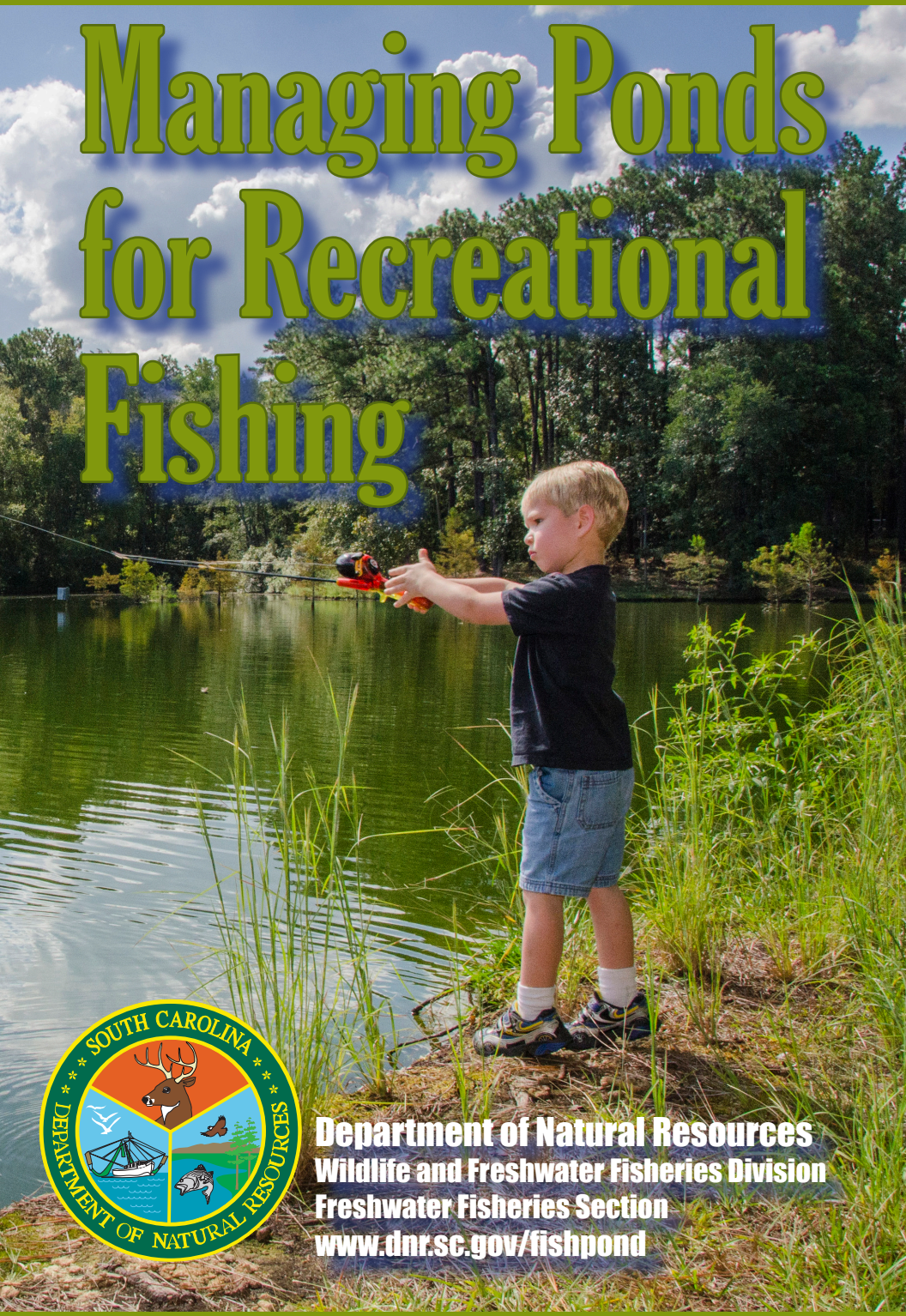
Managing Ponds for Recreational Fishing



Department of Natural Resources
Wildlife and Freshwater Fisheries Division
Freshwater Fisheries Section
www.dnr.sc.gov/fishpond

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INTRODUCTION

Fishing is one of the most popular participation sports in South Carolina and interest continues to grow. A recent survey by the United States Fish and Wildlife Service showed that over 609,000 anglers participate in some form of freshwater fishing in South Carolina and contributed nearly $1.2 billion to the state's economy, an indication that fishermen will spend considerable time and money to enjoy their sport. While the majority of this angling effort occurs in public waters, the state abounds in privately-owned fish ponds, which, when properly managed, provide excellent fishing near home for a reasonable cost. But good fishing in ponds seldom just happens, they take careful planning and management. This publication provides South Carolina pond owners with guidance to increase their pond's potential to produce quality fishing year after year.

A properly managed fish pond can provide hours of angling enjoyment as well as aesthetic value.

POND CONSTRUCTION

A prudent person would not start building a house without first designing and planning a structure that suits his needs. A prospective pond owner should likewise plan a pond that is suitably located, designed and built properly and that satisfies his fishing requirements. A number of considerations and details that should be addressed regarding the planning and physical construction of a pond are beyond the scope of this guide booklet. Prospective pond owners should research all available information regarding pond construction and seek advice provided by state and county agencies such as the Natural Resources Conservation Service (NRCS), the South Carolina Department of Natural Resources (SCDNR) and the various county extension services.

Note: More information can be found online at *www.dnr.sc.gov/fishpond*

STOCKING PREPARATIONS

Once construction is completed and the pond basin contains sufficient water, it is time to stock the fish. Competition from "wild" fish species is one of the major reasons for poor fishing in South Carolina ponds. It is important that any fish present be eliminated prior to stocking, regardless of whether the pond is newly constructed or is an existing pond in need of **renovation** and restocking. In some instances, this can be accomplished by completely draining the pond and

allowing the pond basin to dry over a period of time. In most cases, the use of a federally approved chemical **piscicide** or fish toxicant is required. The chemical most commonly used for this purpose is **rotenone.** This compound is used to kill fish without harming other animals (it affects only creatures having gills). Ponds located on a stream may be subject to the introduction of wild fish entering from upstream but this situation is largely unavoidable. If rotenone is to be applied to the pond's feeder stream, legal issues dictate the application be restricted to only that stream reach under the direct ownership of the pond owner(s).

Note: Rotenone is a restricted-use **pesticide**, which means that a category 5, South Carolina-certified applicator license is required for its purchase and/or use in South Carolina. Unfortunately, no feasible alternatives to rotenone are currently available. Therefore, it is necessary to obtain the assistance of a certified applicator. The use of rotenone in ponds located on a stream can pose a number of possible complications including questions of legal liability and environmental responsibility should the material be allowed to contaminate waters downstream of the immediate pond site. The use of rotenone in these situations demands extreme care and vigilance and should be carried out only by licensed individuals who have proper knowledge and experience.

As with all chemical products, read and follow all label instructions.

Rotenone should be applied at the rate of 6 pounds of 5% powder per **acre-foot** of water. An acre-foot is an acre of water one foot deep. To determine the number of acre-feet in your pond, multiply the number of surface acres by the average depth in feet. Be sure to take into account shallow edges as well as deep holes in calculating average depth. It is better to actually measure the area and depths, rather than estimating them. Since the powder does not dissolve well in water, it should first be worked into a paste with a small amount of water. Gradually add more water until a thin slurry is obtained. The mixture should then be applied to any water remaining in the pond, including any potholes or areas of standing water, regardless of size. Some fish can survive for extended periods in nothing more than a deep footprint that contains water.

Liquid rotenone is also available but is often difficult to obtain. The 5% liquid formulation should be applied at a rate of one half gallon per acre-foot of water. Dilute it enough to cover the treatment area and apply it in the same manner as the powder.

Rotenone should be applied by a SC certified applicator during the first half of September, so as to allow it to detoxify prior to restocking with fish purchased from an aquaculturist in November or December. The rotenone will detoxify in 7 to 30 days, depending on water temperature. The cooler the water temperature the longer the chemical remains active. This time frame will also reduce the time period wild fish can enter the pond prior to the stocking, should this potential exist.

When renovating a pond, first lower the water level as much as possible. By doing this, less rotenone will be required and a more efficient kill will occur. All drain outlets in the pond must be closed during renovation and until the rotenone is completely neutralized. Rotenone that escapes downstream is toxic.

Remember, you are responsible and liable for any downstream effects!

After applying rotenone, fish should begin to surface within about 5 minutes. A large percentage of the fish will surface only once, then sink to the bottom and rise the next day or the day after as they begin to decompose. The dead fish may be removed from the pond and disposed of in an acceptable manner. If they are left in the water, no harm will be done except for appearance and temporary, unpleasant odors. Turtles, birds and other scavengers will remove many of the carcasses.

POND STOCKING

Young largemouth bass fingerlings for stocking.

To provide the best recreational fishing opportunities, only certain species are recommended when stocking a pond. These include a combination of largemouth bass, bluegill and redear sunfish, (also known as shellcracker). Channel catfish may be stocked to provide additional fishing opportunities, but they are not necessary to maintain a balanced fish population. The fingerling fish for stocking may be obtained from commercial fish breeders, called aquaculturists, licensed by the SCDNR. A list of approved aquaculturists is available on the SCDNR web site *(www.dnr.sc.gov/fishpond)* or by contacting one of the agency's regional offices.

Normally, bluegill and shellcracker stocked in the late fall or early winter with largemouth bass stocked the following spring. If channel catfish are desired, they should be stocked prior to the bass. Before purchasing any fish, the pond owner should decide whether or not pond fertilization will be part of the future management of the pond. This determines the appropriate stocking rate. A discussion of pond fertilization may be found on page 8. Fertilized ponds are stocked at the rate of 1,000

LARGEMOUTH BASS

BLUEGILL

CHANNEL CATFISH

REDEAR SUNFISH

bream (a combination of bluegill and shellcracker at a 3:1 ratio) and 100 largemouth bass per acre. A pond that will not be fertilized should be stocked at one half this rate. Channel catfish can be stocked at a rate of 25-50 fish per acre (Table 1). It is critical not to overstock the pond as this could result in a population imbalance and dissatisfaction with the fishing it produces. If you wish to stock species other than those recommended by the SCDNR, you should first consult with the regional fishery biologist. There are pitfalls associated with other species that may not be evident to pond managers, including a tendency for some species to overpopulate or otherwise outcompete with the bass/bluegill population and negatively impact their successful reproduction and growth.

Table 1: Recommended species, stocking rates and time for fertilized and unfertilized ponds.

FERTILIZED POND			
Species	**Bluegill/Redear Sunfish**	**Largemouth Bass**	**Channel Catfish***
Stocking Rate	1000/acre	100/acre	25-50/acre
Stocking Time	Nov-Jan	May-mid-June	Nov-Jan
UNFERTILIZED POND			
Species	**Bluegill/Redear Sunfish**	**Largemouth Bass**	**Channel Catfish***
Stocking Rate	500/acre	50/acre	25/acre
Stocking Time	Nov-Jan	May-mid-June	Nov-Jan

*May be stocked, but not necessary to maintain balanced fish populations.

Two species that are commonly advertised for pond stocking are crappie and "Georgia Giants" or hybrid bream. Crappie do well in large lakes and reservoirs where water levels often fluctuate. In smaller lakes and ponds, their abundance is cyclic or erratic, causing overcrowding and a severe population imbalance. They also compete directly with bass and bream for food. "Georgia Giants" are bream hybrids reputed to have a very high growth rate. Stocked in a similar manner as bluegills, they are aggressive and bite well. One of the hybrid bream's primary problems is that after several generations, they will genetically revert back to the original parent crosses used to produce them which are bluegill and green sunfish. Green sunfish are highly competitive and are not considered a suitable fish for a

GREEN SUNFISH

GOLDEN SHINER

BLACK CRAPPIE

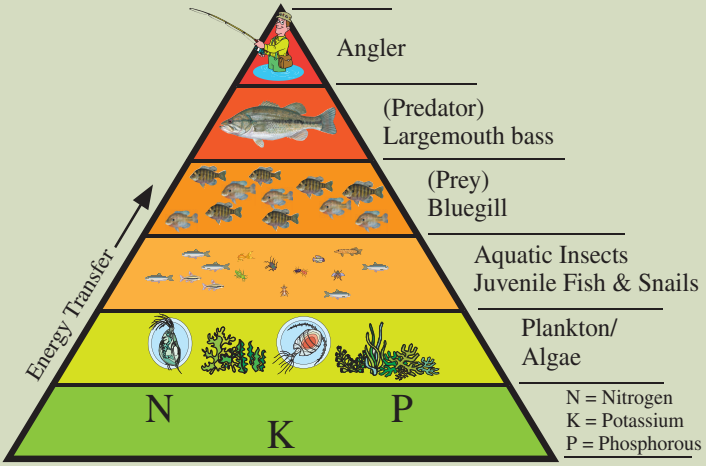
YELLOW BULLHEAD

Wild fish species such as golden shiner, bullhead catfish, crappie and others compete with the pond's bass/bluegill population for food, cover and space.

recreational fish pond. In order to maintain the hybrid characteristics of the "Georgia Giant," renovation of the population and restocking will likely be required about every three years. Most pond owners who have tried these hybrids in South Carolina report that these fish fall considerably short of expectations; thus, SCDNR does not encourage their use. In addition, the use of shiners as bait is not recommended due to their tendency to overpopulate and become competitive with bluegill, should they be introduced into the pond.

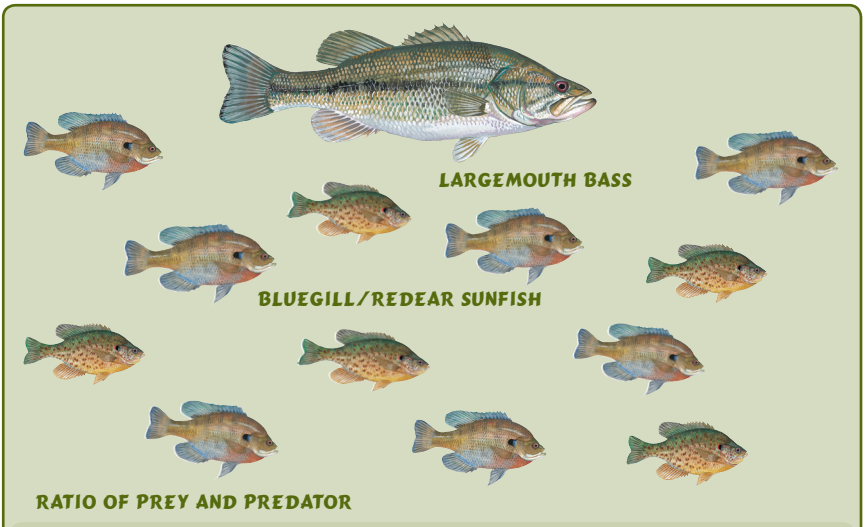
FISH PRODUCTION

In order to successfully manage a recreational fishing pond, the owner should be aware of some basic principles that govern the status of the pond's fish population and ultimately the quality of the fishing. The organic and inorganic nutrients found in every pond serve as the building blocks for the pond's aquatic



AQUATIC FOOD PYRAMID

food pyramid. Simply stated, these nutrients support the microscopic algae or **phytoplankton** that are eaten by equally small animals called **zooplankton.** Zooplankton is, in turn, eaten by small aquatic crustaceans, insects and other organisms. These food items are consumed by bluegill, shellcracker and young bass that ultimately are eaten by the pond's larger bass. Properly managed ponds maintain a more productive food web and have a higher **carrying capacity**, or ability to support and grow fish, than those that are neglected or are poorly managed. Carrying capacity refers to the maximum weight (usually expressed in pounds per acre) of fish that a pond will support during a set period of time. In highly productive ponds, the carrying capacity may exceed 300 pounds of fish per acre per year, although most well-managed ponds produce considerably less. In order to achieve and maintain a balanced fish population, proper stocking and fish harvest are essential. **Balance** refers to the ratio and weight of predatory fish (largemouth bass) to forage fish (bluegill/shellcracker) in the pond. A well-balanced fish pond can sustain the growth and reproduction of each species, over time, in the presence of angler harvest and natural **mortality.** The bass depend on a healthy, reproducing bluegill/shellcracker population for food and, in turn, serve to keep the numbers of bream in check. In order to maintain a proper balance, the pond should have roughly 3 to 5 pounds of bluegill/shellcracker to one pound of largemouth bass. For any number of reasons, a pond's fish population may become out of balance, including improper stocking, introduction of competitive species, improper harvest, excessive aquatic vegetation or failure to maintain the pond's fertility level. Once a population imbalance occurs, all species are likely to be impacted and may exhibit symptoms of overcrowding, emaciated body condition and a reduced level of reproductive capacity. These situations ultimately result in poor fishing.



Maintaining a proper ratio of bream (prey) and largemouth bass (predator) is essential to ensuring optimum productivity and growth of the pond's fish population.

POND FISHING

Do not begin to fish a newly-stocked pond until June of the following year after the bass were stocked (or after the bass have spawned for the first time). At this time, the bass will generally weigh from one half to one pound and the bream should weigh approximately one quarter pound.

One cause of poor fishing in South Carolina ponds is the common practice of "saving" the pond by allowing only limited fishing with the expectation that this will result in larger and more numerous fish. This is a serious error and produces an overabundance of small, slow-growing fish. The bass/bream combination, stocked at proper rates, depends upon adequate harvest to produce good fishing year after year. While every pond is unique and the carrying capacities will vary from pond to pond, annual fish harvest should be near the following rates: Fish harvest should be spread out over the year so that no more than 25% of the total is removed in any given month. During the first fishing year after stocking, it is recommended that bass be harvested at slightly less than the above rates.

Table 2: Suggested fish harvest rates for fertilized and unfertilized ponds.

	BREAM	BASS
Fertilized ponds	75-100 lb/acre/year	18-25 lb/acre/year
Unfertilized ponds	30-40 lb/acre/year	8-10 lb/acre/year

Bluegill

As a general rule, for every one pound of bass harvested, 3 to 5 pounds of bluegill/ shellcracker should be removed. The harvest rate of channel catfish, if present, is left to the discretion of the pond owner since they generally represent a "put-grow and take" species that will require restocking as their numbers diminish over time. Proper harvesting of your pond is very important! Failure to do so may result in population imbalances and ultimately in poor fishing. One helpful management practice is to keep a log recording a close estimate of the numbers, size and time fish are harvested from the pond. Paying close attention to the numbers and size of the fish typically caught in the pond can provide a good indicator of the status of the pond's fish population balance. Table 3 shows examples of fishing results, the condition they may represent and management recommendations.

Table 3: Evaluation of a pond's fish population, via angling.

FISH CAUGHT	POPULATION CONDITION	RECOMMENDATION
• Bluegill/Shellcracker – various sizes (5"- >8") • Largemouth Bass – various sizes (commonly 1-3 lbs)	Fish population in balance	• Follow normal management practices
• Bluegill – many 2"-5" (few of harvestable size) • Largemouth Bass – few caught (generally large > 2 lbs)	Bluegill/shellcracker overcrowded	• Remove all bluegill caught by angling, seine or trap • Do not harvest any bass
• Bluegill/Shellcracker– few but large (7"-10") intermediate sizes (3"-5") few	Bass overcrowded	• Increase bass harvest, target younger fish ½ - 2 lbs
• Largemouth Bass – few caught (> 2lbs) • Bluegill/Shellcracker few of harvestable size (>5") • Competitive species present (i.e. crappie, shiners, bullhead catfish, etc.)	Competitive fish dominate	• Renovate fish population and restock

LIMING AND FERTILIZATION

Pond fertilization has a number of advantages. A properly- fertilized pond will have a higher carrying capacity via increased fish production. The planktonic algal **bloom** which results from fertilization produces a light-green color to the water, reducing sunlight penetration. This shading effect also aids in preventing unwanted aquatic plant growth. In order to achieve the desired results from pond fertilization, the pond must have suitable water chemistry. The three chemical parameters most important in determining this include the water **hardness**, **alkalinity** and **pH**. Fish ponds in South Carolina are often constructed in relatively infertile, acidic soils, or receive water from swampy watersheds. Such conditions generally do not provide adequate water chemistry to support pond fertilization without corrective measures. In situations where water chemistry improvements are necessary, the application of crushed Dolometic limestone (calcium magnesium carbonate) or agricultural limestone (calcium carbonate) is recommended, prior to pond fertilization. Other forms of limestone, such as hydrated, quick or slaked lime, should only be used under very specific conditions as these compounds can be toxic to fish. The limestone should be applied at rates varying from one to four tons per acre, depending on the water chemistry. Bulk agricultural lime is considerably cheaper than the bagged variety, which is

Excessive pond fertilization may result in dense "blooms" of undesirable blue green algae.

normally practical, if only a very small quantity is needed. Remember, the objective is to lime the soil the pond covers, not the water, so proper distribution of the limestone is necessary. In the case of a dry pond, the lime can be applied by a spreader truck or broadcasting it over the pond basin, but if the pond is full of water, the lime must be scattered over the entire pond surface. This can be done by rigging a liming platform made of plywood on the front of a sturdy boat and shoveling the lime out as evenly as possible as the boat travels over the pond. If large quantities of lime are required, the pond owner may opt to employ a private pond consulting company to conduct the application.

Lime should be applied in the fall or winter so it will have adequate time to react with the soil prior to fertilizing in the spring. The duration of the lime's effectiveness will vary from pond to pond and is largely governed by the **retention time** or the volume of water entering into and flowing out of the pond. In ponds with low to moderate water loss, liming will last about three years. Once a pond has been well-limed, small annual applications (25% of the original rate) may be applied to maintain the desired water chemistry and avoid having to apply the bulk amount.

Once the pond has been adequately limed, fertilization can be conducted. Pond fertilization should begin in the spring when the water temperature reaches 60° F or above and continue until late summer or when water temperatures again fall below 60° F. The initial spring applications should be done at two-week intervals until the desired algal bloom is established. The algal bloom will appear as a uniform green or greenish-brown color to the water. Generally, once this is accomplished fertilizer should only be reapplied when water clarity exceeds 18-20 inches which normally occurs after 30-45 days. Some ponds require more or less fertilization than others. If an algal bloom is not established by late spring or it is difficult to maintain the proper bloom, the pond's water chemistry is inadequate to support a fertilization program and additional liming may be required. Do not over fertilize as it produces excessively dense algal blooms that can increase the possibility of low oxygen and fish kills.

In general, three fertilizer formulations can be used successfully in fish ponds (Table 4). Granular fertilizer is the most widely-used method and usually produces a moderate to heavy algal bloom in most ponds. Granular fertilizer may be applied in several ways. The most efficient way is to use an underwater platform or table. The platform should be about 4 feet x 4 feet square and situated so that it is covered by 18-24 inches of water. It should also be located well away from the pond's spillway or water control structure. Next, pour the fertilizer onto the platform where water and wind currents will distribute the nutrients as they dissolve. This method keeps the fertilizer from direct contact with the pond's bottom soils which can tie up the fertilizer's nutrients and significantly reduce its effectiveness. One platform is sufficient for a pond three to five acres in size. A second, less effective method is to slit the fertilizer bag widely on one side and place it in shallow (one to two feet deep) water with the slit side up so that the fertilizer can dissolve. This method will not disperse the nutrients as efficiently as a platform. Broadcasting the fertilizer granules onto the pond bottom is not recommended because much of the mineral content is wasted as it is tied up in bottom sediments.

Table 4: Formulations and application rates for the three types of pond fertilizer.

FORMULATION*		
Fertilizer Type	**Nitrogen (N)-Phosphorous (P)-Potassium (K)**	**Application Rate****
Granular	20-20-5	40 pounds/surface acre
	18-46-0	18 pounds/surface acre
	0-46-0	12-18 pounds/surface acre
Liquid	10-34-0	1.0-2.0 gallons/surface acre
	13-38-0	1.0 -2.0 gallons/surface acre
Powdered	10-52-0	2-8 pounds/surface acre
	12-49-6	2-8 pounds/surface acre

*Other similar formulations may be available
** General fertilization rates. Follow rates and application methods on product label.

Liquid fertilizers are popular and provide a good alternative to the granular form. Liquid fertilizers generally produce alga blooms more quickly than granular products because they dissolve immediately into the water. Applications should be made by mixing the prescribed amount of the liquid fertilizer with water and distributing the mixture over the entire pond using a boat. Do not apply concentrated liquid formulations directly to the pond as this material is heavier than water and will simply sink to the bottom, losing much of its effectiveness.

Recently, highly soluble, powdered fertilizers have become available. Typically applied at rates as low as two to eight pounds per surface acre, they can be broadcast directly over the pond's surface. The low rates required and ease of application are offset to some degree by the powdered fertilizers' higher cost.

There are several circumstances when a pond should not be fertilized. This includes:

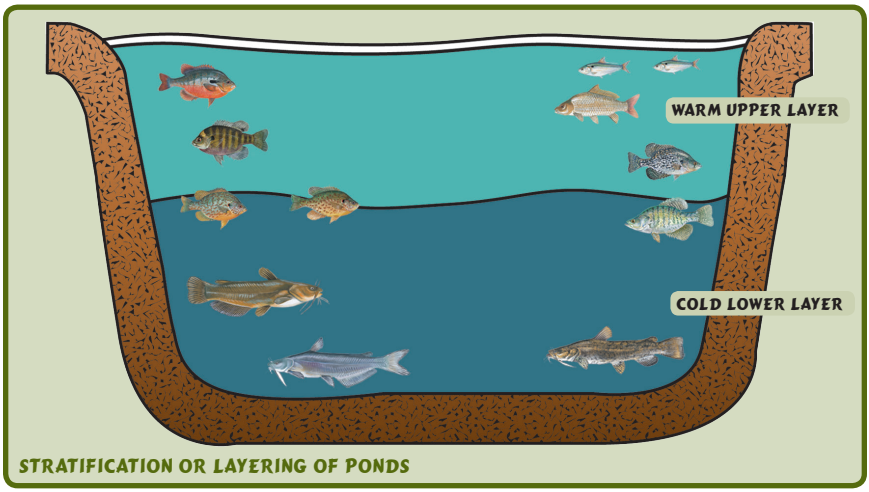
- when water chemistry (pH and alkalinity) is not sufficient to support fertilization,
- the pond is frequently muddy,
- nuisance algae or aquatic vegetation are present,
- when the pond has excessive water flow through it which flushes the fertilizer or bloom out (the ponds need at least a 30-40 day retention time for fertilization to be effective, or
- the pond is located in livestock pasturelands or otherwise receives high nutrient input from the surrounding watershed.

A properly fertilized pond should exhibit a uniform light green or brownish green tint to the water. This is a result of microscopic algae suspended in the water column, commonly referred to as a "bloom."

Note the visibility in the water column has been reduced to a depth of about 18"-20."

WATER QUALITY

Good water quality is essential to maintaining a healthy pond and ensuring successful fish production. The many factors involved and their relationships are complex. Pond owners should be aware of the following important factors. Warmwater fishes grow best at temperatures between 75° F and 90° F. Since waters in South Carolina drop below that level in the winter, management procedures such as fertilization are halted or reduced during that time. In the summer, water temperatures frequently rise above 90° F, reducing the amount of **dissolved oxygen (DO)** that can be held by water. High water temperatures cause the water to form layers or to **stratify,** where a warm upper layer forms over a cooler layer. The upper layer may be from three to six feet deep, usually supporting a good growth of phytoplankton, has ample dissolved oxygen and maintains good overall water quality. The lower, cooler layer, which frequently comprises most of the water in the pond, extends to the bottom, is low in or devoid of DO, supports little phytoplankton growth and generally has poor overall water quality. Due to this poor habitat, pond fishes will not stay in this layer for any length of time. Most South Carolina ponds stratify in the late spring and remain that way until cooler temperatures return in the fall.



STRATIFICATION OR LAYERING OF PONDS

Dissolved Oxygen

Dissolved oxygen (DO) is the most critical water quality variable in a pond. Its main source in water is the growth activity of the pond's phytoplankton. Some diffusion of oxygen into the water from the air occurs, but this is negligible. Since oxygen is produced by these microscopic plants and their growth is dependent upon sunlight, the amount of DO in a pond is related indirectly to the amount of sunlight received during the day, as well as to the amount of algal bloom produced. DO is lost from the water in two principal ways, through aquatic animals and photoplankton. Fish and other aquatic animals remove a

portion through their respiration. While phytoplankton produce oxygen during sunlight hours, during the process of photosynthesis, and use it at night during the process of respiration. In properly fertilized ponds, the DO levels might typically range from 4 mg/l **(milligrams per liter)** at dawn to over 10 mg/l by late afternoon on a sunny day. Remember that in the summer, the pond is probably stratified and nearly the entire DO is in the uppermost portion of the water column. Fish require at least 3 mg/l of dissolved oxygen for long-term health and good reproduction, but can tolerate as little as 0.3 mg/l for short periods. Fish will die at DO concentrations below 0.3 mg/l. Extended exposure to marginal DO conditions can cause poor growth, increased disease and other adverse effects.

pH

The pH is a measure of the acidity or basicity of a solution. The pH ranges from 0 - 14.0 with 7.0 being neutral. A reading below 7.0 is acidic and a pH from 7.0 to 14.0 is alkaline or basic. The pH of pond water is greatly influenced by the presence of carbon dioxide, an acidic substance that is removed from the water by plants during the day. Consequently, the pH rises during the day and decreases at night. In fertile ponds, phytoplankton activity may cause the pH range to fluctuate significantly in a 24-hour period depending on the pond's water chemistry. Fishes grow best between a pH of 6.5 and 9.0, which can be obtained in properly-limed and fertilized ponds. At long-term values outside of this range, growth and reproduction will be reduced and death can occur.

Alkalinity and Hardness

Hardness refers to the concentration of elements (mostly calcium and magnesium) in the water. Alkalinity is the total concentration of bases. The two values are related and in most South Carolina ponds are typically very low – below 20 mg/l. For fertilizer to be effective, hardness and alkalinity must be above 20 mg/l, and this can be accomplished by proper liming. In addition, proper alkalinity and hardness levels will help to counteract the wide pH swings during periods of high photosynthesis from algal blooms.

AQUATIC VEGETATION CONTROL

Aquatic weeds that grow in your pond are usually undesirable. If left uncontrolled, they can interfere with fishing and boating, utilize nutrients needed for phytoplankton growth, allow small bream to successfully escape bass predation, provide breeding places for mosquitoes and may cause DO depletions if they die-off suddenly. Once established, aquatic vegetation can be very difficult and expensive to address. The best cure for nuisance aquatic vegetation is prevention or early detection of and response to the problem. One step towards prevention is proper pond construction, including rapidly sloping edges and an overall water depth of not less than 3 feet. A properly-conducted pond

fertilization program is also of great benefit. The resulting phytoplankton bloom discourages the growth of most aquatic weeds by shading them out so that they cannot gain a foothold. Fertilization should be considered a preventative measure, not a cure. Under no circumstances should a pond owner fertilize a pond with a pre-existing vegetation problem as this will likely only make matters worse. The weeds must be controlled prior to conducting fertilization.

Several methods of aquatic vegetation control can be employed in the event this becomes necessary. The pond owner should carefully consider all the circumstances present before embarking on any efforts to control a nuisance weed problem. The SCDNR recommends the pond manager seek technical advice from a qualified source to ensure the most effective, cost efficient and safest control option is used. Commonly used methods of aquatic vegetation control such as winter drawdown, mechanical means, herbicides, and biological controls as further discussed as follows.

If left unattended, aquatic vegetation can seriously restrict the use of a pond and reduce its aesthetic value. Reclaiming such situations can be difficult and costly.

Winter Drawdown

A winter drawdown provides an inexpensive method of combating aquatic weeds, particularly in ponds with large expanses of shallow water. This technique involves lowering the water level each year from the first of December until the first of March so that the shallow, weed-infested areas are exposed to freezing and drying conditions during this period. Winter drawdowns rarely result in total control of a weed problem, but can act to slow regrowth in the spring. A drawdown has the added benefit of concentrating forage fish populations, which allows bass and other predators to readily feed on them reducing stunted bream numbers and producing healthier bass. If the pond is

uniformly shallow, be sure enough water remains after drawdown to support the entire fish population, even if some weeds must remain submerged. A good rule of thumb is to leave enough water to maintain 50% of the pond's surface area. Be sure the method used to remove the water does not allow fish to escape.

Mechanical

Mechanical or hand removal of weeds is sometimes possible. Hand removal is usually feasible in situations where only a few plants are present or in very small ponds. Pond owners should be aware that some plant species may actually spread due to fragmenting the plant into pieces during removal, so extreme care should be exercised when employing this control method.

Herbicides

Aquatic herbicides are a widely used method of vegetation control. Properly applied, they can safely and efficiently combat a number of nuisance plant species. Accurate identification of the target plant is an absolute must prior to treatment, as many herbicides are very selective in their action and level of control on a particular weed species. A pond owner should seek professional advice on the plant's identification and recommendations for the appropriate herbicide treatment. This assistance is available, free of charge, from several state and federal agencies, including the SCDNR Regional Fisheries Offices. It is neither economical nor environmentally responsible to use a herbicide that is not effective. Use only herbicides that are federally-approved and labeled for aquatic weed control. **Always read the entire label before you use any herbicide and follow label directions carefully.** Misuse or the use of unapproved herbicides could be dangerous to the environment, causing negative impacts on fish, mammals, turtles, birds and bankside vegetation. They could cause downstream damage, for which you could be liable. If you have any doubt about the label directions, contact an expert – don't guess.

Biological Control

Several species of fish have been successfully used to control weeds in recreational fishing ponds, such as tilapia (African bream) and triploid grass carp (white amur). Other fish species may also consume vegetation, but for the most part have been shown to be marginally effective or may be illegal to import or possess in this state. If you have any doubts about a particular species of fish, contact the SCDNR Regional Fisheries Office for clarification prior to obtaining them. Tilapia are tropical fish that are advertised by their producers to consume a wide variety of aquatic vegetation. Unfortunately, they are usually less effective than advertised, but will control some species of filamentous algae when stocked in the spring at rates from 250-400 fish per acre. These fish cannot survive winter water temperatures so annual restocking is required.

Triploid grass carp are a sterile form of the original white amur. They often produce better long-term results for the money than herbicide treatments. Although grass carp will control a wide variety of submersed vegetation, they should not be considered a "cure all" solution. They will not control plant species that grow out of the water like cattails, lilies or alligator weed. Since grass carp do not effectively control all weed species, pond owners are strongly encouraged to have the pond inspected by a pond or lake management consultant prior to stocking, so that the weeds can be correctly identified and stocking recommendations can be provided. The required stocking rate varies depending upon several factors including the target weed, extent of infestation, size of the water body, abundance of potential predators and potential for escape. In most cases, 10-25 fish per acre will provide satisfactory control. Grass carp with a minimum length of 12 inches should be stocked in the spring or early summer.

When used in the appropriate situations, triploid grass carp can provide an effective and cost efficient method of vegetation control as an alternative to aquatic herbicides.

Fish of this size or larger are less vulnerable to predation. This species tends to migrate from a pond during high water events, so escapement issues should be addressed prior to stocking. These fish can be obtained directly from a state-approved and licensed commercial dealer, a list of whom is available on the SCDNR web page or from any of the regional offices.

Note: Fertile (diploid) forms of grass carp are illegal to import or possess in South Carolina without a permit from SCDNR; such a permit is only available to commercial aquaculture operations. A state-authorized permit is required to buy or possess sterile (triploid) grass carp. This permit will be provided to the pond owner by the supplier at the time of purchase.

MISCELLANEOUS PROBLEMS AND CONSIDERATIONS

Fish Mortality

Most fish mortalities occur in South Carolina as a result of dissolved oxygen depletion, pesticide toxicity, or parasite and disease damages.

Oxygen depletion is by far the most common cause of fish kills in ponds. They can be largely prevented by good management practices, but will occasionally occur in even the best managed ponds. Although conditions are most favorable in the summer and early fall for low oxygen problems, generally these events are not predictable or wholly preventable by the average pond owner. Some of the most common causes of DO depletion are:

- **"Turnover"** - Remember that ponds stratify during the summer and the lower layer of water contains little or no DO (pg. 16). A sudden cold front, heavy rain or even strong winds can physically mix the water in the pond or overturn it. This mixing of the water column results in DO levels too low for fish to survive. If the previous few days have had little sunshine, the effect will be worse, since oxygen levels in the upper layer are likely to be lower initially.
- Over fertilization - Excessive fertilization can produce excessively dense blooms of phytoplankton or undesirable alga problems. These produce oxygen on sunny days, but very heavy blooms will utilize nearly all of that oxygen during the night, leaving very little for fish respiration.
- Aquatic vegetation or algae die-off - Sometimes a heavy phytoplankton bloom or infestation of aquatic weeds in a pond will die off naturally or as a response to herbicidal treatment. As the plants decompose, oxygen is consumed and DO levels may fall to a level lethal to fish.

Symptoms of DO depletion may include fish gulping at the surface of the water. This is especially noticeable early in the morning when oxygen levels are likely to be lowest or fish congregate near sources of fresh incoming water. Large fish usually die first in situations of low DO, but if the problem is severe enough, smaller fishes will soon follow.

The only effective treatment is to aerate the water, either by using mechanical aerators or by exchanging the water in the pond with fresh water from a source. A number of aeration devices are available, but are generally not considered cost efficient to purchase and install in recreational fishing ponds. Do not stir or agitare the water up with an outboard motor or by other means as this acts to further dilute the small amount of oxygen that may be present in the water column.

Pesticide or Toxic Pollutant Exposure

Fish deaths due to pesticide toxicity are more common in intensively farmed areas. Occasionally, a heavy rain immediately after a pesticide application will wash chemicals off the plants and into an adjacent pond. Careless aerial spraying may also result in pesticide mortality.

Runoff accidents can be prevented by diverting field runoff from your pond, either with a diversion ditch or **berm.** Aerial applicators should be encouraged to spray carefully and only under minimum wind conditions if ponds are near the treatment area. In urban settings, fish kills can result from exposure to a wide variety of pollutants including petroleum products, industrial chemicals, wastewater or chlorinated water. These materials may enter the pond via storm water runoff, nearby ruptured pipeline, or vehicular accidents. Once the toxin is in the water, little can be done. Exposure in sufficient concentrations will usually affect smaller fishes first, rapidly working its way up to the larger ones. In the event a pond owner suspects a fish kill has occurred as a result of a pesticide or other pollutant, they should contact the South Carolina Department of Health and Environmental Control (SCDHEC) at 1-888-481-0125 immediately. Time is often critical in identifying the cause and minimizing its impacts. The pond owner should pay close attention and record any observations regarding the event, as this will prove helpful in any investigation into the cause of the kill that follows.

Parasites and Diseases

Parasites and diseases are common for fishes in warm South Carolina waters. Infestations usually kill just a few fish at a time and generally present no major problem except to intensive commercial operations. The situation almost always corrects itself within a few weeks and treatment is seldom practical, if even possible, for the average pond owner. The Regional SCDNR Fishery Biologist can often aid in identifying the problem and advise the best course of action.

Muddy Water

Turbidity, or muddy water, prevents light penetration and prevents the growth of beneficial phytoplankton, which are the base of the food chain in ponds. Fish can tolerate turbid water, but growth is often compromised because food production has been impaired. Turbidity or muddy conditions are usually caused by runoff from unstabilized watersheds impacted by improperly managed agriculture, highway drainage and construction sites. This can be prevented by using appropriate land use practices on the watershed, construction of diversion ditches or the use of silt fences. In excavated ponds, it is sometimes sufficient to construct a low berm or dike around the pond perimeter to slow down unwanted siltation. It is important to identify the source of the problem and to stabilize the area with vegetation or other means; otherwise, the muddy conditions will continue following each rain event. If excess turbidity persists, it may be removed by the application of **aluminum sulfate** (filter alum) at the

rate of 50 pounds per acre-foot of water. The alum should be dissolved in water and quickly distributed over the entire pond surface, preferably by spraying. Application should be made during calm, dry weather and the water should be agitated as little as possible during and after application.

In ponds with a total alkalinity below 20 mg/l (as is the case with many South Carolina ponds), alum treatment may lower the pH to dangerous levels. Hydrated lime (slaked lime or builder's lime) applied at the same time at the rate of 30 pounds per acre-foot of water will counteract undesirable acid formation. It is important to distribute the recommended amounts of material as evenly as possible for best results.

An alternate method of clearing turbidity that has proved to be successful consists of adding 12 pounds of superphosphate for each 1,000 cubic feet of water. This works out to about 520 pounds of superphosphate for every acre-foot of water. The superphosphate is applied by dumping it slowly from the bow (or stern) of a boat while moving slowly over the pond. It is important to distribute the recommended amounts of material as evenly as possible for best results. As it clears particulate turbidity, the superphosphate may also produce a heavy plankton bloom; however, the pH shift associated with aluminum sulfate is absent.

Ponds that suffer from frequent or prolonged muddy conditions rarely make productive fish ponds. All effort should be made to identify and address the cause or source of the muddy conditions.

Another alternative is to lime ponds as recommended in the fertilization section (pg. 8), prior to alum treatment. The lime will often precipitate clay turbidity by itself, but if cloudiness persists after liming, alum treatment may be used without danger of pH depression. If persistent turbidity occurs, consult a pond or lake management consultant. Remember, identifying and addressing the source or cause of the muddy conditions is the key to eliminating the problem long term.

Artificial Fish Feeds


Bluegill

If a pond is properly managed, supplemental fish feeding is not necessary for good fish growth. In ponds that cannot be fertilized effectively, a regular feeding program can be used to increase production. Some pond owners enjoy the practice as it allows them to actually see their fish and it also concentrates the fish temporarily for easy hook and line harvest. In addition, the high protein content of these feeds will increase growth in the fish at a more rapid rate. Both bluegill and channel catfish will readily accept artificial feed once they become accustomed to a feeding program. Commercial fish food is available in a pellet, floating or sinking ration; however, the floating variety is best because the amount of uneaten food can be easily determined. A fingerling, catfish-sized pellet is recommended due to its smaller size allowing easy consumption by small bluegill. Feed only as much as the fish will consume in 30 minutes, because uneaten food is wasteful and may cause water quality problems as it decomposes. Feeding should be conducted daily during the spring, summer and fall and reduced or discontinued during the winter months when fishes' metabolism decreases. An automatic feeder is useful and can be set to feed several times a day. Gradually increase feeding rates to 7-10 pounds per acre per day without accumulating uneaten food. Reaching these feeding rates may take a period of time in infertile ponds. It should be noted that if sterile grass carp are present they often divert their appetite for vegetation and focus on the artificial feed intended for the pond's game fish.


Channel Catfish

Alligators


American Alligator

Alligator populations in South Carolina and throughout the Southeast have rebounded. Consequently, it is not unusual for one to take up residence in a fish pond. If this happens, it is generally not necessary to take any action. Alligators are opportunistic feeders and will consume fish, turtles and occasionally wading birds and small mammals that venture into the water. Alligators in a pond are a sign of a healthy ecosystem and do not represent a problem with the fish population as a general rule with the exception of grass carp, which are recognized to be particularly vulnerable. It is illegal to feed, molest or injure alligators. Never feed an alligator. Children and pets should not be allowed to swim in ponds containing alligators larger than six feet in length. If a problem with an alligator is anticipated, contact your regional SCDNR office or conservation officer for assistance on possible depredation permits.

Snakes


Water Moccasin

The wet margins of ponds can be ideal habitat for a number of snake species, including non-venomous water snakes and occasionally the venomous cottonmouth (water moccasin). It is unlikely that any of these species would feed extensively on live, healthy game fish. They tend to feed on dead, dying and sick fish. As scavengers, water snakes play an important role in the ecology and health of ponds, helping to maintain healthy fish populations. Maintenance of pond banks by controlling brush and undergrowth, mowing or bush-hogging and eliminating rip-rap can deter snakes. Avoid unnecessary contact with snakes and regard them as a natural part of an aquatic or wetland environment.


Banded Water Snake

Turtles


Yellow-bellied Slider

Several species of freshwater turtles can occur in ponds. Most of these species feed on plants and invertebrates (such as insects and crayfish) or are scavengers on dead and dying fish. Turtles rarely pose any problem to the pond's fish population. The only species capable of catching live game fish is the snapping turtle; however, they typically do not occur in large numbers. When air temperatures are warmer than water temperatures, turtles bask on logs and pond banks. Many people mistakenly think they have an overpopulation of turtles when they see multiple turtles basking. Turtles, however, are long-lived species with high death rates in the egg and juvenile stage, and their populations are self-regulating. While trapping turtles from ponds is not a recommended management practice, it is not illegal to trap turtles in South Carolina for personal use or for management purposes.

Beavers & Other Problem Mammals


Beaver

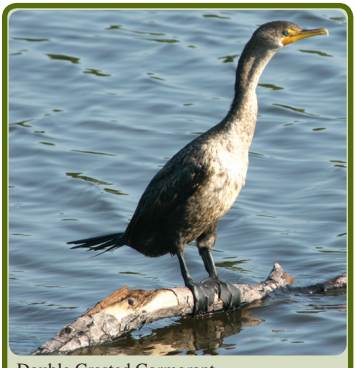
Beavers, otters and muskrats may cause problems by interrupting water supplies, destroying vegetation, or by burrowing into dams or pond banks. Otters can consume significant numbers of fish, particularly in smaller ponds. Trapping is the best way to reduce mammal populations, but all game laws must be observed. There are open seasons at certain times on otter, beaver and muskrat. Depredation permits may be obtained during closed seasons with proper justification. Seek advice from a SCDNR Furbearer Program Coordinator (1-803-734-3886) as to the best way to address problem mammals.


Otter

Livestock

Cattle and other livestock that have free access to a fish pond can cause damage in several ways. Their wading stirs up sediments, causing muddy water, as well as bank damage or erosion. Wading will also hamper fish spawning in the spring and summer by damaging eggs and nests and by frightening fish from guarding their nests. If livestock must be given access to your fish pond, they should be restricted to a small portion of the pond. This can be accomplished by the appropriate use of fencing.

Pond owners in South Carolina frequently place hog lots adjacent to their fish ponds to allow the hogs access to the water. While this practice is beneficial for swine, it poses a direct threat to pond fishes. Hog lot waste is very high in organic matter and can cause a DO depletion if washed into a pond suddenly by a heavy rain. A possible link also exists between animal manure and fish disease. Hog lot runoff should be diverted from the pond with berms or diversion ditches.



Double Crested Cormorant

Water Birds

Fish are major food items for several water birds including kingfishers, egrets and herons. However, their consumption of fish is so low that there is no danger to a pond's population balance. Ignore them, or, better still, enjoy observing their unique habits. Another species of fish-eating bird, whose numbers have increased dramatically in South Carolina in recent years is the double-crested cormorant. This diving bird is an efficient predator of fish and can consume large numbers in its daily feeding activity. Cormorants are protected, as are most other bird species, leaving the pond owner with little more than deterrent options should these birds invade the pond. Ducks or geese often take up residence in ponds. These birds do not harm fish or their eggs and, despite a common belief, they are of little value for aquatic weed control.

Great Blue Heron

APPENDIX A: GLOSSARY

Acre-Foot: An acre of water a foot deep. It contains 43,560 cubic feet of water. To calculate acre-feet, multiply the number of surface acres by the average depth in feet.

Alkalinity: The amount of bases (mostly carbonate and bicarbonate ions) in the water. Moderate to high alkalinity in a pond helps to prevent rapid pH changes and also insures an adequate supply of available carbon for phytoplankton growth. South Carolina ponds usually have low alkalinities.

Aluminum Sulfate: A compound that causes suspended clay particles (turbidity) to coagulate and precipitate from the water column. It is also called filter alum.

Aquaculturist: Individual permitted to raise fish for commercial purposes to include food and recreational fishing.

Balance: The ratio and weight of predatory fish (largemouth bass) to forage fish (bluegill/shellcracker) in the pond. A well-balanced fish pond will sustain the growth and reproduction of each species, over time, in the presence of angler harvest and natural mortality.

Berm: A low dike or retaining well.

Bloom: The green color produced in a pond when it has been fertilized. It is composed of millions of microscopic plants (phytoplankton) floating freely in the water, and provides the basis for the pond's food web.

Carrying Capacity: Refers to the maximum poundage of fish per acre a pond can support at a given time.

Dissolved Oxygen (DO): Oxygen which is dissolved in water. It is the form of oxygen that fishes require for respiration.

Hardness: The total amount of metal ions (mostly calcium and magnesium) dissolved in water. Ponds with a water hardness below 20 mg/l are difficult to fertilize economically. Hardness may be raised in a pond by liming. Alkalinity and hardness in South Carolina ponds are usually near the same magnitude.

Milligrams per liter (mg/l): Unit of measurement; the equivalent is one part per million. Example: To obtain a salt solution of 1 mg/l in one acre-foot (43,560 cubic feet or 325,830 gallons) of water, 2.7 lbs. of salt would have to be added.

Mortality: The state of being subject to death.

Pesticide: A chemical substance used to control pests, either plant or animal varieties. Herbicides are specifically for plant pests and insecticides for insects.

Piscicide: A chemical specifically used to kill fish.

pH: Measure of the acidity or basicity of a solution.

Phytoplankton: Microscopic plants in the water column that form the "bloom" in ponds. They represent the basis of the food web and generally produce a green or greenish brown color to the pond.

Renovation: Process of removing an existing fish population from a pond, usually with rotenone, and restocking with fingerling fish.

Retention Time: The period of time it takes for a pond to completely exchange all of its water (outgoing vs. incoming). Retention times may vary, depending usually on the volume of incoming water. If the retention time of the pond is less than about 3 weeks, fertilizer does not have a chance to work properly before it is flushed from the pond.

Rotenone: A restricted use herbicide that is used to kill fish. It causes them to be unable to process the oxygen available to them. Rotenone is harmful to any animal that possesses gills.

Stratify: The phenomenon in which water "layers" in a pond with respect to temperature. The warmer, lighter water forms a high quality upper layer and the cooler, heavier water forms a low-quality layer on the bottom. The bottom layer usually has a much larger volume than the upper layer.

Turbidity: Muddy water. It is usually caused by suspended clay particles.

Turnover: An event wherein the upper, oxygenated layer of water in a pond is displaced, either by wind action or by a heavy, cool rain. This causes pond waters to mix, frequently creating overall conditions so low in DO that fish cannot survive.

Zooplankton: Microscopic, free-swimming animals that feed on the phytoplankton. They comprise the second order of food items in the pond's food web.

APPENDIX B: AGENCY CONTACTS CONCERNING PONDS

The Natural Resources Conservation Services (NRCS) has field offices in every county in the state. For phone numbers, look in your local phone book under Government offices, U.S. Agriculture Department. *www.nrcs.usda.gov/*

The South Carolina Department of Health and Environmental Control (SCDHEC) is located at 2600 Bull Street, Columbia, SC 29201. For fish kill assistance only, call the EMERGENCY RESPONSE NUMBER: 1-803-253-6488. *www.scdhec.net*

South Carolina Department of Natural Resources Offices:

Fisheries Region 1 Office
(Greenville, Oconee, Pickens, Spartanburg, Greenwood, Laurens, Union, Cherokee, McCormick, Edgefield, Abbeville, Anderson)

311 Natural Resources Dr.
Clemson, SC 29631
(864) 654-1671

Fisheries Region 2 Office
(Chesterfield, Darlington, Dillon, Florence, Marion, Marlboro, York, Lee, Chester, Fairfield, Kershaw, Williamsburg, Lancaster)

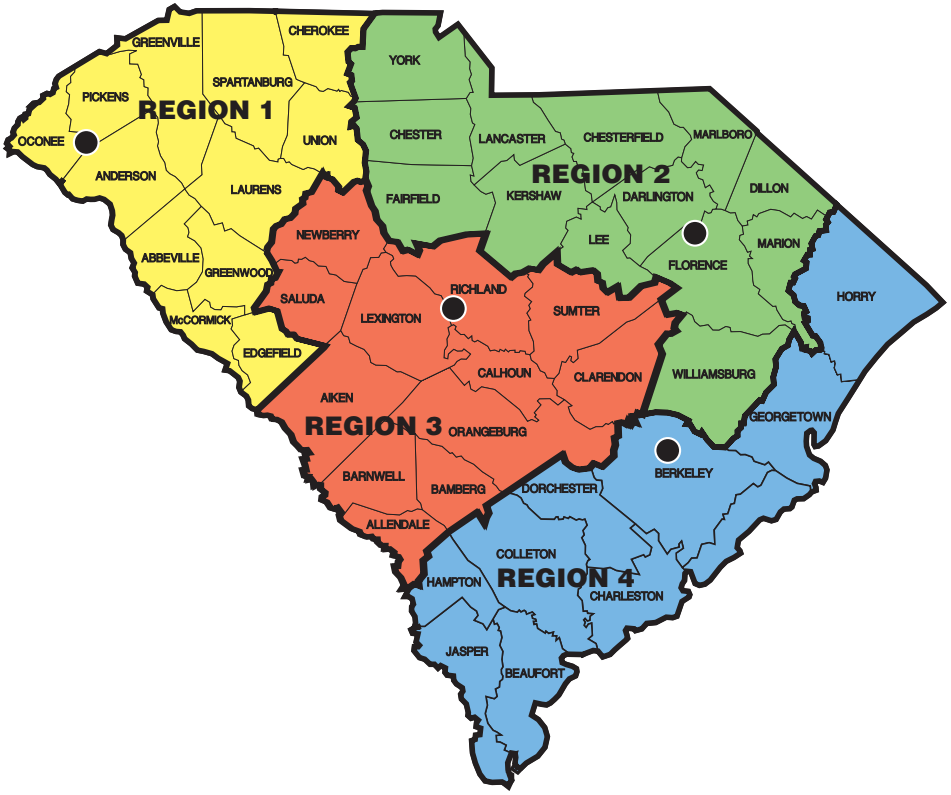
2007 Pisgah Road
Florence, SC 29501
(843) 661-4767

Fisheries Region 3 Office
(Newberry, Saluda, Lexington, Richland, Aiken, Calhoun, Orangeburg, Bamberg, Barnwell, Allendale, Sumter, Clarendon)

P.O. Box 167
Columbia, SC 29202
(803) 955-0462
(803) 259-5474

Fisheries Region 4 Office
(Georgetown, Berkeley, Charleston, Dorchester, Horry, Colleton, Jasper, Beaufort, Hampton)

305 Black Oak Rd.
Bonneau, SC 29431
(843) 953-5160



REGION	OFFICE LOCATION	SCDNR FISHERIES CONTACTS
1	Clemson	(864) 654-1671 ext. 24
2	Florence	(843) 661-4767
3	Columbia	(803) 955-0462 (803) 259-5474
4	Dennis Wildlife Center	(843) 825-3388

If you have an emergency, such as a fish kill, and cannot contact a fisheries office near you, call the Emergency SCDNR Law Enforcement number: 1-800-922-5431. The operator should be able to contact the appropriate person. Please do not call the Emergency number for routine requests.

ADDITIONAL POND MANAGEMENT INFORMATION

For information on any of the following topics, please visit *www.dnr.sc.gov/fishpond*

- **Tips to restore your fish population balance**
- **Where to purchase fish**
- **Find a lake management consultant**
- **Pond construction and management**
- **Fertilization and liming**
- **Finding a pay to fish (commercial fee) ponds**

Fish illustrations by Duane Raver.
Thank you to the Tennessee Wildlife Resources Agency
Division of Fisheries for photography.

Total cost	$2500.00
Total copies	5000
Cost per copy	$0.50
14-10116	7-14

Printed on recycled paper.