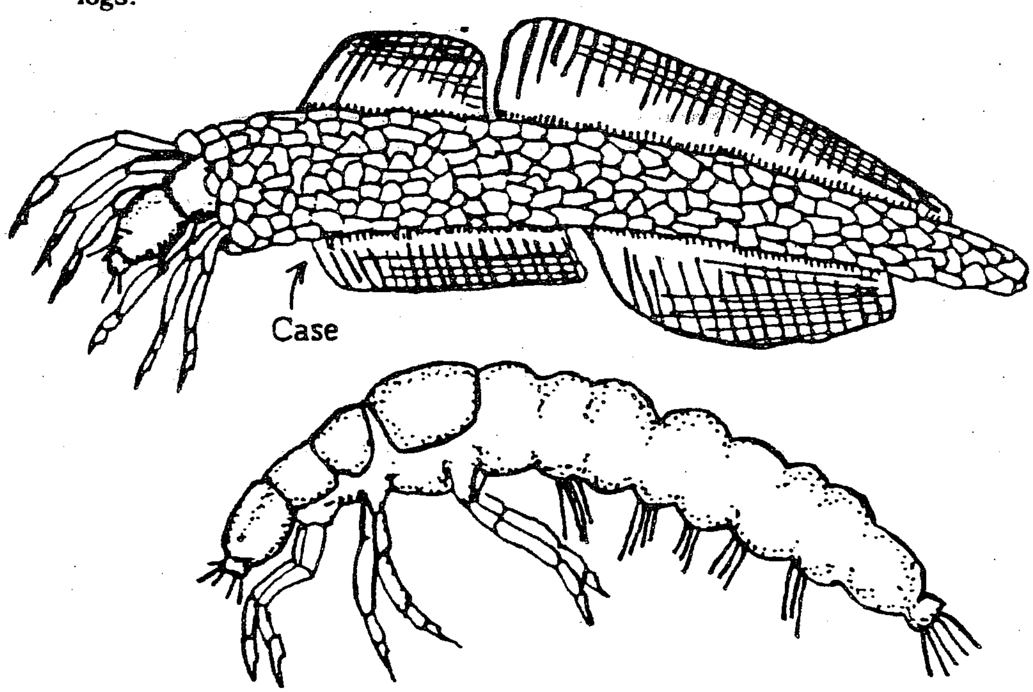


Figure 2-26.
Mayflies (Order *Ephemeroptera*): Wherever there is an abundance of oxygen in a freshwater environment, mayfly nymphs exist. They may be seen climbing on submerged vegetation or crawling along or plowing their way through the bottom. Adult mayflies are often seen in the spring, summer, and fall, awkwardly flying over streams.

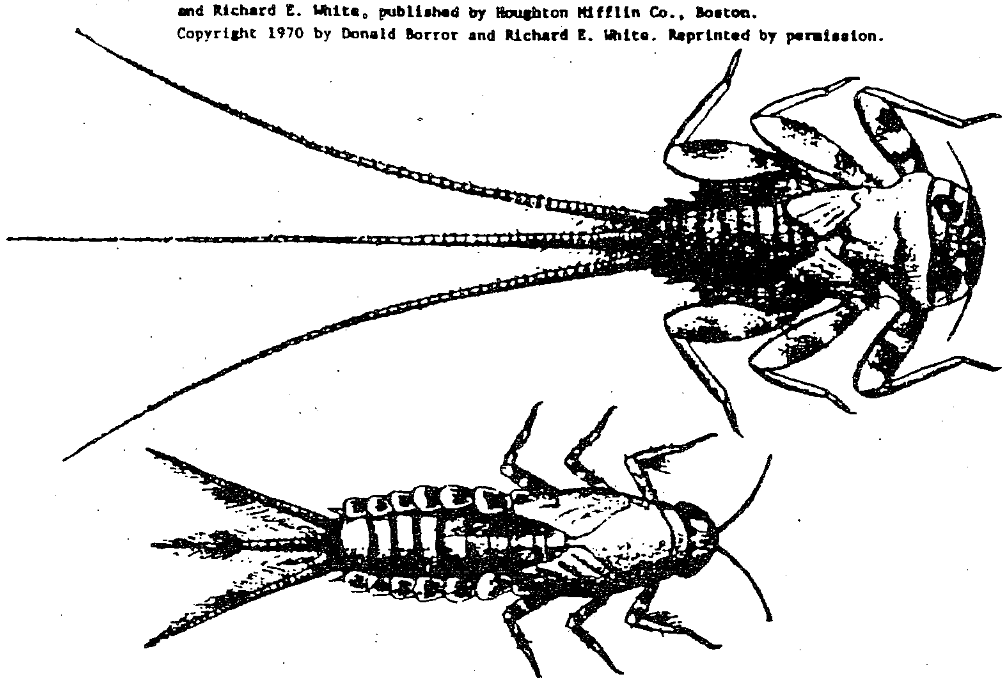


Figure 2-27.
Stoneflies (Order *Plecoptera*): Anglers should be familiar with these insects already. They spend the earlier nymph stage of their life in the water and provide a good food source for fish. Two tails extend from their rears and each leg ends with a double hook. They may be white, tan, yellow, brown or a glossy black. Some even appear to be clad in armor, exquisitely decorated in yellows and deep browns. Generally, these insects are slow and stay under debris, leaves, or stones. Many are voracious predators. They prefer clean, cool waters where there is a good supply of oxygen. The group as a whole is sensitive to pollution.

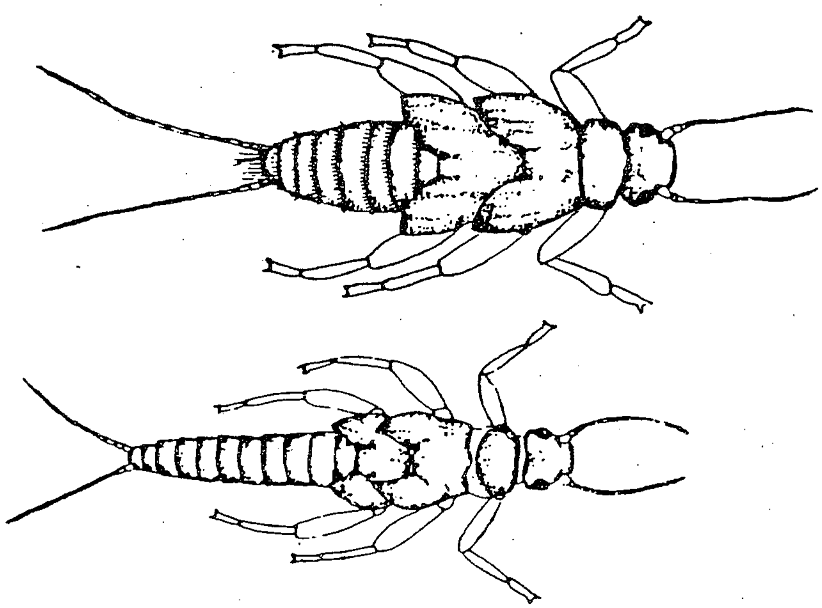


Figure 2-28.
Alderflies, dobsonflies, and fishflies (Order *Megaloptera*): While in the larval stage, these aquatic insects are quite striking. Dobsonfly larvae, also called hellgrammites, are known far and wide as a fine fish bait. Often found crawling on the bottom or buried in the mud of lakes and wetlands, they have a fierce appearance which suggests their predatory nature.

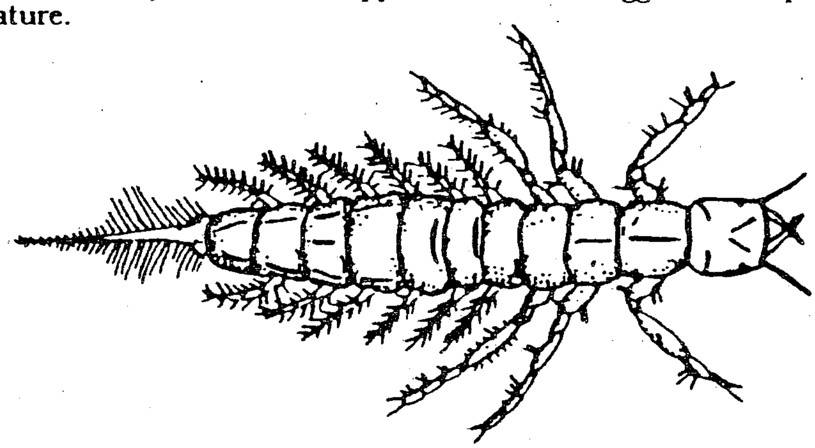


Figure 2-29.
Dragonflies and damselflies (Order *Odonata*): The way these flies flit and play around water makes these organisms highly visible and very well known. Adults are sometimes called darning needles or mosquito hawks due to their size, shape, and feeding habits. The aquatic nymphs are spider-like creatures with a spoon-shaped food-gathering device (labium) that folds back underneath the head. Prey are seized suddenly and effectively by the lightning-like extension and contraction of the labium. All species are predatory. They are commonly found on submerged vegetation, on the bottoms of wetlands, and in the shallow areas of lakes.

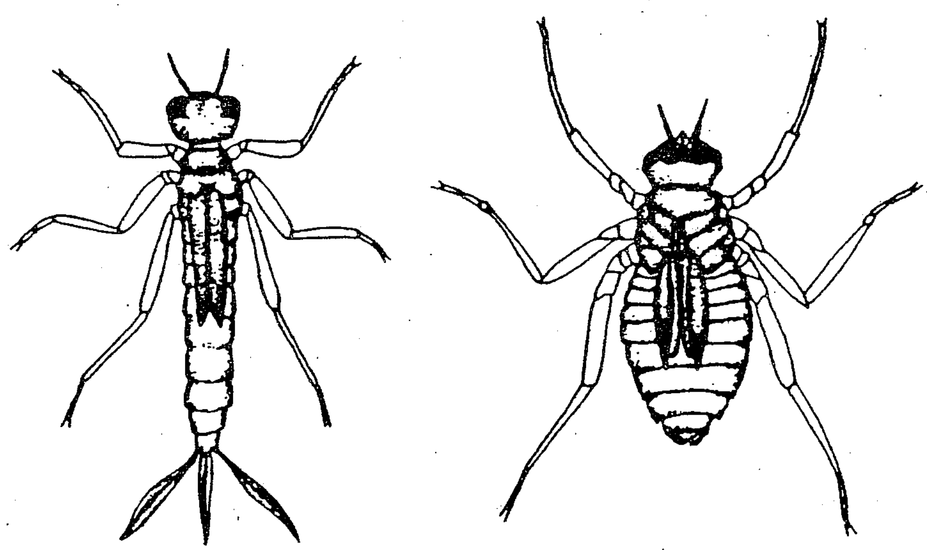


Figure 2-30.
Flies and midges (Order *Diptera*): These insects spend their youth in water and their adulthood on land. The larvae, which inhabit every type of freshwater environment, have a long, wormlike body, no true legs, and vary from black and brown to red, white, and yellow. Some of the more noticeable dipterans are the deer flies, mosquitoes, and midges. Mosquito larvae hang from the water surface where they breathe through tubes, although they will dive when disturbed. Midge larvae remain on the bottom during the day, but some species forage through the water at night. They can be unbelievably abundant. Over 50,000 individuals per square meter have been found on the bottom of some lakes. Many species are tolerant of a wide variety of pollutants, while others are intolerant.

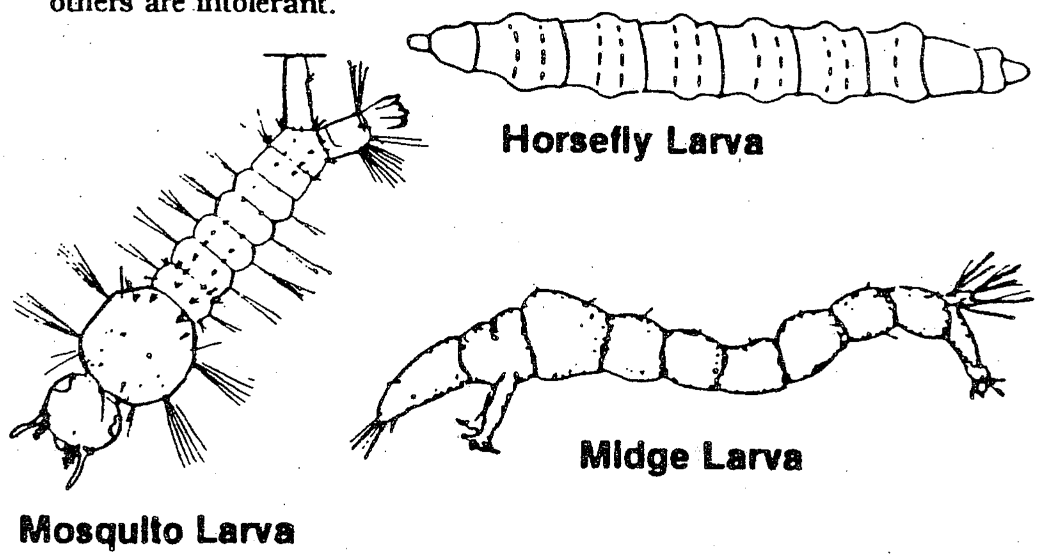


Figure 2-31.
Beetles (Order *Coleoptera*): The largest order of insects, with approximately 5,000 aquatic members, beetles tolerate a wide variety of pollutants, but their larvae have more critical water quality requirements. Some adults require atmospheric oxygen, which they either store under their wing covers or capture as bubbles on the fine hairs which cover their legs and stomaches. The "silver beetle" derived its name from its bubble as the film of water gives off a silver glow. Adults are usually located on vegetation or debris in shallow areas. The whirly-gig beetle (*Gyrinidae*) can be seen swimming around in circles on lakes and wetlands. If you catch one, smell it. It has an apple odor. Some beetles live their entire lives in the water. The adults can crawl, swim, or fly. Some beetle larvae can crawl and some can swim. The larvae are similar to the megalopterans in their elongated and sometimes flat shape.

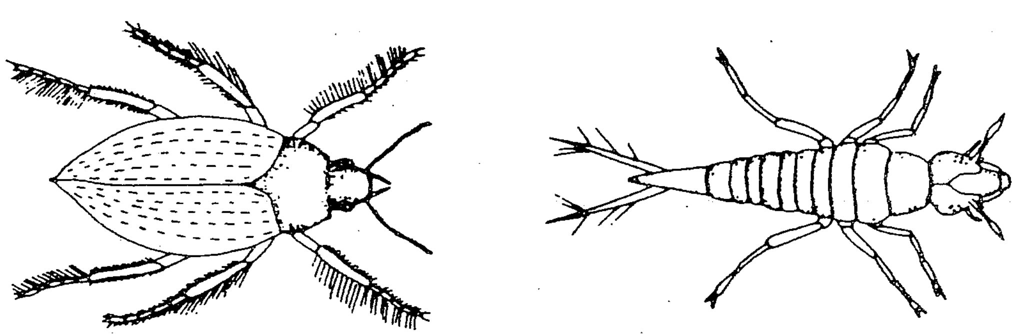
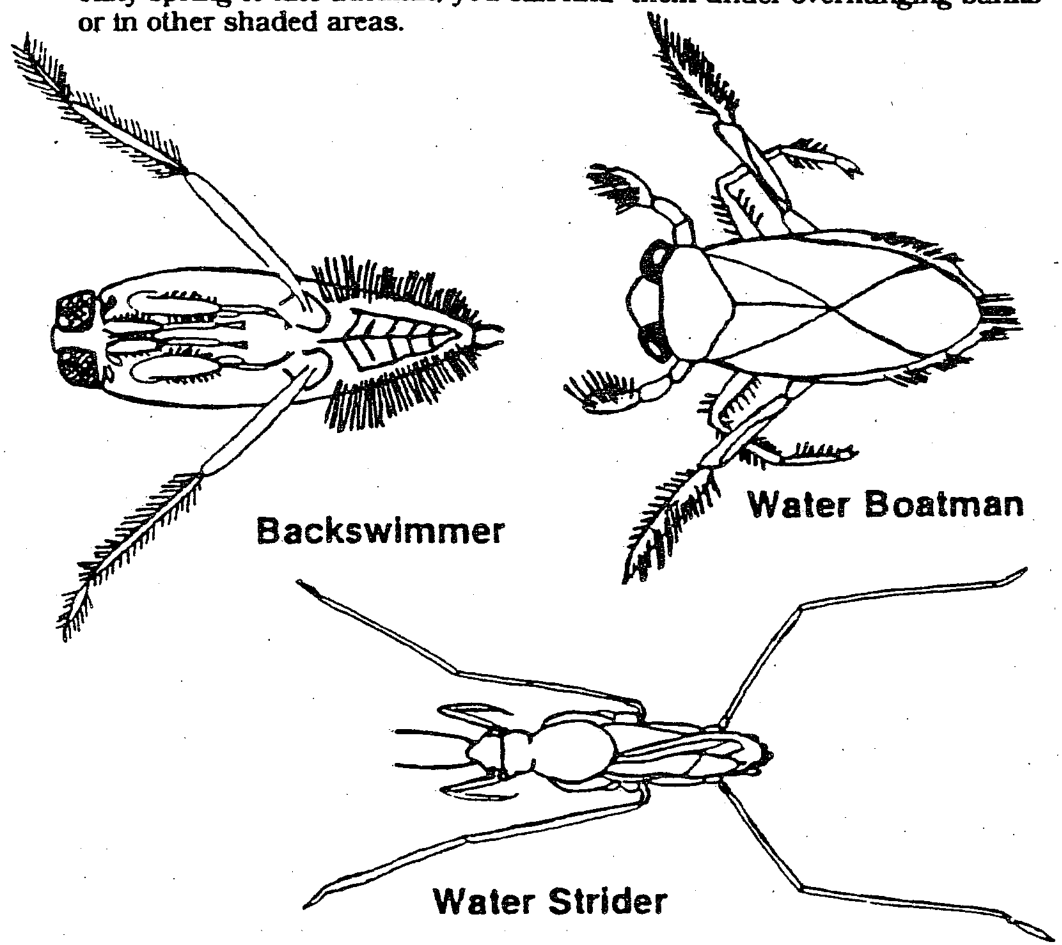


Figure 2-32.

True Water Bugs (Order *Hemiptera*): Waterboatmen, backswimmers, and water-striders use their long, flattened hind legs, similar to oars, to dart about on and within the water. Their long, sharp snouts are used for feeding. They remain in the water except to fly. Waterboatmen, somewhat flattened are usually dark gray, brown, and black. They live in the shallow, slow-moving sections of streams, rivers, or ponds. The adults are strong flyers and may migrate to other water bodies. Backswimmers actually swim powerfully on their backs, using rapid, oar-like strokes. They have unusually large eyes and show considerable color variation, with patterns adorning their heads and bodies. These insects, abundant in the backwaters of streams, ponds, and small lakes, are often found resting on the surface upside-down or clinging to submerged objects. With long legs specially designed to skate over the water without piercing its surface tension, the semi-aquatic water-strider is found "striding" the water surface of streams and rivers. From early spring to late autumn, you can find them under overhanging banks or in other shaded areas.



Other Aquatic Macroinvertebrates

Bryozoa (Class *Bryozoa*): Commonly called moss animals, bryozoans are usually found in unpolluted and unsilted ponds and shallow areas of lakes. These colonies are often mistaken for matted algae. Bryozoans can cluster to form attaching or gelatinous masses the size of a grapefruit or small watermelon.

Figure 2-33.
Leeches (Class *Hirundinea*): Tradition has endowed the leech with an evil and mysterious aura, stemming mainly from medicinal folklore and its often slimy appearance. Early physicians used leeches to bleed their patients, which sometimes resulted in the patient's death. Actually, only a few species will take blood from an animal. Most are nonparasitic and find their food by scavenging and predation. Leeches often are quite beautiful, brightly colored and patterned. Wormlike but flattened, they possess suction disks on either end of their bodies. Leeches are found in shallow, warm waters on submerged objects and in general are nocturnal.

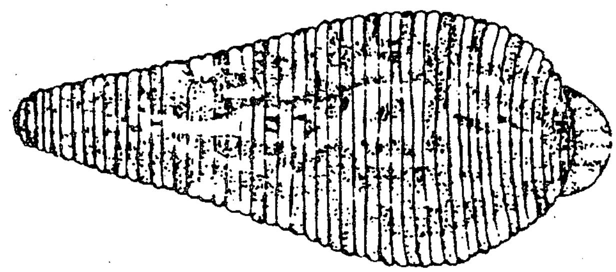
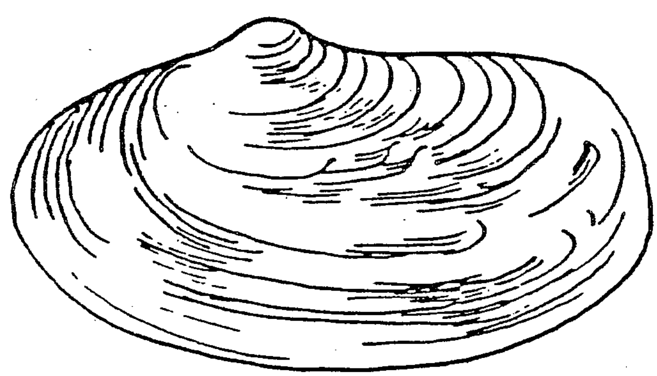
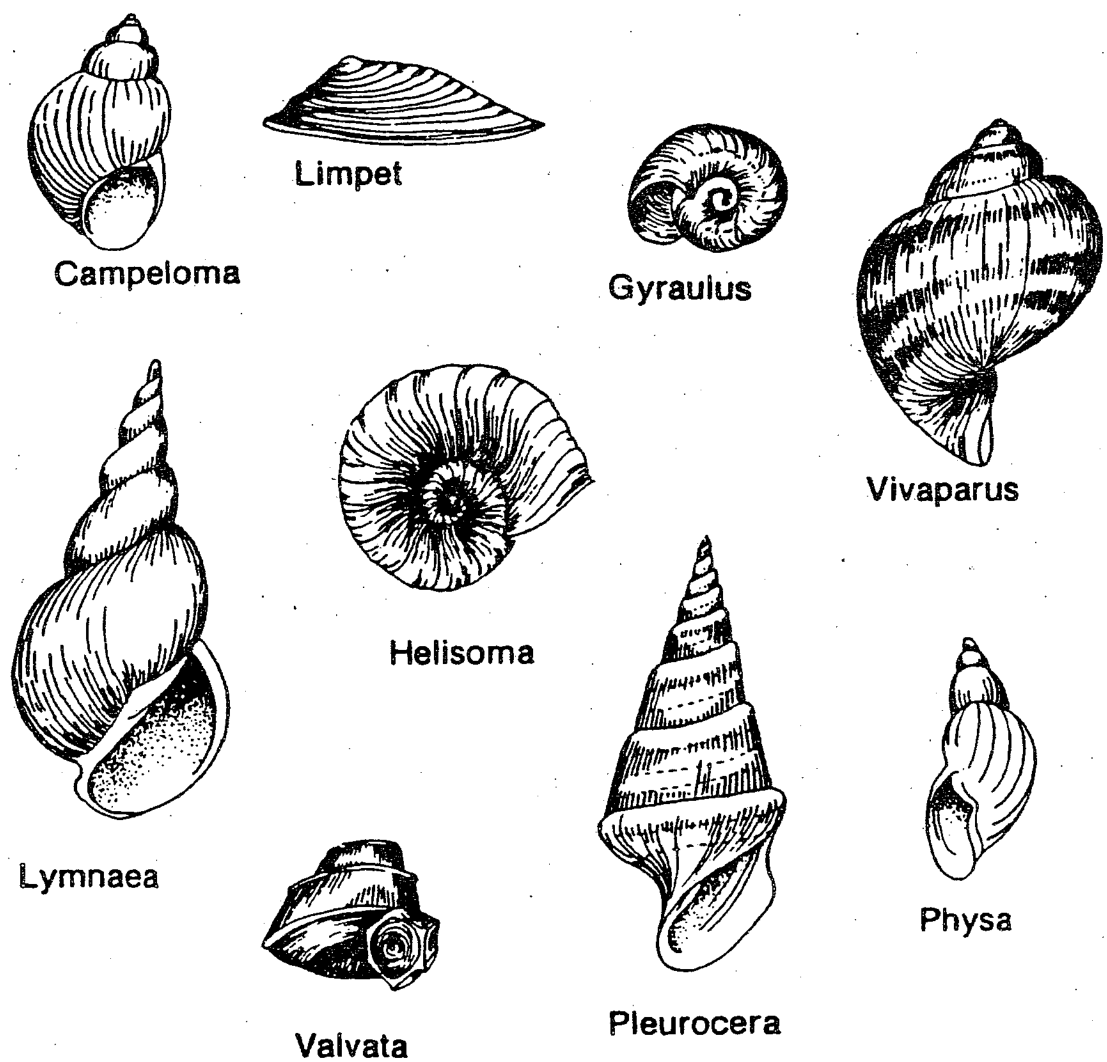


Figure 2-34.
Mussels and Clams (Class *Pelecypoda*): Mussels have shells with two halves connected by an elastic hinge. Found in all aquatic habitats, mussels are most abundant in medium to large streams. At least 120 species of native freshwater mussels and fingernail clams, and one Asiatic clam (*Corbbicula fluminea*), are found in South Carolina waters. Unlike snails, mussels have no head; the foot is all that protrudes from its shell. Most freshwater mussels prefer sand and gravel substrate in riffle areas. Clams have less stringent requirements and are found on all types of bottoms. Mussels and clams do not move over large distances during their life. They anchor themselves into the substrate with the aid of their muscular foot. These animals filter-feed with a pair of tubes called siphons. Their diet consists of microscopic plants, animals, and organic debris.



Worms (Class *Oligochaeta*): Aquatic worms possess the same fundamental shape as the terrestrial earthworm, but most have a more delicate body. Many crawl, although there are a few swimmers. You'll find them in all areas, especially burrowing in mud and sand.

Figure 2-35.
Snails (Class *Gastropoda*): Familiar snails can be found creeping over the bottoms of most water bodies and crawling about on plants growing in shallow waters, usually less then six feet deep. Sometimes you may have to hunt all day to find just a few, while on other days or in other spots they may be present in enormous numbers. Areas with low amounts of oxygen have few snails, with the exception of a few air-breathing species. Mussels and snails have long been used by North Americans as food and their shells have been used for jewelry and tools. From the early to mid-1900s, mussel shells were manufactured into buttons, and in the last few decades, their shells have been used in the Japanese cultured pearl industry.



Fishes

Fish, quite naturally, are generally numerous in many water bodies. Fishing is one of the experiences that makes South Carolina an enjoyable place to live and is also an important part of the state's economy. Talking to fishermen can teach you a lot about the fish populations of your adopted water body. Quite often, they know more about the fish in your water body than anyone else. Politely inquire as to what they catch most often, what other fish they know are there, especially nongame species, and what changes they have witnessed in the fish population over the last few years. Remember that all fishes-- game and nongame-- are valuable components of the aquatic ecosystem and that each type performs a specific role in the habitat it prefers. Thus, it's important that fish species be accurately identified in the body of water under investigation.

Approximately 150 species of fish live in the freshwaters of South Carolina. The number of different species found in a specific water body depends on many factors. Some species, such as the brook trout, live only in cold, mountain streams. Other species, such as the bluespotted sunfish, live only in the blackwater streams of the coastal plain. A list of the freshwater fish species found in South Carolina's watersheds is presented in Appendix VI. Most people can accurately identify game fishes, but many other fish species are less familiar. Because they live underwater, they are rarely observed and their ecology is only vaguely understood. All fishes are valuable as small but unique parts of the natural system of interdependence.

In recent years, many of our fishes have declined seriously in population, chiefly because of human activities. Habitat loss and pollution threaten many species. Watershed impacts, such as construction, habitat alteration, and the channelization and draining of wetlands have also decimated many sensitive species. Fish are usually present, even in the smallest streams and in all but the most polluted waters.

Fish Communities

A fish community generally includes a range of species that represent a variety of trophic levels (or feeding levels). These trophic levels include the plant eaters, **herbivores**, the plankton eaters, **planktivores**, the plant and animal eaters, **omnivores**, the insect eaters, **insectivores**, and the fish eaters, **piscivores**.

Depending on the habitat, a fish community should have species from different trophic levels because different species are adapted to use various components of the aquatic ecosystem. In disturbed systems, a shift in the number of species within a trophic level may change as the habitat's diversity is reduced. A partial list of trophic levels or food groups for common South Carolina fishes is given in Table 2-1.

Table 2-1 Feeding

Planktivores -	*Filter plankton from water.*	
		Paddlefish (spoonbill) **Young of many species**
Herbivores -	*Scrape algae off rocks or eat vegetation.*	
		Stoneroller **Silvery minnow**
Omnivores -	*Eat both plants and animals.*	
		Shad **Bluntnose minnow** **Creek chub** **Carp** **Buffalo fish** **Carpsucker** **Channel catfish** **Bullhead catfish** **Common shiner** **Redbelly dace** **Redhorse suckers**
Insectivores -	*Eat aquatic, and terrestrial insects and some small fish.*	
		Many shiners and minnows **Darters** **Bluegill and other sunfish** **Mosquitofish** **White sucker and spotted sucker** **Madtoms** **Hogsucker** **Trout**
Piscivores -	*Eat fish, crayfish and insects.*	
		Bass: largemouth, smallmouth, spotted **Crappie** **Rock bass** **Gar** **Bowfin** **Muskellunge and pickerel** **Flathead catfish** **Sculpin** **White bass and striped bass** **Sauger and walleye** **Drum (white perch)**

Some species of fish are more sensitive to disturbances than others. A newly hatched striped bass or rainbow trout, for instance, is approximately 100 times more susceptible to certain chemical contaminants than an adult bluegill. Often, the smaller, lesser-known species of a fish community, such as the various darters, are the best indicators of water quality. Specific information on the tolerance level of certain fish is provided in the scientific literature referred to in the reference section. The following tables show some of the more common fish species and their tolerances.

Table 2-2. Fishes Tolerant of Turbidity and Silt
Shad
Goldfish
Carp
Bluntnose minnow
Bullhead catfish
Crappie
Drum (white perch)
Green sunfish
Bigmouth buffalo
White sucker
Some minnows and shiners

Table 2-3. Fishes Tolerant of Low Dissolved Oxygen
Bowfin
Gar
Mosquitofish
Carp
Bullhead catfish
Pickerel

Table 2-4. Intolerant Fishes
Most darters
Hogsucker
Most redhorse suckers
Spotted sucker
Rock bass
Trout-perch
Madtoms
Sculpin
Silverside
Smallmouth bass
Chubs and many minnows and shiners
Trout

Available habitat determines the number and kinds of fish present in an aquatic community of a specific water body. Large rivers such as the Congaree, for example, support many different kinds of fish with approximately fifty species living there, but small mountain streams may support only four or five types of fish, none of which may occur in the Congaree.

Habitat loss and pollution threaten the survival of many species in our state. Watershed impacts such as draining wetlands, urban and agricultural run-off, road construction, streamflow alteration by dams, and mining can reduce the diversity and abundance of fish in a specific body of water. Pollution disturbs the natural balance of an aquatic system. If this disturbance is great enough, the number and kinds of fish in a community will change. If pollution is severe, an entire fish community can disappear from a water body. Thus, it's important that you know how to identify fish and that you have an idea of what species should be in a system under investigation.

Identifying Fish

Some of the more common families of fish are discussed below. For accurate species identification, obtain one of the fish identification textbooks listed in the reference section. Since species identification of some fish families, such as the minnows, requires professional expertise, additional technical assistance may be required. Contact fishery biologists at the Wildlife Department or fishery science faculty members at state universities.

The Importance of Scientific Names

Quite often, the same fish may have different names in various regions of the state. Because of the abundance of common names and because many smaller, lesser-known fish have no scientific names, it's important to be familiar with the scientific names of fish. The scientific name consists of two parts: the generic name or **genus** and the specific name or **species**. The scientific name of the largemouth bass, for instance, is *Micropterus salmoides* and the smallmouth bass is *Micropterus dolomieui*. The genus name *Micropterus* , which both share, indicates a relationship between the two fish, while the species names reveal each to be unique. Genera of fishes which have some characteristics in common are grouped into families. The genus *Micropterus* is placed in the sunfish family (*Centrarchidae*) which also includes bluegill and other sunfish (genus *Lepomis*) and crappies (genus *Pomoxis*). Some of the more common families of fish are discussed below.

Minnows and Carps (Family *Cyprinidae*)

Minnows are usually small fish, but some, such as carp and goldfish, can grow quite large. Minnows occupy nearly all types of aquatic habitat and provide a food source for many game fish. The minnows are an extremely diverse group comprising a large portion of the biomass in most streams. This family is, in fact, the largest and most widely distributed of the present-day fishes. Approximately forty species of minnows live in South Carolina. Some minnow species are valuable indicators of water quality. The chubs, shiners, daces and stonerollers, along with bluntnose minnows, flathead minnows and golden shiners, sold by bait shops, are the more common species. Not all small fish are minnows; many are simply the young of other species.

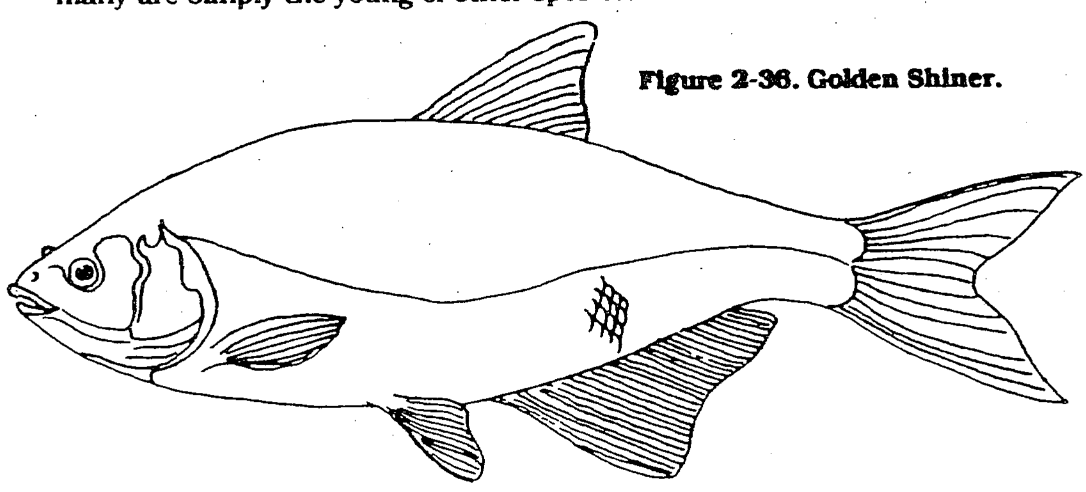
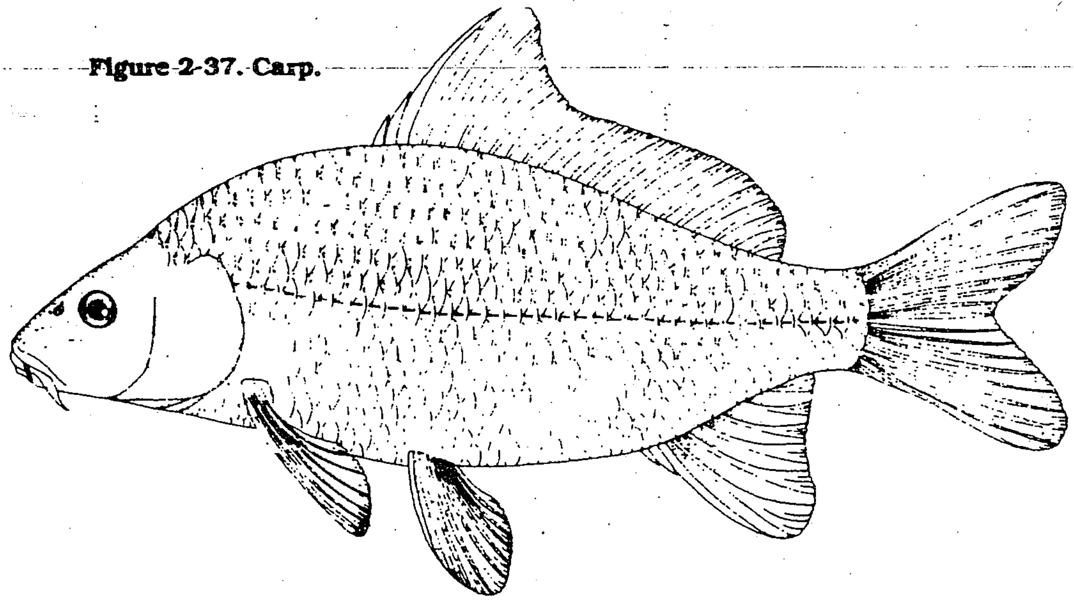


Figure 2-36. Golden Shiner.

Figure 2-37. Carp.



Suckers (Family *Catostomidae*)

Suckers are closely related to minnows but can generally be recognized by their specialized lips and mouth parts adapted for sucking. Most suckers are bottom feeders. Generally, suckers are clean water fishes that cannot tolerate extensive habitat modification. Some, such as buffalo fishes, carpsuckers and red horses are important commercial and food fishes.

Figure 2-38. Common Sucker.

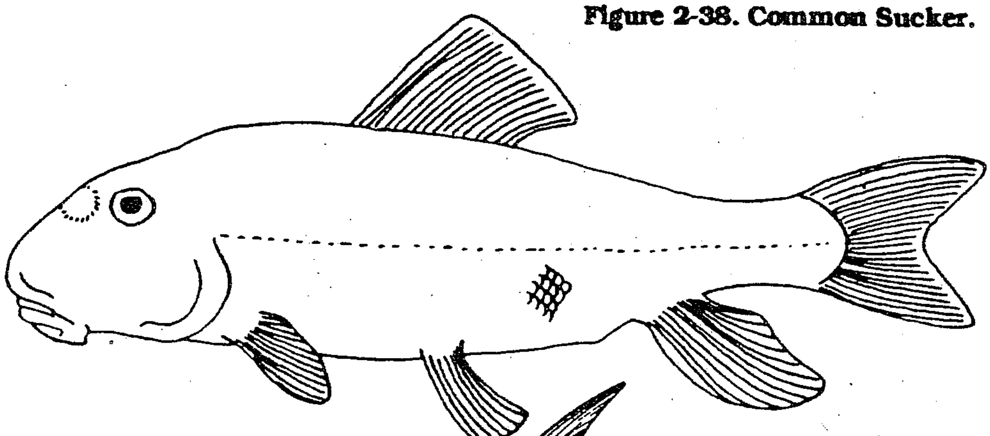
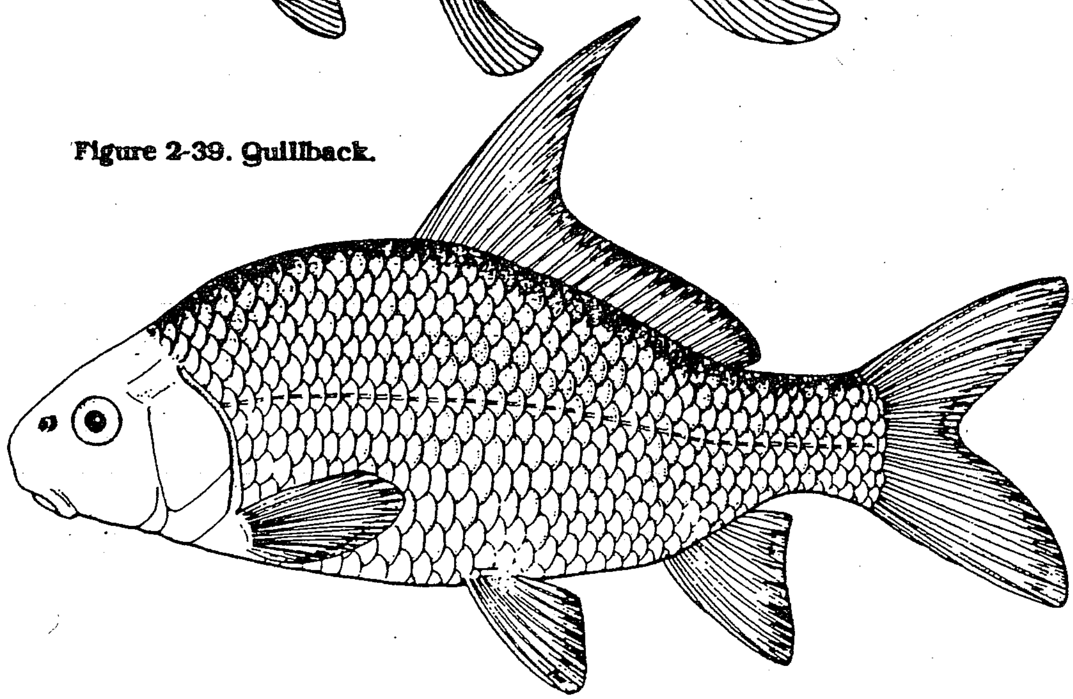


Figure 2-39. Quillback.



Catfish (Family *Ictaluridae*)

The catfishes are easily recognized by their broad flat heads, barbels or whiskers and scaleless bodies. In general, three types of catfish exist. Species such as the channel, blue and white catfish possess deeply forked tails and are popular sportfishes. Bullheads possess a square tail and seldom grow more than a couple of pounds. Madtoms, the smallest catfish, also possess a square tail. This species is often is a good indicator of water quality. Smaller species such as bullheads and madtoms are found in many streams.

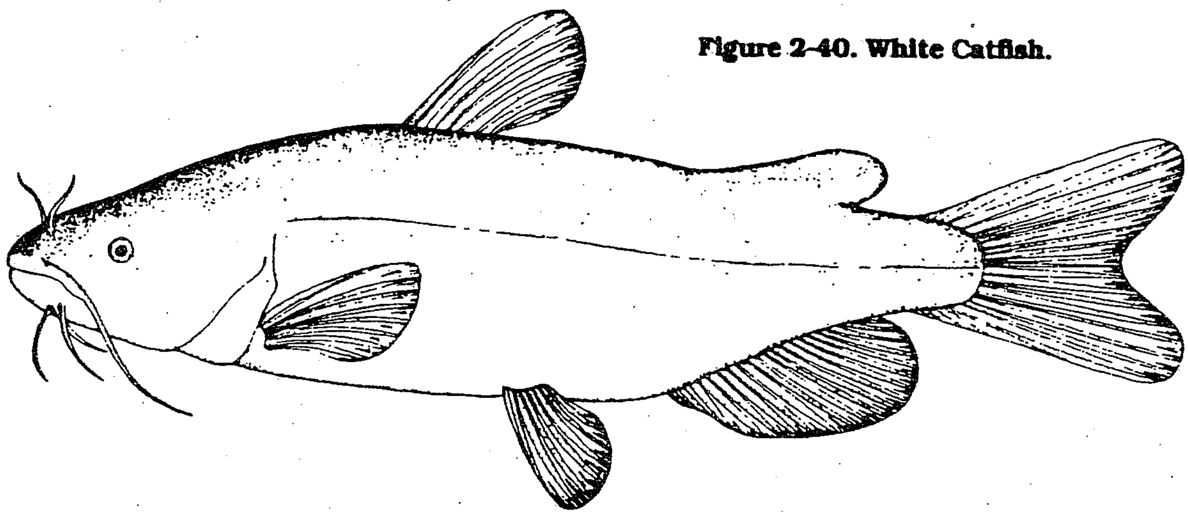


Figure 2-40. White Catfish.

Sunfish (Family *Centrarchidae*)

This family contains many easily recognized sportfish such as largemouth bass, crappie, bluegill, redear and redbreast sunfish. Many sportsmen often refer to certain sunfish as "bream" in South Carolina as well as elsewhere. Members of this family occupy diverse habitats feeding on a variety of organisms, mostly insects, crayfish and other fish.

Figure 2-41. Flier.

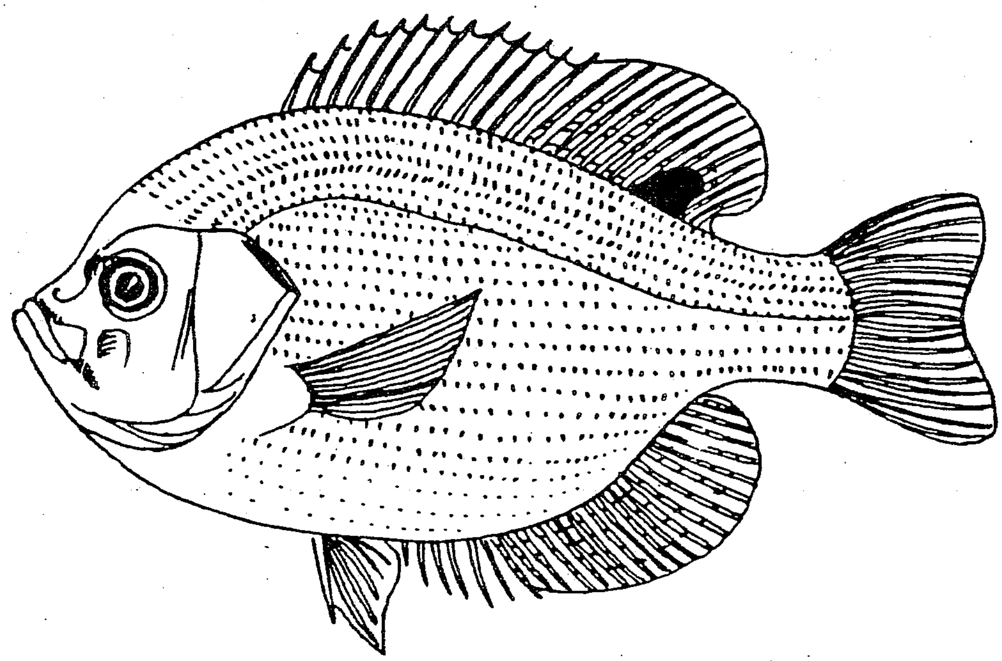
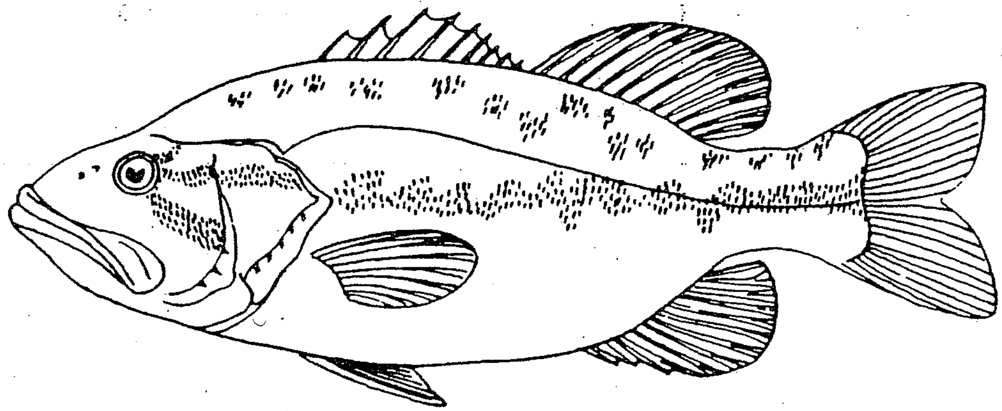


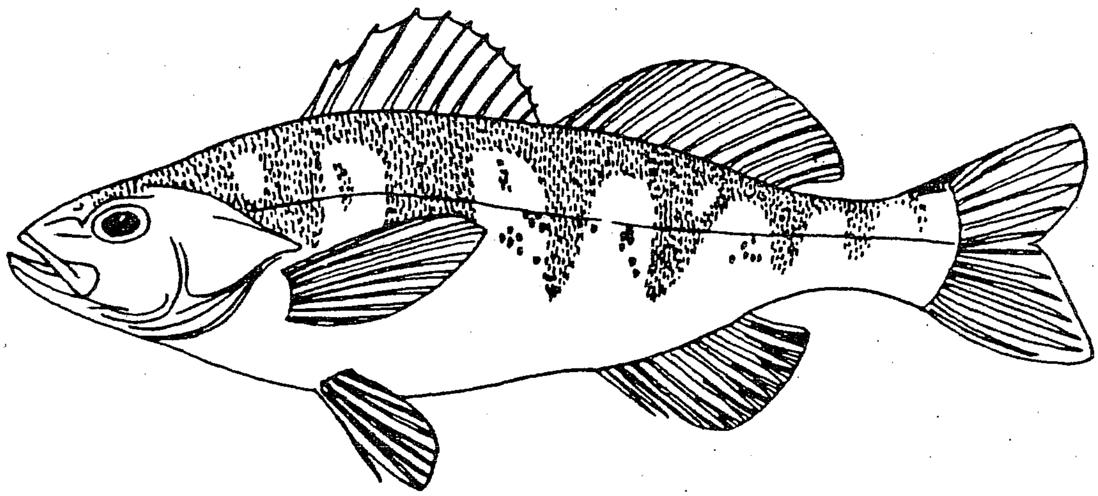
Figure 2-42. Largemouth Bass.



Darters and Perches (Family *Percidae*)

Most members of this family are small and not very well known by sportsmen. Some larger members, however, such as the walleye, sauger and yellow perch are prized as food and sportfish. The darters are small fish which live mainly on gravelly bottoms in riffle areas of streams. Some darters live in pools or sloughs. Most darters are delicate indicators of water quality and environmental modifications within watersheds. The breeding male darter is often brilliantly colored.

Figure 2-43. Yellow Perch.

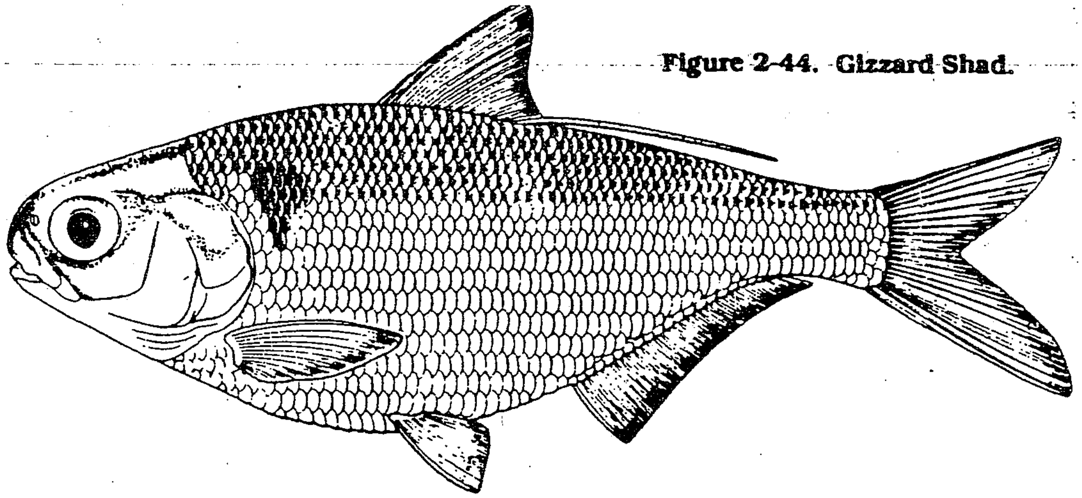


Shad and Herring (Family *Clupeidae*)

Threadfin and gizzard shad are important forage species in South Carolina reservoirs and large rivers. Because these species feed primarily on plankton, they generally are the most abundant fish in our state's reservoirs. Threadfin shad, however, cannot tolerate water temperatures below 42 degrees Fahrenheit and large numbers often die during winter.

Blueback herring, alewife, hickory shad, and American shad are generally anadromous, that is they live in the ocean and migrate into freshwater during the spring to spawn. Landlocked, reproducing populations of blueback herring are found in many of the state's inland reservoirs.

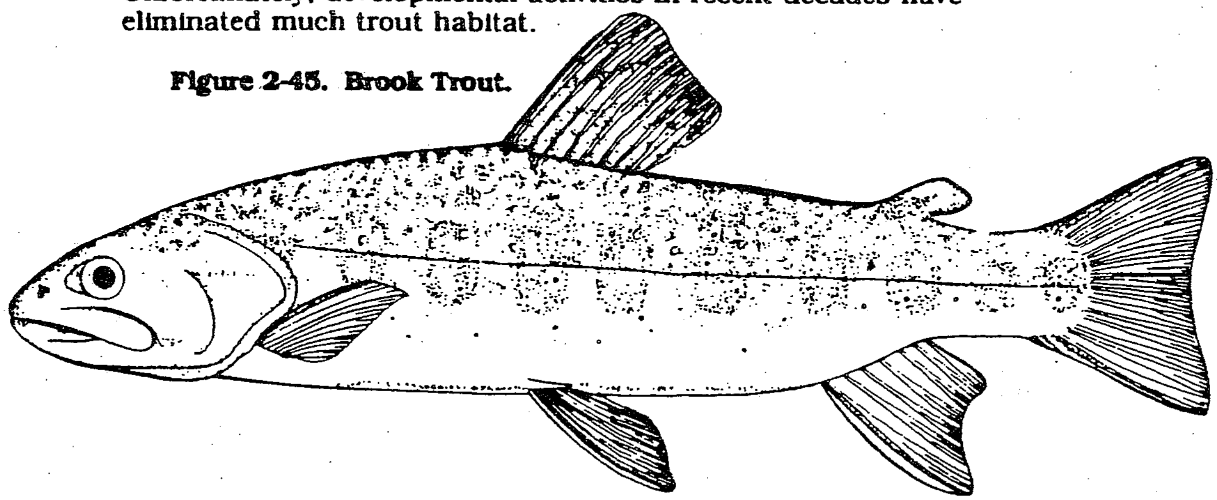
Figure 2-44. Gizzard Shad.



Trouts (Family *Salmonidae*)

Trout are popular sport fish since they readily take artificial lures and provide excellent tablefare. Because trout require clear, cold water, their habitat is generally restricted to the mountain region. Some trout fisheries do exist in the tailrace of dams, however. The Saluda River beneath the Lake Murray dam supports trout, for instance. Unfortunately, developmental activities in recent decades have eliminated much trout habitat.

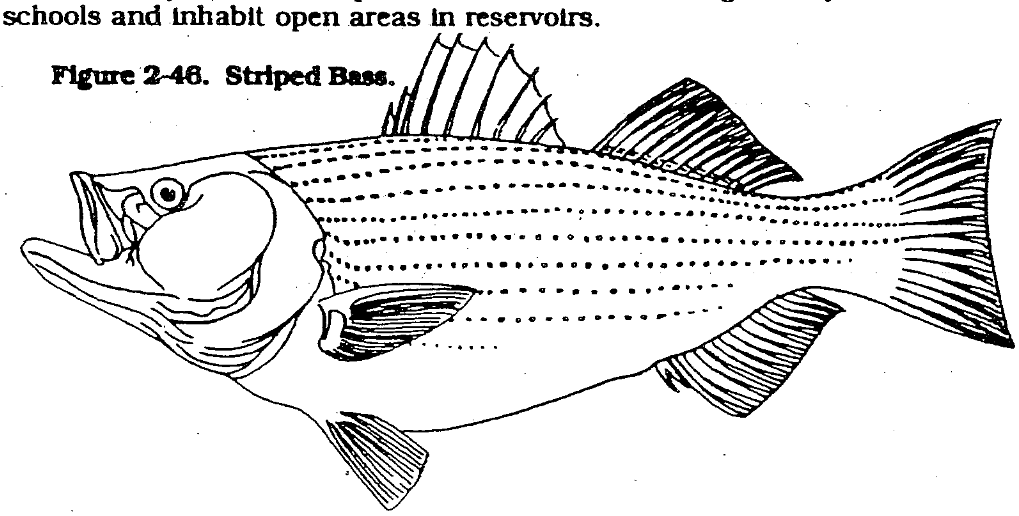
Figure 2-45. Brook Trout.



Temperate Basses (Family *Percicthyidae*)

The important sportfishes, the striped bass, white bass and white perch make up this family. Each spring, these fishes migrate from reservoirs into tributary streams to spawn. As adults, these fish generally form schools and inhabit open areas in reservoirs.

Figure 2-46. Striped Bass.



Background

Before beginning your lake, wetland, river or stream survey, first determine long- and short-term goals and familiarize yourself with the area under consideration. Begin by acquiring maps of nearby watersheds. United States Geological Survey (USGS) maps are very useful for learning the characteristics of a drainage basin. Two types of USGS maps may prove helpful. The 7.5 minute series topographic maps show topography, roads, towns, streams, some wetlands, ponds and lakes, mines and a variety of additional information. The geological quadrangle maps provide some of the information listed above as well as a detailed picture of the watershed's geology. USGS maps and other maps are available through the SC Land Resources Commission's Cartographic Information Center located in Columbia. County road maps available from the Highway Department may also prove helpful.

All of the above maps will be useful in locating sampling areas and access points and may provide historical watershed information. Try to develop a feel for land-use characteristics of the area surrounding your adopted water body. Walk or canoe along as much of a stream channel as possible. This will provide information on stream size, habitat types, stream drop or gradient and bordering vegetation as well as scenic qualities. Knowing the surrounding land leads to a better understanding of the factors that affect the environmental health of your adopted water body.

Once you have a general understanding of the watersheds in your area, choose the lake, wetland, river or stream to be monitored. Try not to take on too large a project, an area too large for you to consistently monitor. If you really want to study a large expanse of water, consider coordinating your efforts with another **Water Watch** group. Remember that the larger the adopted area, the more work there will be and the greater the possibility that some group members may lose interest. The important goal of this program is for you and your group to enjoy learning about bodies of water. Choosing a body of water appropriately sized to your group's ability can yield a more satisfying level of understanding and prove more effective in protecting your selected water resource.

When choosing a study area, locate one that is accessible. Consider the land you must cross, depth of the water body, etc. Deep or fast-flowing waters are difficult and possibly dangerous to sample and require special equipment and techniques not covered in this manual.

If you must cross private lands, be sure you first get the landowner's permission. You might even consider asking him to help you with your survey. One word of caution, however. If a landowner doesn't give permission to cross his land or some trouble arises, find another site.

Prior to sampling, the study group may wish to contact departments within federal, state and local governments, as well as regional universities, to see what information is available on your adopted water body. Federal, state and local organizations that may have pertinent information are listed in the Agency Assistance Section of your **WATER WATCH PROGRAM MANUAL.**

Before any decision is made regarding the techniques you may use to monitor your watershed, introduce your group to the chosen water body by taking a casual hike along its banks. Provide background information so that everyone is aware of the group's goals. Encourage city planners, wildlife biologists and anyone else who might have expertise on your adopted water body to help conduct the first walk. This presents an opportunity to address the water body's historical importance, its ecology, possible problems and the individual interest each person has in the adopted area. Walk along the banks pointing out attributes, past uses and problems. Discuss the water body as a group. Upon returning, exchange ideas on what you have seen. After this initial walk, you'll probably be ready to decide what activities your group should plan for its adopted resource.

Choosing Your Survey

The objectives of your survey may be either aesthetically or scientifically oriented or both. Regardless, two objectives of surveying a water body should be:
(1) determining ambient (present day) characteristics -- biological, physical and/or chemical;
(2) monitoring the water body over time to determine if it is improving, remaining the same or worsening.

To determine these two objectives, three types of surveys can be used:
(1) the visual survey;
(2) the physical/chemical survey;
(3) the biological survey.

Be sure to record your observations on copies of the survey data record forms found in Appendix V.

The Visual Survey

Although the visual survey is the simplest survey type, it can provide a great deal of information about your adopted water body while requiring little equipment. Basically, all you need is a clip board, pencils, the data sheets in Appendix V, maps, the problem diagnosis section in Appendix II, and possibly hip boots and a camera. You might want to take a walking stick of known length for balancing, probing and measuring. Safety requires that two persons conduct the visual survey and, besides, two or more people can do a better job describing the traits of their adopted water body.

Map Making

As part of the visual survey, map the entire water body or at least that part to be surveyed. The map need not be a perfect likeness, but it should include major habitat types, dams, bridges, location of discharge pipes and dumps. Indicate the size of the area and bottom types. Make notes on the data sheet regarding depth, width, substrate types (rock, sand, mud, etc.), types of riparian vegetation, adjacent land uses and unusual water colors and odors. This is where a camera can especially prove useful. You may find it helpful to set up photographic stations where pictures can be taken at various times of the year over a period of several years. Such photographs make slowly occurring changes more evident. Just be sure to label all photos with their proper location, date, time, photographer's name and witnesses.

If some members of your group own boats, you may want to conduct your visual survey with some members walking along the water body while others follow in boats. This will provide more information on the extent of shallow areas and vegetation. If a boat has a depth-finder, you can prepare a bottom-profile map of lakes.

The Physical/Chemical Survey

The physical/chemical survey is designed to delineate some of the basic physical and chemical traits of your chosen water body. Physical features include temperature, visibility (turbidity) and color, while chemical attributes include dissolved oxygen, conductance, hardness, pH, and a multitude of other characteristics. Because most chemical analyses require laboratories, this handbook doesn't discuss them. However, relatively inexpensive, easily operated field kits are commercially available if your group decides it wants more detailed information on its adopted water body. Regardless of the kind of physical/chemical data collected, over time such information will allow you to see changes in water quality. Just remember to record the date, time, location and your name along with the other data.

Some physical/chemical analyses can be done easily and inexpensively. Three of these are temperature, visibility and pH.

pH, is a measure of water's acidity or alkalinity. A pH of seven indicates the water is "neutral" -- neither acidic or alkaline. Most natural water has a pH range of six to nine. Anything above or below this range may indicate a problem. Approximate pH can be determined by using the pH paper available from many drugstores.

Visibility, easily measured with a simple instrument called a **Secchi disk**, is a measure of the depth to which one can see into the water. Easily built, the disc is 20 cm. in diameter (8 inches) with the surface painted in opposing black and white quarters. A ring at its center is attached to a line marked at six-inch intervals, so that the disc hangs horizontal to the ground.

To determine Secchi disc visibility, slowly lower the disc into the water until it disappears; make a note of the depth. Lower the disc a few more feet, then slowly raise it until it reappears; note this depth. The average of the two readings is the Secchi disc visibility depth. This value can be used to compare visibility in different areas of a water body at different times of the year. Factors such as clear or cloudy weather, time of day, and roughness of the water affect readings, so be sure to make a note of such conditions along with the visibility depth.

Temperature is easy to measure in shallow water but difficult when depths are great. An inexpensive thermometer designed to take readings at various depths can be purchased at some sporting good stores. If such a thermometer can't be found, use a sampler like the one illustrated on the next page. Simply stopper the bottle, lower it to the desired depth and give the line a sharp tug. Water from that depth will fill the bottle. Quickly bring the bottle to the surface and measure the temperature below the neck of the bottle. Both the Secchi disc and water sampler are designed to be lowered from a boat.

Figure 3-1. Secchi Disk.

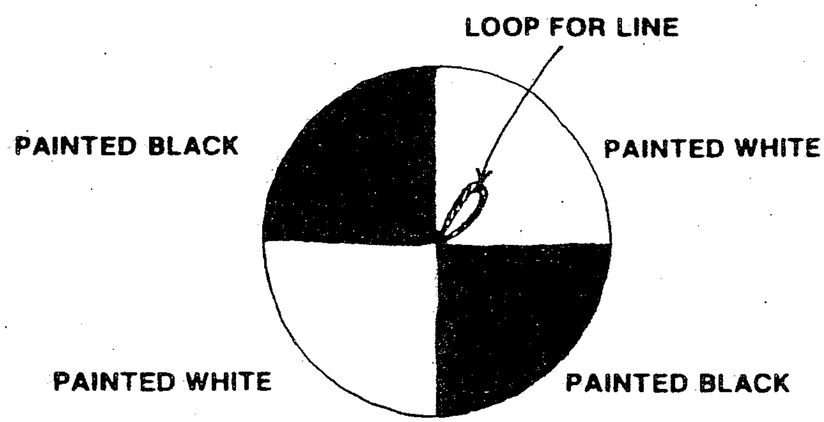
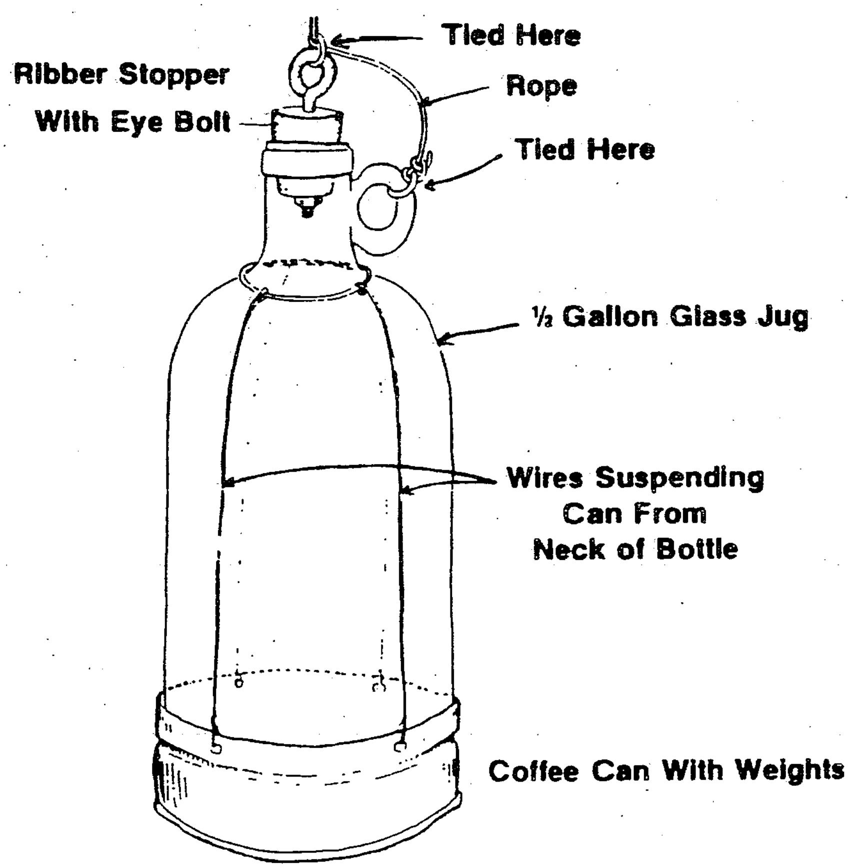


Figure 3-2. Water Sampler.



The Biological Survey

Biological surveys of water bodies usually involve collecting algae, aquatic macroinvertebrates and fish. Data from such collections can determine past and present water quality as well as determine if that quality is improving, degrading or remaining stable over time. An analysis of aquatic organisms provides valuable water quality information. Chemical and physical measurements generally capture only one moment of a water body's history. Aquatic invertebrates have proven to be excellent organisms for water quality analysis because they are stationary residents. They also have life spans that generally last at least a year. All this means that the investigator observing the numbers and types of aquatic invertebrates may be able to gain a general insight into the past year's water quality events and, thus, deduce environmental impacts.

The equipment required to collect algae is easy to obtain and inexpensive. Collection equipment includes a knife to scrape algae from rocks and sticks, a small jar and ziplock plastic bags. Observations are best made in the field and recorded on the data sheets in Appendix V for reference to a field identification guide.

Surveying for Macroinvertebrates

There are several ways to sample for macroinvertebrates using fine mesh nets or screens and washing or picking organisms directly from rocks, gravel, logs, sticks and aquatic vegetation. After reading this section, **see Appendix III & IV** for specific directions on equipment, sampling methods, and interpretation of findings to assess water quality.

River Sampling

Handscreens or kicknets can be used to take samples from the middle and edges of streams, the margins of weed beds, bank undercuts and other habitats. Placing the net in roots, stick piles, aquatic vegetation and vigorously shaking it for several seconds is a good technique for capturing samples.

Other collection methods include lifting rocks, sticks and carefully looking for invertebrates. As you sort your samples in an area with good light, you'll find a magnifying glass and fine-tipped forceps invaluable. If organisms are sorted in the field, take care not to overlook any of them. Place your specimens in a white-bottomed plastic or enamel pan. Many macroinvertebrates are smaller than a half dollar. Often they will have an incredible array of colors and fascinating shapes.

Lake & Pond Sampling

Many macroinvertebrates can be seen on the surface or swimming in water. A dip net can easily scoop these up for examination. Other invertebrates are more difficult to find, especially during the daytime. Often they hide on or under aquatic vegetation. Turning over floating leaves like lily pads or closely examining the stems and bodies of emergent and submerged plants can reveal specimens. Pulling up vegetation mats and rinsing them off over a white pan or cloth often reveals an amazing array of organisms.

Benthic or bottom-living macroinvertebrates are especially adept at hiding, but many of them can be found beneath logs and stones in shallow water. You can also scoop up bottom sediments in a sieve, swish it through the water to remove most of the mud and examine the remaining debris in the white pan. Deep-water sediments can be sampled by lowering a dredge from a boat, but please note that this can be a difficult and dangerous task.

Sample Analysis

Identify the invertebrates and release them quickly. If you choose to save your samples, preserve them in a 70 percent alcohol solution. Isopropyl alcohol, better known as rubbing alcohol, is a suitable preservative readily found at drug stores. Carefully label preserved specimens indicating the collection date, location and collectors' names.

Count and record the total number of specimens and separate them into "look-alike" groups based on body shape and the number of legs and tails. The total number of individuals, number of kinds, and number of individuals per kind are all-important to judging the water quality of your adopted water body. Surprisingly, it's possible to learn much about the condition of the invertebrate community and water quality without identifying the organisms. By carefully sorting the collection and grouping similar organisms, you can determine the types present. Sorting by similarity involves the use of body shape, number of legs, and the presence or absence of tails. Secondary sorting characteristics, such as size and color patterns, may also be used. If a broad variety of types are present in small numbers, then the water body most likely enjoys good water quality. Poor water quality will generally feature only a few types of organisms in large numbers.

To identify your samples and assess water quality refer to Chapter 2 and Appendix IV.

Surveying Vertebrates

Vertebrates, simply put, are animals with backbones. Fish, amphibians such as salamanders, frogs, toads, and sirens, reptiles such as snakes, lizards and turtles, birds and mammals are all vertebrates. Reptiles and amphibians, collectively called "herptiles" or simply "herps" should be noted when seen and also when heard. Many frogs and toads give characteristic calls that can be identified by listening on warm or early summer evenings. Birds are highly visible and very interesting to many people, and they, like frogs, can be identified by songs or calls. Bird song records, in fact, are readily available from several sources. Keep field notes of the numbers and kinds of all vertebrates observed. Refer to the identification manuals listed in the reference section.

Collecting Fish

Fish may be collected by a variety of methods, but small- and medium-sized streams are easily surveyed with a minnow seine. Please be aware, however, that a valid South Carolina fishing license is required to seine. Also note that in order to keep collected fish, you must receive a collection permit from the South Carolina Wildlife and Marine Resources Department. Failure to have either a valid fishing license or a collection permit can result in fines, loss of equipment and possibly imprisonment.

Fish collecting in riffles is most easily accomplished by working one five or six-square-foot area at a time. One or two people can hold the net stationary at a 45 degree angle to the water in a downstream direction. One or two other people should move along five or six feet above the net vigorously disturbing the substrate with their feet while slowly working toward the net. When the collectors reach the net, lift it from the water and take it to shore. The fish should quickly be identified and returned to the stream unharmed. Specimens from fish kills which may require analysis should be wrapped in aluminum foil, placed in plastic bags and deep-frozen.

Macroinvertebrates can also be collected from the net. When seining pools, make short hauls, preferably starting near the middle and working to the bank when possible. Be sure to sample areas of cover such as log piles, undercut banks, weedbanks and other cover.

See **Appendix III** for directions on collection equipment.

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APPENDIX I

Water Watch: What to Watch For!

Water Watch is intended to provide people with the knowledge they need to solve problems affecting streams, lakes, and wetlands. Therefore, Water Watch can help solve water quality problems by providing people with the knowledge to identify and correct the causes of pollution and other adverse impacts.

Described below are the normal channels used to resolve a wide array of problems. The problem categories listed below account for the majority of South Carolina's water pollution problems. When a problem is initially discovered, it is the responsibility of the individual Water Watch volunteer to initiate corrective action. Water Watch provides the volunteer with support in this early problem solving phase in the form of training materials and access to other Water Watch volunteers who have tackled similar problems in the past.

The bottomline to continuing progress in eliminating water pollution is heavily dependent upon the active involvement of people like Water Watch volunteers. If we are to protect and restore our state waters, ideally we should have volunteers watching every potential problem source in every river basin. It's a big job but you need only commit yourself to one problem.

Here are the primary problems to consider. Remember, Water Watch can offer information and training regarding the causes and cures for these and other water quality issues.

Farm Pollution

Pollutants stemming from agricultural activities include eroded soils from croplands and overgrazed pastures, wastes from cattle and other livestock, pesticides and fertilizers applied to croplands and orchards, and thermal pollution due to reduced shade along stream banks. Farm pollution problems are usually identified through biological testing, temperature measurements or visual indicators (e.g. barren pastures, gullied croplands, streams of water flowing from manure laden areas). Corrective action is initiated through a referral to the Department of Health and Environmental Control (DHEC) which, in turn, may contact the local Soil Conservation District (SCD) for technical assistance. The SCD can contact the farm operator and schedule an on-farm meeting to develop solutions.

Construction Sites

Mud (sediment pollution) is the principle stream quality problem resulting from construction activity, sand and gravel and other mineral extraction operations. The sediment coming from one construction site can damage 3 to 5 miles of stream below the site for 10 to 100 years. Some counties, but not all, have laws requiring that sediment be captured on construction sites prior to reaching any body of water. Sediment movement is controlled through ponds and other devices. Whether a site is in compliance with these laws is determined through a visual examination of the condition of the control devices. Sediment control deficiencies are corrected through a referral made to a local county inspector or the local Soil Conservation District. Water Watch can offer a short training course which will provide the volunteer with the knowledge needed to assess and refer sediment control problems.

Well Contamination

Improper industrial waste disposal, failing septic systems, sanitary landfill leachate, excessively fertilized croplands and poor well installation can cause well water to become contaminated. The Department of Health and Environmental Control (DHEC) can provide assistance with testing well water. Once contamination is found or suspected DHEC can determine the cause and develop corrective measures. These measures can run the gamut from additional grouting around well pipe to a massive clean-up effort in the case of contamination affecting a number of wells.

Septic System Failure

The most frequent cause of septic system failure is inadequate maintenance. Every 2 to 5 years accumulated solids must be removed from the septic tank. If the solids are not removed they may travel into the drain field and clog the soil. Septic system failure may be obvious. One may see a gray to black, foul smelling liquid flowing from lawns or trickling down a street gutter. Failures may also be detected by measuring bacteria levels. Normally, once a septic system fails it must be replaced at a cost of $1,500 to 2,500. If a number of systems have failed, connection to the nearest sanitary sewerline may be the only solution. Corrective action on septic system failures is initiated through a referral made to your local DHEC office.

Timber Harvesting Operations

Stream quality problems associated with timber harvesting operations result from sediment eroded from haul roads and skid trails, thermal pollution caused by a lack of recommended wooded buffers between streams and harvested areas, and the accumulation of slash (branches and other cuttings) in stream channels. There are no laws in South Carolina to directly regulate timber harvesting. Problems caused by timber harvesting may be corrected through DHEC, the South Carolina Forestry Commission and the South Carolina Forestry Association. Water Watch can provide information detailing what steps the logging company should take to protect stream quality.

Suburban/Urban Runoff

Rainwater runoff from residential neighborhoods, schools, shopping centers or any developed area can be just as contaminated as raw sewage and can increase flooding by 100-fold. Any cluster of homes on lots smaller than 2 acres or any tract with 10% or more of the soils covered by impervious materials (rooftops, asphalt or concrete) can degrade the quality of waters receiving rainwater runoff from the site. Correcting this source of stream quality degradation requires involving each landowner in a strategy for eliminating the entry of contaminated runoff into nearby waters. There are a number of steps which can improve the situation. The SC Coastal Council has expertise in planning for the control of stormwater runoff and Water Watch can provide information on urban/suburban stream restoration strategy.

Sewerline Overflows

Sewage may escape from sewerlines at manholes (due to pipe blockages), breaks in the line or at sewage pumping stations. Overflows of large quantities of sewage or discharges from pumping stations can normally be corrected rather quickly by calling the local public works department or DHEC office. Smaller losses, through cracked pipes or poorly sealed joints, may require an extensive program of sewerline rehabilitation or replacement. These less obvious losses can take much longer to correct.

Sewage Treatment Plants/Industrial Discharges

Throughout South Carolina there are hundreds of sewage treatment plants and industrial discharges. The most frequent problems associated with these plants are the toxic effects of chlorine used to disinfect sewage and the release of organic matter which may lower oxygen levels in the receiving waters. Like other "point sources" of pollution, sewage treatment plants are issued Discharge Permits. These permits impose limits on the types and quantities of pollutants that the plant may release. These limits are set at levels which will protect uses in the receiving waters. DHEC can provide information on specific treatment plants, how well they meet discharge permit limits and, where compliance is good, how effective the permit limits are in protecting the receiving waters.

Problems associated with sewage treatment plants are corrected by contacting your local DHEC office. If the problem results from poor operation or maintenance, then correction will be simple. If problems result from the basic plant design - the lack of adequate treatment system components - then correction may take a year or more. Your efforts may result in the initiation of these corrective actions sooner than otherwise would have been the case. The public (Water Watch groups) can be involved in area-wide planning for sewage discharges, the review of proposed discharge permits and increases in discharge permits to ensure protection of their interests in the receiving stream.

Sanitary Landfills

A landfill, in very simple terms, is a pit excavated in the earth which may or may not be lined with a material which prevents or collects water flowing from decomposing garbage. The bottom of each pit is usually located over a good soil which forms a barrier above the water table or bedrock. The most significant problem associated with landfills is the movement of leachate (water which has become contaminated after passing through decomposing garbage) into nearby waterways. Sediment, due to erosion on exposed soils, is a secondary problem. If sufficient leachate is travelling from the landfill to cause surface or groundwater contamination, DHEC should be contacted for corrective action.

Hazardous Wastes

Hazardous waste includes a wide variety of materials which may be directly toxic, acidic, caustic, or combustible. Generators of hazardous waste are required to document the safe disposal of these materials. If you suspect that a hazardous waste is being released into public waters, then you should contact DHEC.

Stream & Wetland Alterations

A permit is required from either the Coastal Council, the Water Resources Commission, or the U. S. Army Corps of Engineers for any work or alterations of land areas influenced by tidewater and within the channel or floodplain of all streams. This "work" or alteration is generally anything requiring the use of heavy equipment such as a bulldozer. When heavy equipment is found working in or near a stream, wetland or tidal area, the Coastal Council or Water Resources Commission should be contacted to ensure that the activity has received a permit. Water Watch groups can be involved in the review of proposed alteration to ensure that minimal environmental damage results.

Litter, Logjams & Bank Erosion

No state or local programs exist which will routinely remove litter or debris from streams. Neither is there much help available for correcting channel erosion problems. Generally, these problems are corrected through volunteer efforts. Water Watch groups can get involved by organizing these activities.

APPENDIX II

Diagnosis

How can you tell what might be wrong with a river, lake or wetland? Just like diagnosing the cause of a pet's sickness, you can take all the symptoms and signs together and try to determine what might be causing the problem. The following tables are designed to help you know the types of problems that might occur in your area and the obvious signs of those problems. Read each table several times, allowing yourself to get a feel for threats to water bodies. You may want to take these tables with you on your next visit to your adopted area.

Table A-1. Land-use Indicators of Water Pollution Possibilities.

Woodland: Check for sedimentation (cloudy or muddy water) from erosion caused by logging, road building, or mining.

Farmland (crops, pasture and feedlots): Check for excessive algal growth (green water or a lake or wetland clogged with water plants) caused by fertilizers or manure draining into the lake or wetland. Also watch for sedimentation from farming practices.

Cities and Towns: Urban stormwater runoff can carry with it all sorts of pollution including metals (such as lead), salts, chemicals and oil. Insect and fish counts may indicate the presence of one of the above, but chemical analysis of the water may be needed to pinpoint the cause.

Industries: Keep an eye out for color changes, excessive algae, odor, absence of aquatic life such as insects and fish, and fish kills. If these occur, the water body should be tested for inorganic (metals), organic (pesticides, phenols, oil, etc.), and other toxic substances.

Sewage (treatment plants or pipelines): Look for "organic" pollution indicated by excessive algal growth, white foam or suds from detergents, sludge beds, absence of some species of fish and insects, and/or extreme abundance of others (See following Tables 3 and 4).

Mining: Check for sedimentation and acid drainage. Acid drainage can be detected by a low pH (pH less than 4.0). A yellowish-orange deposit often is present on the bottom due to high iron content of most mine drainage. Oftentimes, waters with an extremely low pH will be exceptionally clear.

Construction: Land-disturbing activities, such as development and road building, are a leading cause of erosion and sedimentation, so watch for cloudy or muddy water.

Residential: Lawn fertilizers, detergents used for washing clothes or cars, oil drained from autos, septic tank outflow, and general trash (cans, bottles, etc.) are common forms of residential pollution. Keep an eye open for excessive algae growth, white suds, color sheen (oil) on the water surface or bank, or absence of aquatic organisms.

Table A-2. Physical Indicators of Water Pollution

A. Water Color

Green: If the water is noticeably green, this could be an indication of "organic" pollution being released into the water body feeding algae (hence the term algal bloom) and other aquatic plants.

What to do: Check for discharges of sewage, fertilizer (including lawn fertilizer) or livestock run-off areas.

Orange-Red: Orange to red deposits on stream bottoms could be caused by acid mine drainage or oil runoff. The color is due to an iron compound in such areas.

What to do: Check for drainage from mining, drilling or industry.

Light Brown: Sediment deposition (muddy or cloudy) caused by erosion.

What to do: Search the watershed for disturbed ground left open to rainfall and subsequent erosion.

Multi-color Reflection: Indicates oil floating on the water.

What to do: Check the watershed closely for the source. Waste oil may have been dumped into or beside the water body by an individual or service station.

Dark reds, purple, blues, blacks: Indicates organic dye pollution from leather tanning or clothing manufacture.

What to do: Check the watershed closely for the source. It probably enters the watershed through a discharge pipe from an industrial operation.

B. Water Odor

Rotten Egg Odor: Indicates sewage pollution.

Musky Odor: May indicate presence of untreated washwater, sewage or livestock waste, decaying algae or other conditions.

Acrid Smell: May indicate presence of industrial or pesticide pollution.

Chlorine: May mean that a sewage treatment plant or chemical industry is over-chlorinating their effluent.

What to do when you detect these odors: Check the watershed for industrial, municipal, residential, or agricultural waste.

C. Foaming (Suds)

When white, and greater than 3 inches high, foam generally is due to detergents.

What to do: Check the watershed for industrial, municipal, or residential waste entering the stream.

Table A-3. Fish as Biological Indicators of Water Quality.

A. Erratic Swimming

Fish swimming near the surface, gasping for air at the surface, or swimming in circles may indicate the presence of a toxic substance.

B. Disease

Red sores or white cottony-like places on fish indicate the presence of disease. Several diseased fish in an area may indicate the presence of toxic substances at levels not great enough to immediately kill the fish.

C. Absence of Fish

This may be a strong indication of a badly stressed water body. The cause could be urban run-off, or sewage or toxics (organic and inorganic) entering the water body.

What to do for A-C: Chemical analysis of the water may be needed to find the source, but check upstream in the watershed to see where the problem begins.

Table A-4. Aquatic Macroinvertebrates as Biological Indicators of Water Quality.

A. A great variety of macroinvertebrates with a few of each kind: clean water.

B. Less variety, but greater abundance of each kind: water is overly enriched with organic matter (nutrients from agricultural runoff, sewage runoff).

C. Only one or two kinds of macroinvertebrates, with great abundance: Severe organic pollution.

D. Few or no macroinvertebrates, but the lake or wetland appears clean: Toxic pollution.

What to do for B-D: Check the watershed for potential sources of pollution. A chemical analysis may be needed to pinpoint the pollutant(s) causing the problem(s).

APPENDIX III

Collection Equipment

A Word On Collection Equipment

Most freshwater organisms can be collected with the simplest of homemade equipment. A bit of ingenuity is all that's necessary. A few pieces of equipment that have proven useful over the years are described below. While all can be purchased at a biological supply house, most can be made at home.

Personal Equipment

Clothing suitable for field work such as rubber boots or tennis shoes, waders and other waterproof gear.

A small case such as a discarded pocketbook or tobacco pouch outfitted with:

> a magnifying glass or pocket lens to view small samples,
> notebook and pen to record your findings, and
> forceps (tweezers) to pick out small critters in your samples.

Containers suitable for bringing back specimens. Such containers include small jars of assorted sizes with tight-fitting lids and one or two large jars for bringing home unsorted material. You'll also need a few vials of 70 percent alcohol and some heavy-duty plastic bags.

Sampling Equipment

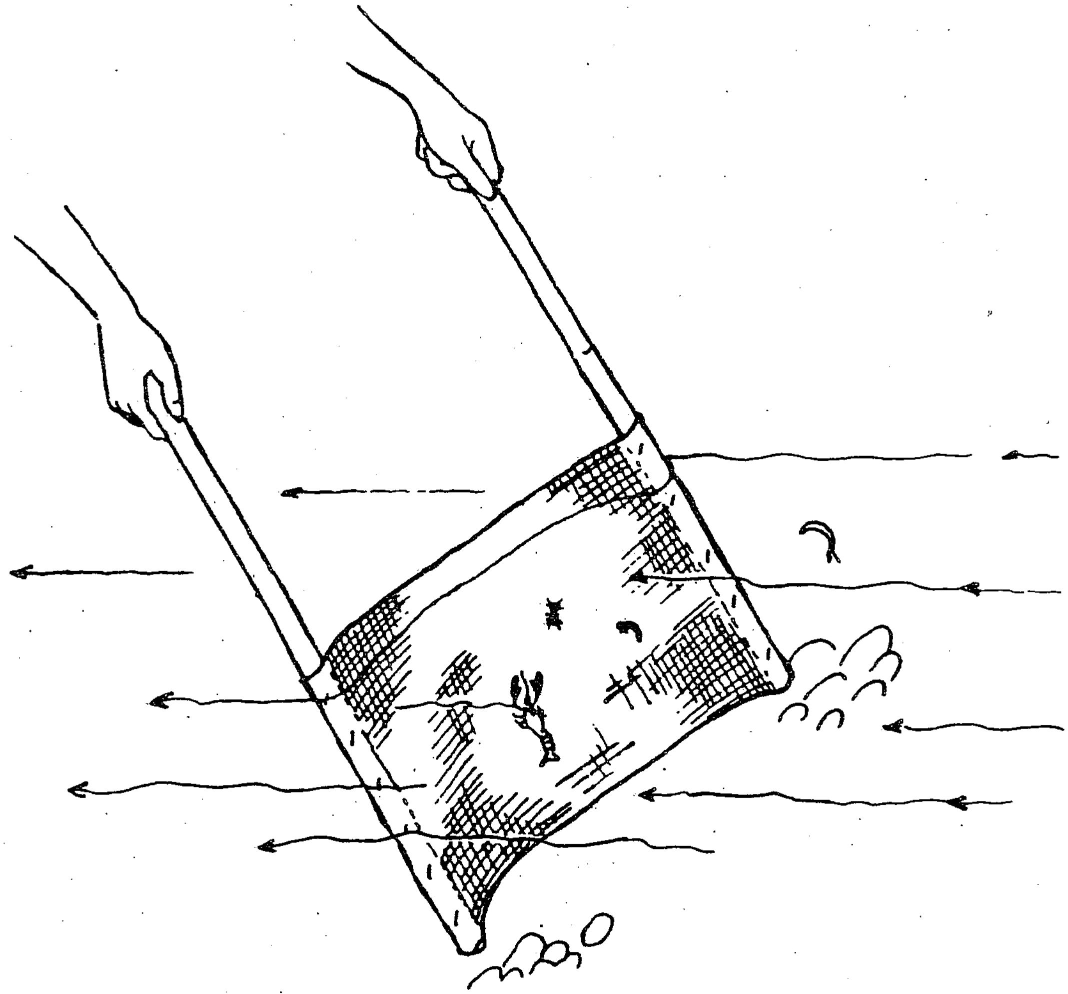
A **hand screen** also known as a **kicknet** can be made from the following materials:

Nylon or metal screen (as used for screen doors).
Two wooden poles 5' to 6' long, for handles.
Finishing nails or staples,
Tinner's Shears.

Refer to the hand screen illustration. The netting between the two handles is metal screen about 1' x 2'. If wire screen is used, the woven edge is put on the bottom. The opposite edge should be folded, leaving no projecting wire-ends. The folded ends of the screen should be wrapped around the poles and either nailed or stapled. Use the hand screen to sample for macroinvertebrates in a variety of habitats. See Chapter 3 and Appendix IV for sampling methods.

Observation Pan
An ordinary white enamel or plastic pan for examining a catch. The white surface makes it easier to see small insects and animals.

Figure A-1. Handscreen or kicknet.



Dip Nets
Aquarium dip nets, sold by most pet stores, prove useful for sampling small fish around weed beds and along banks. An ordinary kitchen sieve or tea strainer tied to a long handle will serve well as a small dip net for light work.

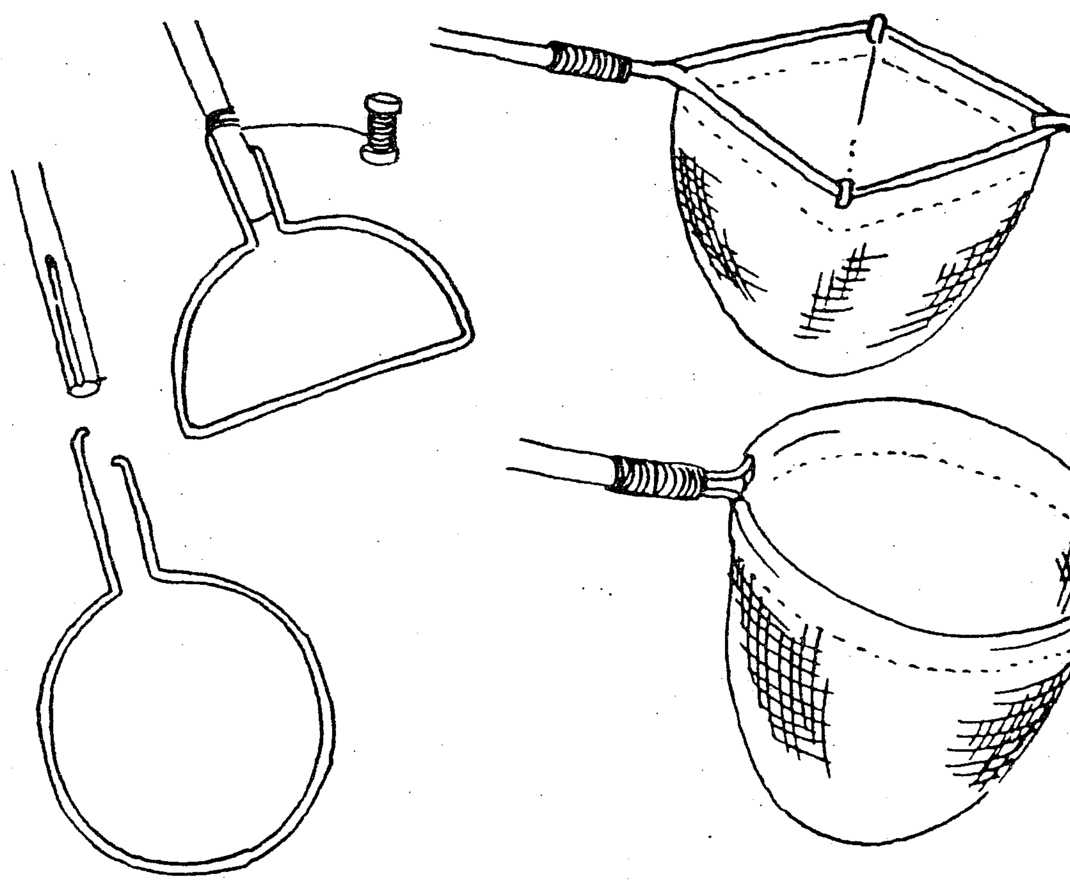
To make a large dip net use:
Heavy gauge steel wire for the frame,
A wooden pole 5' to 6' long for the handle,
Meshed fabric such as curtains or mosquito netting to make the net,
Heavy twine to bind the wire frame to the handle,
Duct tape to attach the netting to the wire frame.

Minnow Seines
Minnow seines 6' x 4' can be purchased from most bait shops, or you can make a seine by cutting a burlap sack down the sides. Attach the sack to two wooden poles six feet long with finishing nails or wire. Add lead weights to the bottom and floats to the top if necessary.
See "Collecting Fish" in Chapter 3 for instructions on using a seine.

Bucket
A regular galvanized metal or plastic water bucket is useful for washing sticks and stones and scraping up bottom sediment to sample for macroinvertebrates. See Appendix IV.

Sieve
A sieve can be made with a large plastic embroidery hoop fitted with a mesh fabric such as cheese cloth. A sturdier sieve could be made by building a square, wood frame with metal screen stapled over it. Use the sieve to strain macroinvertebrates from sediment samples and material washed from submerged rocks and sticks.

Figure A-2. Dip net construction.



Macroinvertebrate Sampling & Water Quality Assessment

There are many methods of sampling for macroinvertebrates to assess water quality. In Chapter 3 a general description of where to look for macroinvertebrates and techniques for sampling them is provided. Appendix III provides a description of the sampling equipment needed for biological sampling and inexpensive ways to make your own sampling equipment.

This appendix provides direction for macroinvertebrate sampling projects, ie. sampling methods, sampling equipment needed, and interpretation of your samples for water quality assessments. These sampling methods are oriented towards stream and riverine habitats. If you wish to sample lakes, refer to techniques described in Chapter 3 and the section, "Assessing the Quality of Your Stream", found below to analyze your samples.

Where to Start.

In streams there are two general types of habitat; pools and riffles. Pools are the deep, slow-moving portions of a stream. The bed of a pool is usually coated with sand or silt. Riffles are those areas of a stream where the water flows shallow and swift. Within riffles the bed is usually armored with gravel, stones, or boulders.

This distinction between these two habitat types is particularly significant for stream insects. Most of these creatures dwell in the riffle areas. Therefore, all your sampling will be done within a riffle. Stream insects prefer riffles because that is where life is easiest. In the riffle an insect can sit in one spot and simply capture food from the swiftly flowing water. An insect leading a quiet life is far less susceptible to predators and can use more energy for growing and reproducing.

Most stream dwelling insects are immature. The majority spend their adult lives on the land. There are three major groups, or orders, which will normally account for 90% or more of the insects collected from a stream. These groups are the true flies (Diptera), caddisflies (Trichoptera), and may flies (Ephemeroptera). The illustrations in this guide will allow you to identify most aquatic insects. See "Macroinvertebrates" in **Chapter 2 for illustrations** of aquatic insects.

Assessing The Quality Of Your Stream.

(The following directions are from the Maryland Save Our Streams program.)

Use the following system when analyzing your macroinvertebrate samples to assess the ecological health of your stream.

There are four groups of insects which should be present in all streams; stone flies, may flies, caddisflies , and true flies. Generally, the stone flies are the most sensitive to pollution, followed by the may flies, then caddisflies, with most true flies tolerating highly contaminated waters. the assessment of stream quality is based solely on the first three groups.

The true flies tend to be small and difficult to see. Following is a description of a specific stream quality rating system.

EXCELLENT: If stone flies, may flies, and caddisflies are present, then stream quality is rated as excellent. An excellent quality stream is suited for virtually any human use. It will probably support a very healthy population of game fish and would need little treatment prior to human use. Such a stream should also be quite enjoyable as a place to wade, swim or picnic.

GOOD: Stream quality is rated good if the stone flies are absent, but may flies and caddisflies are present. A good quality stream can support a healthy fish population and should be suited for swimming and wading. If an industry or town wishes to utilize the stream as a water source, then it will probably face moderate treatment costs.

FAIR: If both the stone flies and may flies are missing, but caddisflies are found, then stream quality is fair. Fish populations in fair quality streams tend to be poor. The more sensitive fish are probably gone. One should not wade or swim in a fair quality stream. Water treatment costs will likely be quite high.

POOR: If you cannot find stone flies, may flies, nor caddisflies, then rate the stream poor. Such a stream is probably devoid of all fish life. It is unsuited for contact with the human body and would make a very unsatisfactory water supply source.

If you find that stream quality is poor or fair, then your first step should be to verify the condition. Repeat the sampling procedure at another riffle or stretch of the stream. If stream quality is still less than good, then attempt to pin-point the source of the condition.

Sources of poor or fair stream quality can be detected by using the sampling technique to work upstream. You'll be looking for a point where stream quality improves. In other words, look for a point where one or more of the missing insect groups reappear. Normally, this is best done by working upstream, road crossing by road crossing.

Ideally, you eventually find one riffle where may flies are present, but the next riffle downstream lacks this insect group. In the pool between the two riffles you may find a pipe, projecting from the bank, spewing out some foul liquid. Perhaps you might find an empty steel drum, with an EPA hazardous waste number on its side, lying on the bank. Or you may find a sewerline manhole with toilet paper lying about its base - indicating a recent overflow. Usually common sense will indicate the cause of the problem once you're bracketed the source to this degree.

When you find the source, or if you encounter difficulty tracing the problem, then please contact the nearest Department of Health and Environmental Control District Office or the Water Watch Coordinator. You should never assume that someone already knows about the problem. Also, if you encounter difficulty with the sampling technique, never assume the fault is yours. Always contact the Department of Health and Environmental Control or the Water Watch Coordinator so we can have someone assist you in working out the difficulty; that's what we're here for!

The Kicknet Sampling Method.

(The following directions on the kicknet method for sampling macroinvertebrates are from an article published by the Izaak Walton League of America.)

Equipment needed: two people, hand screen (kicknet), observation pan, forceps (tweezers), notebook and pen.

1. Select a riffle area, that is, a shallow fast-moving area.

2. Place the kicknet at the downstream edge of the riffle. Be sure the bottom of the net fits tightly against the stream bed so no creatures can escape along this point. Also, try not to allow any water to flow over the screen top.

3. Disturb the stream bed for a distance of three feet upstream of the net. Brush your hands over all the rock surfaces to dislodge any attached insects. Stir up the bed with hands and feet until the entire three square feet have been worked over. (Remember to be careful of your hands. Watch for object that might cut.) All detached creatures will be carried into the net.

4. When step 3 is completed, remove the net with a forward scooping motion. The idea is to remove the net or screen without allowing any of the critters to be washed from its surface.

5. Place the net on a flat, light colored area. Using tweezers, pick all of the creatures from the net and place them in a pan. (If you do not have a pan, just separate them on the net.) Any creature moving, even if it looks like a worm, is part of the sample. (Do not miss snails and clams.) Look closely since most of these organisms are only a fraction of an inch long.

6. Once all animals have been removed (excluding any fish or other vertebrates-throw these back quickly so they might survive the stress of being out of their habitat) from the net, count the total number. Then separate them into look-alike groups. Use body shape, number of legs and tails, primarily since the same family can vary some in size and color. Record the number of insects, by group, using a notebook or the "Survey Data Record Forms" in Appendix V.

7. Refer to "Assessing the Quality of Your Stream" to interpret your sampling results.

Alternative Sampling Methods.

(The following directions for sampling macroinvertebrates are from the Maryland Save Our Streams program.)

Again, all sampling is done in the riffle areas. The specific sampling technique varies according to the type of material coating the riffle bed. Use the **Rock Scraping Method** in riffles where you can find stones six inches in diameter or larger. If large stones are absent, but gravel is present, then use the **Bucket Scraping Method**. Finally, if neither stones nor gravel can be found, then use the **Stick Picking Method**.

Equipment needed: bucket, sieve, forceps (tweezers), observation pan, notebook and pen.

ROCK SCRAPING METHOD.

1. Walk a 100-yard section of the stream you wish to sample. Select the riffle with the most rapidly flowing water and the largest stones.

2. Remove three stones from this riffle. Each stone should be about 6 inches in diameter, bathed in rapidly flowing water, and lying relatively loose upon the stream bed. Avoid stones buried in the bed or lying in a slow moving areas.

3. Place each stone in a bucket filled with stream water. While holding each stone beneath the water surface, brush each with your hands. Try to dislodge every foreign particle from the surface of the stones. Use your thumbs to apply sufficient pressure to clean the entire surface.

4. When each stone has been thoroughly brushed, then begin pouring the contents of the bucket through the sieve.

5. When an inch of water remains, then swirl the bucket to get the remaining contents in motion. Quickly pour the remaining water through the sieve. Fill the bucket once more and pour it through the sieve.

6. Identify each organism using the illustrations provided in this publication. Record the number of insects, by group, using a notebook or the "Survey Data Record Forms" in Appendix V.

7. Refer to "Assessing the Quality of Your Stream" to interpret your sampling results.

BUCKET SCRAPING METHOD.

1. Walk a 100-yard section of the stream you wish to sample. Select the riffle with the most rapidly flowing water and the largest gravel.

2. Using a bucket, scrap a layer of bottom material from the portion of the riffle with the most rapidly flowing water and the largest gravel.

3. Repeat step 2 until you have at least 2 inches of sediment in the bottom of the bucket. Fill the bucket about two-thirds full of water.

4. Use your hands to swirl and agitate the sediment in the bottom of the bucket. Grate the particles against each other to dislodge attached organisms. Try to suspend all the particles momentarily in the water.

5. Pour the water from the bucket onto the sieve. When an inch of water remains, then swirl the bucket to get the remaining contents in motion. Quickly pour the remaining water through the sieve.

6. Fill the bucket once more, agitate the sediments with your hands, and pour the overlying water through the sieve.

7. Identify each organism using the illustrations provided in this publication. Record the number of insects, by group, using a notebook or the "Survey Data Record Forms" in Appendix V.

8. Repeat steps 2 to 7 at two other locations within the same riffle. After you've processed sediments from all three points, then refer to "Assessing the Quality of Your Stream" to interpret your results.

STICK PICKING METHOD.

1. From the stream you wish to sample, collect wood objects, such as sticks, branches, lumber, etc. Each object should be at least two inches in thickness. Also, the object should have been in the stream for a long period. Generally, such objects will be completely waterlogged and will have a soft, pulpy surface.

2. As you collect each object, place it in a bucket filled with stream water.

3. When you have three objects, brush the entire surface of each with your hands. Peel off any bark and brush all surfaces. Try to pick apart soft surfaces to remove any insects.

4. Stir the contents of the bucket and pour the water through the sieve.

5. Identify each organism using the illustrations provided in this publication. Record the number of insects, by group, using a notebook or the "Survey Data Record Forms" in Appendix V.

6. Repeat steps 1 to 5 until you find no new insect groups.

7. Refer to "Assessing the Quality of Your Stream" to interpret your sampling results.

Appendix V

Survey Data Record Forms

Water Watch Survey Checklist

River Basin:

Collectors:

Stream Name:

County:

Weather Conditions: __ Clear __ Cloudy __ Rain
__ Other_____

Type of Sampling: __ Water __ Biological
__ Bacteriological

Time of Collection ____

Field Tests:

Air Temperature ______ Conductivity (mmhos) ____
Water Temperature ____ pH _____
Dissolved Oxygen _____ Other ____

Water Appearance:
__ Scum
__ Foam
__ Muddy
__ Milky
__ Clear
__ Colored sheen (Oily)
__ Brown
__ Other

Stream Bed Coating:
__ Orange to red
__ Yellowish
__ Black
__ Brown
__ None
__ None

Odor:
__ Rotten egg
__ Musky
__ Acrid
__ Chlorine
__ Other

Habitat:
__ Pool
__ Riffle
__ Wetlands
__ Backwaters
__ Undercut banks
__ Rock ledges
__ Tree roots
__ Logs or stumps
__ Log piles
__ Weed beds
__ Large boulders
__ Man-made objects
__ Other ________________________________.

Depth: Pool ________ Riffle ________
Width: Pool ________ Riffle ________

Stream Cover: Stream is --
__ Fully exposed (0-25% of stream is shaded from the sun)
__ Partially exposed (25-50%)
__ Partially shaded (50-75%)
__ Fully shaded (75-100%)

Riparian Vegetation:
___% Trees
___% Shrubs
___% Plants
___% Root Mats
___% Exposed
___% Other

Biological Samples:

Algae - Is algae located: ___ Everywhere ___ In spots.
Is algae: ___ Attached to substrate ___ Floating.
__ Other ______________________________.

Macroinvertebrates:
No. of macroinvertebrates ____ No. of different types ____
Kinds of macroinvertebrates collected
(crayfish, mayflies,etc) ______________________________

Fish: Types of fish observed or collected (bass, sunfish, etc.)

Other aquatic and semi-aquatic organisms (list):

Amphibians:

Reptiles:

Shore birds:

Waterfowl:

Mammals:

Visual Survey Checklist

Land uses in the watershed:

Farming: ___ Pasture/grazing land ___ Crops ___ Woods
___ Other:

Urban Areas: ___ Homes ___ Factories ___ Stores

Mining: ___ Surface ___ Deep

Logging: ___

Other: ____

Water Uses:

___ Drinking water supply
___ Industrial water supply
___ Agricultural water supply: ___ Irrigation ___ Livestock
___ Recreation: _ Swimming _ Fishing _ Other _________

Waste disposal:

Are there any discharge pipes: ___ yes ___ No
If so, where are they coming from: ___ Industry (factory)
___ Sewage treatment plant ___ Farm lots ___ Unknown
___ Other: ________________________________

Stream Channel Alterations: ___ Dredging ___ Channelization
___ Other ______________________

Structures or barriers in the stream:

___ Dams _ Bridges ___ Waterfalls
___ Other _________________

Litter: Average number of small and large items

Paper, small trash	Cans and bottles	Tires, carts, etc.
___ 0-5	___ 0-5	___ 0-5
___ 5-10	___ 5-10	___ 5-10
___ 10-50	___ 10-50	___ 10-50
___ over 50	___ over 50	___ over 50

Verbal site description: Give visual description of stream, substrate, banks, riparian zone and land areas.

Map of sampling location: List pool and riffle areas, hydraulic structures (i.e.. bridges, dams), areas of physical impacts, point sources, gravel bars, islands, etc. Describe banks, width of riparian zone and adjacent land uses. Show dwellings, businesses, roadways and tributaries, direction of stream flow and a north arrow.

APPENDIX VI

A List of Fresh Water Fishes of South Carolina

(Revised 1987)

Abbreviations denote species occurrence and distribution within South Carolina by major river basins, representation is as follows:

P = Pee Dee
SC = Santee-Cooper
E = Edisto
A = Occurs in all drainages
C = Combahee
B = Broad
S = Savannah

* Denotes species known to be introduced to South Carolina waters.

Common Name	Scientific Name	Occurrence
	Petromyzontidae - lampreys	
Sea lamprey	*Petromyzon marinus* (Linnaeus)	A
	Acipenseridae - sturgeons	
Shortnose sturgeon	*Acipenser brevirostrum* (Lesueur)	A
Atlantic sturgeon	*Acipenser oxyrhynchus* (Mitchill)	A
	Lepisosteidae - gars	
Spotted gar	*Lepisosteus oculatus* (Winchell)	S
Longnose gar	*Lepisosteus osseus* (Linnaeus)	A
	Amiidae - bowfins	
Bowfin	*Amia calva* (Linnaeus)	A
	Anguillidae - freshwater eels	
American eel	*Anguilla rostrata* (Lesueur)	A
	Clupeidae - herrings	
Blueback herring	*Alosa aestivalis* (Mitchill)	A
Hickory shad	*Alosa mediocris* (Mitchill)	A
Alewife	*Alosa pseudoharengus* (Wilson)	P
American shad	*Alosa sapidissima* (Wilson)	A
Gizzard shad	*Dorosoma cepedianum* (Lesueur)	A
*Threadfin shad	*Dorosoma petenense* (Gunther)	A
	Salmonidae - trouts	
*Rainbow trout	*Salmo gairdneri* (Rchardson)	SC-S
*Brown trout	*Salmo trutta* (Linnaeus)	SC-S
Brook trout	*Salvelinus fontinalus* (Mitchill)	SC-S
	Umbridae - mudminnows	
Eastern mudminnow	*Umbra pygmaea* (DeKay)	A

Esocidae - pikes

Redfin pickerel	*Esox americanus* (Gmelin)	A
Chain pickerel	*Esox niger* (Lesueur)	A

Cyprinidae - minnows & carps

Stoneroller	*Campostoma anomalum* (Rafinesque)	SC-S
*Goldfish	*Carassius auratur* (Linnaeus)	A
Rosyside dace	*Clinostomus funduloides* (Girard)	P-SC-S
*Grass carp	*Ctenopharyngodon idella* (Valenciennes)	A
*Carp	*Cyprinus carpio* (Linnaeus)	A
East silvery minnow	*Hybognathus regius* (Girard)	A
Highback chub	*Hybopsis hypsinotus* (Cope)	P-SC
Thicklip chub	*Hybopsis labrosa* (Cope)	SC
Rosyface chub	*Hybopsis rubrifrons* (Jordon)	SC-S
Santee chub	*Hybopsis zanema* (Jordan and Brayton)	SC-S
Bluehead chub	*Nocomis leptocephalus* (Girard)	P-SC-E-S
*River chub	*Nocomis micropogon* (Cope)	S
Golden shiner	*Notemigonus crysoleucas* (Mitchill)	A
Highfin shiner	*Notropis altipinnis* (Cope)	P-SC
Satinfin shiner	*Notropis analostanus* (Girard)	P
Ironcolor shiner	*Notropis chalybaeus* (Cope)	A
Redlip shiner	*Notropis chiliticus* (Cope)	P
Greenfin shiner	*Notropis chloristius* (Jordan & Brayton)	SC
Greenhead shiner	*Notropis chlorocephalus* (Cope)	P-SC
Warpaint shiner	*Notropis cocogenis* (Cope)	SC-S
Dusky shiner	*Notropis cummingsae* (Myers)	A
Pugnose minnow	*Notropis emiliae* (Hay)	C-S
Whitetail shiner	*Notropis galacturus* (Cope)	SC-S
Spottail shiner	*Notropis hudsonius* (Clinton)	P-SC-E-S
Sailfin shiner	*Notropis hypselopterus* (Gunther)	A
Bannerfin shiner	*Notropis leedsi* Fowler	S
Tennessee shiner	*Notropis leuciodus* (Cope)	S
Yellowfin shiner	*Notropis lutipinnis* (Jordan & Brayton)	C-E-C-S
Taillight shiner	*Notropis maculatus* (Hay)	A
Whitefin shiner	*Notropis niveus* (Cope)	P-SC-S
Coastal shiner	*Notropis petersoni* Fowler	A
Swallowtail shiner	*Notropis procne* (Cope)	P-SC
Fieryblack shiner	*Notropis pyrrhomelas* (Cope)	P-SC
Sandbar shiner	*Notropis scepticus* (Jordan & Gilbert)	P-SC-S
Mirror shiner	*Notropis spectrunculus* (Cope)	SC-S
*Bluntnose minnow	*Pimephales notatus* (Rafinesque)	SC
*Fathead minnow	*Pimephales promelas* Rafinesque	SC
Blacknose dace	*Rhinichthys atratulus* (Hermann)	SC-S
Longnose dace	*Phinichthys cataractae* (Valenciennes)	S-SC
Creek chub	*Semotilus atromaculatus* (Mitchill)	P-SC-S
Sandhills chub	*Semotilus lumbee* (Snelson and Suttkus)	P

Catostomidae - suckers

Quillback	*Carpiodes cyprinus* (Lesueur)	A
Highfin carpsucker	*Carpiodes velifer* (Rafinesque)	S
White sucker	*Catostomus commersoni* (Lacepede)	SC
Creek chubsucker	*Erimyzon oblongus* (Mitchill)	A
Lake chubsucker	*Erimyzon sucetta* (Lacepede)	A
Northern hog sucker	*Hypentelium nigricans* (Lesueur)	SC-S
*Smallmouth buffalo	*Ictiobus bubalus* (Rafinesque)	SC-P
Spotted sucker	*Minytrema melanops* (Rafinesque)	A
Silver redhorse	*Moxostoma anisurum* (Rafinesque)	A
Shorthead redhorse	*Moxostoma macrolepidotum* (Lesueur)	P-SC
Suckermouth redhorse	*Moxostoma pippilosum* (Cope)	SC
Smallfin redhorse	*Moxostoma robustum* (Cope)	A
Striped jumprock	*Moxostoma rupiscartes* (Jordan+Jenkins)	SC-E-S

	Ictaluridae - freshwater catfishes	
Snail bullhead	*Ictalurus brunneus* (Jordan)	A
White catfish	*Ictalurus catus* (Linnaeus)	A
*Blue catfish	*Ictalurus furcatus* (Lesueur)	A
Yellow bullhead	*Ictalurus natalis* (Lesueur)	A
Brown bullhead	*Ictalurus nebulosus* (Lesueur)	A
Flat bullhead	*Ictalurus platycephalus* (Girard)	A
Channel catfish	*Ictalurus punctatus* (Rafinesque)	A
Tadpole madtom	*Noturus gyrinus* (Mitchill)	A
Margined madtom	*Noturus insignis* (Richardson)	P-SC-E-S
Speckled madtom	*Noturus leptacanthus* (Jordan)	E-C-B-S
*Flathead catfish	*Pylodictis olivaris* (Rafinesque)	P-SC
	Amblyopsidae - cavefishes	
Swampfish	*Chologaster cornuta* (Agassiz)	A
	Aphredoderidae - pirate perches	
Pirate perch	*Aphredoderus sayanus* (Gilliams)	A
	Belonidae - needlefishes	
Atlantic needlefish	*Strongylura marina* (Walbaum)	A
	Cyprinodontidae - killifishes	
Sheephead minnow	*Cyprinodon variegatus* (Lacepede)	
Golden topminnow	*Fundulus crysotus* (Gunther)	A
Banded killifish	*Fundulus diaphanus* (Lesueur)	P
Mummichog	*Fundulus heteroclitus* (Linnaeus)	A
Lined topminnow	*Fundulus lineolatus* (Agassiz)	A
Bayou killifish	*Fundulus pulvereus* (Evermann)	A
*Bluefin killifish	*Lucania goodei* (Jordan)	SC
Rainwater killifish	*Lucania parva* (Baird)	A
	Poeciliidae - livebearers	
Mosquitofish	*Gambusia affinis* (Baird & Girard)	A
Least killifish	*Heterandria formosa* (Agassiz)	A
Sailfin molly	*Poecilia latipinna* (Lesueur)	A
	Atherinidae - silversides	
Brook silverside	*Labidesthes sicculus* (Cope)	A
Inland silverside	*Menidia beryllina* (Cope)	A
	Percichthyidae - temperate basses	
White perch	*Morone americana* (Gmelin)	P-SC
*White Bass	*Morone chrysops* (Rafinesque)	P-SC-S
Striped Bass	*Morone saxatilis* (Walbaum)	A
	Centrarchidae - sunfishes	
Mud sunfish	*Acantharchus pomotis* (Baird)	A
Rock bass	*Ambloplites rupestris* (Rafinesque)	P-SC
Flier	*Centrarchus macropterus* (Lacepede)	A
Everglades pygmy sunfish	*Elassoma evergladei* (Jordan)	A
Banded pygmy sunfish	*Elassoma zonatum* (Jordan)	A
Blackbanded sunfish	*Enneacanthus chaetodon* (Baird)	A
Bluespotted sunfish	*Enneacanthus gloriosus* (Holbrook)	A
Banded sunfish	*Enneacanthus obesus* (Girard)	A
Redbreast sunfish	*Lepomis auritus* (Linnaeus)	A
*Green sunfish	*Lepomis cyanellus* (Rafinesque)	P-SC-S
Pumpkinseed	*Lepomis gibbosus* (Linnaeus)	A
Warmouth	*Lepomis gulosus* (Curier)	A
*Orangespotted sunfish	*Lepomis humilis* (Girard)	P-SC
Bluegill	*Lepomis macrochirus* (Rafinesque)	A
Dollar sunfish	*Lepomis marginatus* (Holbrook)	A

*Longear sunfish	*Lepomis megalotis* (Rafinesque)	A
Redear sunfish	*Lepomis microlophus* (Gunther)	A
Spotted sunfish	*Lepomis punctatus* (Valenciennes)	A
Redeye bass	*Micropterus coosae* (Hubbs & Bailey)	S
*Smallmouth bass	*Micropterus domomieui* (Lacepede)	SC-S
Largemouth bass	*Micropterus salmoides* (Lacepede)	A
White crappie	*Pomoxis annularis* (Rafinesque)	A
Black crappie	*Pomoxis nigromaculatus* (Lesueur)	A
	Percidae - perches	
Carolina darter	*Etheostoma collis* (Hubbs & Cannon)	P-SC
Fantail darter	*Etheostoma flabellare* (Rafinesque)	SC
Savannah darter	*Etheostoma fricksium* (Hildebrand)	E-C-B-S
Swamp darter	*Etheostoma fusiforme* (Girard)	A
Christmas darter	*Etheostoma hopkinsi* (Fowler)	S
Turquoise darter	*Etheostoma inscriptum* (Jordan & Brayton)	E-S
Pinewoods darter	*Etheostoma mariae*	P
Tesellated darter	*Etheostoma olmstedi* (Storer)	A
Saluda darter	*Etheostoma saludae* (Hubbs & Cannon)	SC
Sawcheek darter	*Etheostoma serriferum* (Hubbs & Cannon)	A
Seagreen darter	*Etheostoma thalassinum* (Jordan & Brayton)	SC
*Banded darter	*Etheostoma Zonale* (Cope)	S
Yellow perch	*Perca flavescens* (Mitchill)	P-SC-S
Piedmont darter	*Percina crassa* (Jordan & Brayton)	P-SC-S
Blackbanded darter	*Percina nigrofasciata* (Agassiz)	E-C-S
*Sauger	*Stizostedion canadense* (Smith)	S
*Walleye	*Stizostedion vitreum* (Mitchill)	P-SC-S
	Gerreidae - mojarras	
Striped mojarra	*Diapterus plumieri* (Valenciennes)	SC
	Cichlidae - cichlids	
*Redbelly tilapia	*Tilapia zilli* (Gervais)	P
	Mugilidae - mullets	
Mountain mullet	*Agonostomus monticola* (Bancroft)	S
Striped mullet	*Mugil cephalus* (Linnaeus)	A
	Gobiidae - gobies	
Darter goby	*Gobionellus boleosoma* (Jordan & Gilbert)	SC
	Cottidae - sculpins	
Mottled sculpin	*Cottus bairdi* (Girard)	S
	Soleidae - soles	
Hogchoker	*Trinectes maculatus* (Bloch & Schneider)	A

A

acid mine drainage: Waters that have become acidic (a pH of less than 6.0) as a result of flowing through mine wastes.

acid waters: waters having a pH less than 7.0; streams influenced by acid mine drainage commonly have a pH less than 6.0.

acrid: sharp, stinging, irritating.

acute toxicity: any poisonous effect that, after short-term exposure, produces severe injury or death.

aesthetic quality: characteristics that are pleasing to the eye, such as the beauty of a natural stream or watershed.

algae: simple plants which lack true roots, stems, flowers, or leaves, and which live mainly in water, use sunshine for energy and serve as a basic food at the lower end of the food chain.

alkalinity: a measurement of a water's ability to neutralize acid.

aquatic: living or growing in water.

aquatic flora: plants that spend all or part of their life cycles in the water.

aquatic habitat: all of the areas in a stream, lake, or wetland that are occupied by an organism, population, or community.

aquifer: an underground bed or layer of earth, gravel, or porous stone that contains water.

B

bacteria: spherical, rod-shaped, or spiral microorganisms that lack chlorophyll and belong to the class *Schizomycetes*. Some species of bacteria are concerned in fermentation and putrefaction, the production of disease, and the fixing of atmospheric nitrogen.

benthic region: the bottom of a body of water.

benthos: the animals and plants that inhabit the bottom of a water body.

bioaccumulation: the process whereby a substance becomes concentrated within the organisms that have consumed it.

biota: the plants and animals within a certain area.

bivalve: a class of animals having two shells hinged together. Clams and mussels are examples.

bloom: a nuisance growth of algae and/or higher aquatic plants in a water body, often related to excessive nutrients.

blue-green algae: a group of algae that often, but not always, appear green in color.

BOD: Biochemical Oxygen Demand, a measure of the amount of oxygen used in the breakdown of organic matter in water. The greater the degree of organic pollution, the greater the BOD.

bottom sediments: material such as sand and silt that is found on the stream bed.

bottomland hardwoods: a type of forested wetland associated with river floodplains, containing such valuable hardwood trees as gum, cypress, oak, and water hickory. Very productive fish and wildlife habitat, valuable for flood control

brine water: water that is high in salt content.

C

carcinogen: a cancer-causing agent.

carnivore: a meat-eating organism.

channelization: the modification of a stream, including the straightening of stream meanders, in an attempt to control floods and improve navigation.

chronic toxicity: long-term effects that may be related to changes in appetite, growth, metabolism, reproduction, and even death or mutations.

class: a grouping of biological orders with similar characteristics.

coniferous: cone-bearing, as with pine or cedar trees.

conservation: the protection, improvement, and use of natural resources according to principles that will assure long term ecological and economic productivity for the benefit of society.

D

deciduous: trees that shed their leaves once a year.

decomposition: the breakdown of organic matter by bacteria or fungi; putrefaction or rotting.

degrading: progressive deterioration of physical characteristics.

detritus: partially decomposed organic matter, such as leaves, in the water; debris.

diatoms: microscopic, single-celled algae.

dissolved oxygen: a measure of the oxygen in water. Oxygen is necessary for the life of aquatic organisms. Low DO levels can result from inadequate waste treatment.

diversity: the number of different types of organisms in an aquatic community.

dredging: removal of earth or sediment from the bottom of a water body by using large, shoveling machinery.

E

ecological stress: any condition that can alter the food chain or quality of the environment.

ecology: the relationship of living things to one another and their environment or the study of such environments.

ecosystem: the interacting system of a biological community and its nonliving surroundings.

effluent: partially or completely treated waste material such as liquid industrial refuse or sewage that is discharged into the environment (usually into water).

emergent plants: plants rooted in the bottom of a water body that rise above the water's surface.

entomology: the study of insects.

environment: the combination of all conditions affecting and influencing the life, development and survival of an organism.

epilimnion: the upper, warm layer of a stratified lake.

erosion: the wearing away of land by wind or water.

eutrophic: a highly productive, nutrient-overloaded water body.

eutrophication: the process whereby a lake becomes highly productive and nutrient overloaded. Natural eutrophication occurs when nutrients erode and run off from the land into the lake under natural conditions over a long period of time. Cultural eutrophication occurs when excess nutrients are added to a lake or wetland from agricultural runoff, sewage or other man-related activities.

F

fauna: animals.

floodplain: low areas of land surrounding waterbodies which contain the overflow of water during a flood.

fecal coliform bacteria: the portion of the coliform group which is present in the gut or feces of warm-blooded animals. The presence of coliform bacteria in water is an indication of pollution and potential human health problems.

filamentous algae: small plants, recognizable as attached, hair-like growths, often appearing as waving strands in the water.

filter feeder: those organisms that use a filtration device to strain food from water and mud, including types of insects, mussels and fish.

flora: plants.

food chain: a transfer of energy in a sequence of organisms in a community in which each member of the chain feeds on the member below it.

forested wetland: a wetland dominated by trees over twenty feet in height, commonly called a swamp.

G

grazing insects: insects that feed on plant material growing on the substrate.

groundwater: a supply of fresh water under the earth's surface which forms a natural reservoir.

groundwater recharge: the process whereby water seeps into the ground in certain areas to replenish the groundwater supply.

H

habitat: the place where an organism lives.

hard water: water containing dissolved minerals such as calcium, iron and magnesium. The most notable characteristic of hard water is its inability to lather soap.

heavy metals: metallic elements like mercury, chromium, arsenic and lead, with high molecular weights. Heavy metals can damage living things at low concentrations and tend to accumulate in the food chain.

herbicide: a chemical used to destroy or control plant growth.

herbivore: a chemical used to destroy or control plant growth.

hydrophytes: plants adapted to living in the low-oxygen conditions of water-saturated soils.

I

indicator: anything that, by its presence or absence, shows an environmental condition.

inorganic: any compound not containing carbon.

intolerant species: species sensitive to and affected by water pollution.

invertebrate: animals without a backbone.

L

larva: the immature form of an animal that is .apable of reproduction, lacks wings and is totally different from the adult.

lateral line: a system of sensory organs along each side of a fish's body sensitive to vibrations.

lead: a heavy metal that may be hazardous to health if breathed or swallowed.

limnology: the science that deals with the physical, chemical and biological properties and processes of fresh water.

littoral zone: the shallow region of a body of water, from the highest seasonal water level to the depth where light cannot reach bottom.

M

macrobenthic organisms: animals large enough to be seen with the naked eye living in or on the bottom of a body of water.

macroinvertebrates: animals without a backbone that are large enough to be seen by the naked eye.

macrophytes: the large (macro) plants of a lake or wetland.

marsh: a treeless wetland occupied by grasses, rushes, sedges and other aquatic plants.

meanders: the bends in a winding stream or river.

metamorphose: to change into a different form, such as from an insect pupa to an adult.

mollusk: soft-bodied (usually hard-shelled) animals such as clams and snails.

monitoring: determining water quality on a regular basis.

mutation: the result of a change in the inheritable characteristics of an organism.

N

native fauna: animals originally found in an area.

natural water quality: the physical, chemical and biological conditions of a waterbody which have not been degraded or enhanced by human activity.

nekton: the fish and other free-swimming animals in a body of water.

nocturnal: active at night.

non-point source pollution: a type of pollution whose source is not readily identifiable such as runoff from streets, agricultural land and construction sites. (See point source pollution.)

nutrient: any substance such as phosphorous, nitrogen and carbon which is necessary for the growth of living things.

nymph: a juvenile, wingless stage of an insect.

O

oligotrophic: an unproductive lake.

omnivore: an organism which eats both plants and animals.

order: taxonomic grouping of related families of organisms.

organic: referring to or derived from living organisms; containing carbon.

P

parasitic: a plant or animal that lives in or on another organism (the host) and derives its food from the host.

pathogenic: capable of causing disease.

PCB: polychlorinated biphenyl; a toxic substance of the chlorinated hydrocarbon group capable of causing numerous reactions in humans, including death.

pelagic zone: the region of free, open water in a lake.

periphyton: tiny plants and animals living on submerged surfaces.

pesticide: a chemical used to destroy or control the growth of animals or plants.

pH: the measurement of acidity or alkalinity on a scale of 0 to 14. A pH of 7 is neutral, less than 7 is acidic, and more than 7 is basic (alkaline).

phosphorous: an essential plant nutrient that, in excessive quantities, can contribute to the eutrophication of waterbodies.

photosynthesis: the process by which green plants use sunlight to produce food.

phytoplankton: tiny aquatic plants, commonly referred to as algae.

plankton: tiny plants and animals that drift in water.

point source pollution: a type of pollution that can be traced to a particular point such as a discharge pipe.

pollutant: any substance that harms the environment.

pollution: the presence of substances which make the world around us dirty, fouled or contaminated.

pond: a small lake, usually shallow enough to allow the growth of rooted plants from one shore to the other.

predatory: living by capturing and feeding upon other animals (prey).

prey: an animal hunted or killed by another animal (the predator).

primary producers: the first or lowest level in the food chain composed of green plants.

pupa: the stage where an insect is enclosed in a protective case while changing from larva to an adult.

R

recreation water quality: the ability of water to be used for swimming, boating, fishing or any activity that involves the use of water.

reservoir: any holding area, natural or artificial, used to regulate, store or control water.

respiration: the exchange of carbon dioxide with oxygen from the environment by an animal or plant.

riffles: fast flowing, shallow areas of a stream characterized by turbulence.

riparian: pertaining to an organism which lives or grows on the shore of a lake, stream or other water body.

runoff: water from rain, snowmelt or irrigation that flows over the ground surface and returns to streams, lakes, or wetlands.

S

scavenger : an animal that eats refuse and decaying organic matter.

scrub/shrub wetland: a wetland dominated by small trees and shrubs less than twenty feet in height.

sediment: soil, sand and minerals washed from land into waterways.

sedimentation: the process whereby soil particles (sediment) settle to the bottom of a waterway or water body.

septic odor: the rotten-egg smell produced by the decomposition of organic matter in the absence of oxygen.

sewage: the organic waste and waste water produced by residential and commercial establishments.

sewage fungus: filamentous bacteria associated with organic pollution.

sewage treatment plant: a facility designed to remove organic pollutants from wastewater.

sewer: a channel or pipe that carries waste water and storm water runoff from the source to a treatment plant or receiving stream.

shellfish: an aquatic invertebrate animal with a shell such as a mussel or a clam.

shredder: a group of animals that feed on plant material.

silt: fine particles of soil or rock that can be picked up by air or water and deposited as sediment.

siltation: the process of silt settling out of the water and being deposited as sediment.

sludge beds: any heavy deposit of organic material found below point source discharges, usually black and foul-smelling.

storm sewer: a system that collects and carries rain and snow runoff to a point where it can soak into the groundwater or flow into surface waters.

stratification: the layering of a lake caused by temperature differences between surface and deep water (also called thermal stratification).

substrate: the surface upon which an organism lives or is attached.

spawning areas: regions in streams, rivers or lakes used by organisms for laying and fertilizing eggs.

species: a unit of classification for groups of closely related individuals.

stream bed: the bottom of a stream where the substrate and the sediments are found.

stream depth: a measurement of the depth of a stream from the water's surface to the stream bed.

stream flow: the amount of water moving in a stream in a given amount of time.

swamp: common name for a forested wetland.

specific conductance: a measurement of the water's ability to conduct electricity.

T

terrestrial life: those plants or animals that spend most or all of their life on land.

thermocline: the region of rapid temperature change between upper (warmer) and lower (colder) water in a stratified lake.

tolerant species: an organism that can exist in the presence of a certain degree of pollution.

topography: geographical features (both natural and artificial) of a region such as hills, rivers, cities, roads, etc.

total coliform bacteria: a group of bacteria from human waste that are used as an indicator of drinking water quality. The presence of total coliform bacteria indicates the possible presence of disease-causing bacteria.

toxic substance: poisonous matter, man-made or natural, which causes sickness, disease and/or death to plants and animals.

toxicity: a measurement of how poisonous or harmful a substance is to plants and animals.

toxin: a substance that is harmful to humans and other organisms.

tributary: side stream or river flowing into a main river.

trophic level: a link in the food chain. The first trophic level (lowest) consists of producers (green plants); the second level of plant eaters; and the third level of meat eaters. Bacteria and fungi are organisms in the decomposer trophic level.

turbidity: degree of cloudiness due to material suspended in the water.

turnover: the mixing of a lake from top to bottom usually occurring in spring and autumn when the lake is not stratified.

U

urban runoff: storm water from city streets and parking lots, usually carrying oil, chemicals, litter and organic wastes.

W

waste: unwanted materials left over from manufacturing processes; refuse from places of human or animal habitation.

waste water: water carrying unwanted dissolved or suspended solids from homes, farms, businesses and industries.

water pollution: the addition of enough objectionable material to damage water quality.

water quality: the condition of the water with regard to the presence or absence of pollution.

water quality standard: a management tool that:
(1) considers what water will be used for;
(2) sets levels to protect those uses;
(3) implements and enforces water treatment plants, and;
(4) protects existing high quality waters.

watershed: all the land that serves as a drainage area for a specific stream, river, lake or wetland.

Z

zooplankton: tiny, drifting aquatic animals that fish feed on.