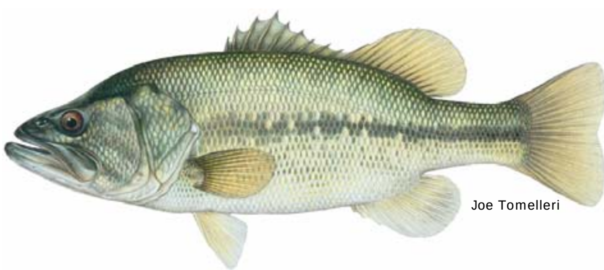
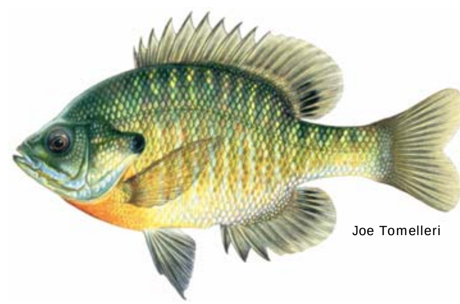
Texas Farm Ponds:
Stocking, Assessment, and Management Recommendations





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Introduction

Most farm ponds and small impoundments in Texas are not managed at their highest potential for fish production. This is unfortunate, since an estimated 20 percent of fishing trips in Texas are to these waters. This publication presents a concise set of guidelines for stocking and managing fish in new, renovated, or old ponds.

This publication was prepared by the Texas Chapter of the American Fisheries Society to provide information to the pond owner who has little or no knowledge of fishery management. Specific information on assessment techniques, interpretation of assessment data, and corrective management strategies are included to help the pond owner develop long-range management plans.

This information is intended primarily for ponds less than 5 acres in surface area, but may be useful for larger impoundments as well; however, you should discuss the management of these larger bodies of water and/or unusual management problems with a qualified fisheries biologist. Stocking and management advice is available from various state and federal agencies, universities, private consultants, and fish farmers.

Management Considerations and Objectives

Before you can develop a management plan for your pond, you must first decide on objectives that are both desirable and attainable. These objectives will be influenced by your preferences for certain species and sizes of fish, the productivity of the pond, and your interest in and commitment to increasing that productivity.

Pond Characteristics

Pond Construction Planning. Planning for the site selection, design, and construction of a pond is one of the most important steps in the pond management process. Unfortunately, many people fail to devote sufficient time, effort, and/or money to this step, only to pay later to address preventable mistakes. Common design and construction mistakes can result in pond or dam seepage, noxious aquatic plant growth in shallow water, lack of fish habitat, water quantity issues pertaining to inadequate or surplus watershed, suspended clay or sedimentation filling from an eroded watershed, among others. This manual is not intended to serve as a detailed guide for pond construction methodology. Instead, the information provided within this section is meant to introduce prospective pond builders to topics relevant to pond construction and to guide readers to resources containing specific and detailed information (see Design and Construction in the references section).

Pond designers must first select a suitable site and establish attainable goals for the pond. Site selection and goal setting must be accomplished concurrently as they are interrelated. What seems to be a suitable site may limit fisheries management options and vice versa. For example, trophy bass management may not be a realistic goal if the available site can support only a 1-acre pond.

There are several components to selecting a suitable pond site.

1. Obtain topographical maps or aerial photographs of your property. Topographical maps and digitized aerial photographs can usually be downloaded from the internet (http://www.tnris.state.tx.us) at no charge or obtained from Natural Resources Conservation Service (NRCS) offices. Viewing these images can help select initial site options.

2. Estimate the area of watershed which will feed your potential pond site(s). Local soil scientists can use watershed area and average annual rainfall data to determine how much water your pond site should receive. This information will help determine the eventual size of the pond.

3. Learn the soil types within your potential pond sites. Soil types can be researched with soil maps or by digging test holes. Ideally, compactable soils containing at least 30% clay are needed to minimize seepage.

4. Design the dam and spillway structures. This requires careful consideration, and for larger ponds (impounding greater than 200 acre-feet of water), professional consultation is recommended. To budget expenses, a pond designer can estimate how much dirt must be moved to construct the dam and a core trench. A core trench is an excavated trench in the foundation material under a dam in which special material, usually clay, is placed to reduce seepage. In order for the dam to impound and release excess water effectively, investigate the advantages and disadvantages of various primary and emergency spillway designs. A primary spillway usually consists of a pipe of appropriate diameter to easily transport excess water through the dam during a "normal" rain event. These pipes usually pass through the dam's center, releasing water into the lowest point downstream. Several primary spillway

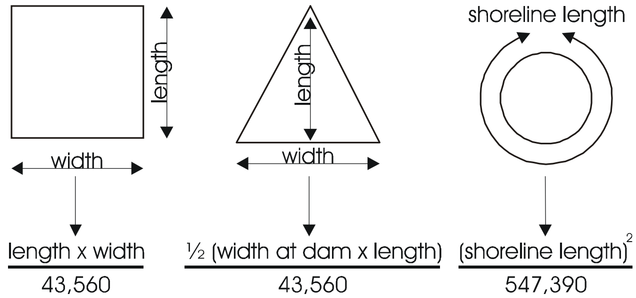
designs exist, ranging from surface-release drains to bottom-siphoning systems. For fishing ponds, the bottom-release designs are considered more desirable because poorer quality water near the bottom is passed through while retaining higher quality surface water. Design emergency spillways to allow passage of flood waters (usually around the end of the dam) with care to avoid soil erosion.

5. Design your pond shoreline slopes. Slopes of at least 2.5:1 ratio (2.5-feet drop per 1 foot from shore) are best to avoid large expanses of shallow water. Shallow water (< 3 feet deep) allows sunlight to penetrate to bottom sediments, which can encourage excessive aquatic plant growth. Steeper slopes can also position fish within easier casting distance of bank anglers. However, slopes should also depend on soil type and effort should be given to guard against erosion of steeply sloping banks.

6. The final planning stage should be devoted to including habitat improvement structures to be added prior to pond filling. Fish habitat can be added later, but is much easier before the pond fills with water. For information concerning pond habitat and fish attraction structures, see the Pond Habitat section and the Habitat heading within the References section.

Pond Size. The size of your pond is the major factor that will determine what fish to stock, the degree of management needed to maintain these fish, and how many fish you can harvest each year. Most farm ponds in Texas are built for livestock watering and are less than 1 acre in surface area. Although owners of small ponds traditionally want “bass in their tanks,” these small ponds are really not suited for bass populations. Bass harvest management in small ponds is especially difficult and unrewarding, as nearly all bass caught must be released to prevent overpopulation by forage species. In small ponds, it is usually better to stock only catfish, since they provide more fishing recreation, food for the table, and can be fed commercially prepared feed. Ponds larger than 1 surface acre are more suitable for multiple species. If these larger ponds are stocked, managed, and harvested properly, you can expect many years of satisfactory fishing for all sport species. If you prefer, they also can be managed for only catfish.

Many pond owners have difficulty estimating the surface area of their ponds. It is easy to overestimate, and this often leads to overstocking. If your pond fluctuates considerably in surface area, stock it based on the average annual low-water surface area. Remember that 1 surface acre contains 43,560 square feet. Formulas for calculating the surface area in acres of the most common pond shapes (square or rectangular, triangular, and round) are provided below to assist you in determining the size of your pond. All dimensions should be measured in feet.



Recent advances in global positioning system (GPS) technology allows pond owners to easily calculate pond surface acreage with a hand-held GPS unit that contains area-calculation programming. These units are available commercially.

Pond Habitat. Pond habitat can be simply defined as the environments that aquatic organisms live in and around. However, this definition encompasses a broad list of chemical, biological, and physical categories such as water depth, temperature, and oxygen content; pond-bottom substrate and contours; live floating, submerged, and emergent vegetation; dead standing or fallen timber; and artificial “cover” such as sunken concrete blocks, rocks, and “trees” or “reefs” constructed out of plastic, PVC pipe, and other structures. Learning the habitat requirements and preferences of common fishes will help pond owners to not only manage the needs of various life stages of those fishes, but also provide habitat that improves angler success.

Water depth, temperature, and chemistry will affect decisions about species to stock, water aeration, and placement of artificial structure. For example, in most southern ponds, warm season water temperatures are too high and oxygen too low for nonnative rainbow trout, but cold winters in the panhandle decrease stocking success of Florida strain largemouth bass as compared to the native northern strain. Introduced hybrid striped bass do not reproduce, so they do not need spawning habitat, but they do need deep, open water and adequate forage production in those habitats (unless you plan on supplemental feeding). During summer months, especially if winds do not regularly agitate the water’s surface, ponds can stratify into sharply defined layers. Stratified ponds become uncomfortably warm for fish nearer the surface, but the cooler bottom layer can become depleted of oxygen. To ensure that fish make good use of added structure, place it in water that will be less than six feet deep when allowing for water level changes, or install air diffuser systems designed to oxygenate and mix the layers (see Aeration section).

A firm, gravel substrate is ideal for nest spawners such as largemouth bass and sunfish. A 10 x 10 foot area of gravel three to six inches thick can be added where water will be three to four feet deep during the spring. Gravel should be placed either on plastic sheeting or some other bottom barrier to avoid sinking into the bottom sediments over time. Nesting largemouth bass prefer sites near large simple structure (natural log or pressure treated lumber held in place above the bottom by concrete blocks). This provides adults with cover, especially from bird predators in clear water. However, it should be located 10 to 20 feet away from complex structure (e.g., sunken brush) that early in the season harbors small fishes that eat eggs.

As ponds age, organic silt is naturally deposited on the pond bottom, covering and "filling in" the crevices between substrate particles. For a balanced pond system, this process is slow, but erosion of soil from an unprotected watershed, or frequent nuisance algae or vegetation growth and die off, can increase sediment buildup. Dredging can be accomplished in old ponds to remove silt deposits, but can be expensive.

Non-breeding, adult fish often prefer areas that offer rapid change in water depth and irregular bottom contours. Many ponds that were built to accommodate livestock watering are "bowl-shaped", offering little habitat complexity. The Pond Construction section of this manual offers ways to effectively address these issues early in the planning stage.

Aquatic vegetation can serve an important ecological role by providing many species, including fish, with a living habitat. Ideally, a fishing pond would support a limited mix of emergent plants that would stabilize the shoreline and prevent erosion, and submerged plants that would provide the basis for a productive food web. Plants offer living environments for invertebrates, which provide food for fish. However, overabundant aquatic vegetation (covering over 20% of the pond surface) limits fishing access, especially for bank anglers and catfish anglers attempting to present baited hooks near the bottom. Weed-choked ponds also reduce the feeding success of largemouth bass, resulting in growth-stunted prey and predator fishes. In smaller ponds, managing for limited coverage of aquatic vegetation and adding artificial "cover" is preferable to allowing aquatic plants to negatively impact fish populations and your fishing experience. Research studies have evaluated the success of establishing a host of native aquatic plants within cages that protect them from herbivores (e.g., grass carp, turtles, and crayfish). If establishment of aquatic plants is a strategy you are considering, consult a professional fisheries biologist or pond manager. The Aquatic Vegetation section of this manual also has tips on control of undesirable plant species.

Artificial "cover" is an excellent, low-maintenance alternative to plants for providing sanctuary for prey fishes and cover for predatory fishes from which to ambush their prey. Artificial cover serves to increase angler catch rates by congregating fish in smaller, more accessible areas. Over time, a pond owner can receive more maintenance-free recreation from an artificial structure than from introduced live plants that might grow out of control. It is also important to know that fish of different sizes and life stages require different kinds of habitat. Juvenile bass and sunfish need tight spaces within which to hide and feed. Christmas trees, rock piles, and thin brush serve this purpose well. Adult bass prefer large interstitial spaces that allow hiding as well as freedom to maneuver and travel within the cover. Brush and trees with larger, open limbs, large rocks, and "PVC trees" work well. When cutting and sinking brush, remember to use hardwood trees (e.g., mesquite, cedar, or oak) that will resist decay longer than softwood (e.g., ash, elm, hackberry and sweetgum). Refer to the References section of this manual for more technical information on construction and placement of artificial habitat.

Muddy Water. Ponds that contain turbid or off-colored water can pose management challenges for pond owners. Do not confuse muddy (red, brown, or khaki colored) water with the green color associated with plankton blooms, or tea-stained water indicative of tannins produced from decomposed acorns, leaves, and pine needles. Ponds that turn muddy following heavy rains and then clear up within a few days are not likely to suffer long-term ill effects. However, chronic turbidity can negatively impact pond fish production, angling success, and aesthetic value. Turbidity limits sunlight penetration into pond water which restricts primary productivity. For this reason, muddy ponds should not be fertilized. In addition, sight-feeding fish such as largemouth bass are less successful at feeding in ponds with severe turbidity.

Factors causing muddy water include watershed erosion, wave action, large populations of bullhead or carp, and livestock wading into the water. Correcting these problems by planting riparian vegetative buffer strips, using rotenone to remove undesirable fish, and fencing off livestock can allow the material to settle to the bottom of the pond. Placing a clear jar full of pond water on a shelf for one week can determine if settling will occur. If, however, the suspended particles are colloidal clay, they will not settle out. These tiny particles remain in suspension because of their microscopic size and the electrical charge surrounding their surface. In this case, a compound must be added to the water to correct the situation.

Flocculating compounds such as aluminum sulfate (alum) and calcium sulfate (gypsum) work through a process that allows clay particles to combine into larger clumps, or "flocs", that become large enough to sink out of suspension. Alum is one of the most effective coagulants, but in low-alkalinity ponds can reduce pH to levels harmful to fish. In this situation, hydrated lime must be added with the alum to offset the reduction in pH. Gypsum is an effective coagulant in most ponds and does not cause a loss in alkalinity. Gypsum is also priced more economically, but application rates are greater when compared to alum. Do not use potting soil gypsum because this material contains a high proportion of inert (non-active) ingredients. Use the purest form of finely ground gypsum available, whether supplied in bags or bulk. Pond owners should investigate the economic factors associated with purchasing, transporting, and applying these materials in addition to their pond's unique water chemistry when deciding on a flocculent.

Flocculents should be applied only after the cause of the turbidity is corrected. Watershed protection and soil conservation practices should receive first attention. Successful clearing of water following an application of alum or gypsum can be short-lived if exposed clay soils within the watershed continue to erode. Sources of more information on clearing muddy ponds can be found in the References section.

Total Alkalinity. Ponds located across the state have different water chemistry, caused by factors such as soil type, water sources, and watershed characteristics. The water chemistry in a pond affects primary productivity which determines the number of fish to stock as well as the pond's fish carrying capacity. One characteristic that controls the ability of a pond to produce fish is alkalinity. Alkalinity is the measure of buffering capacity, and is commonly described as milligrams per liter or parts per million calcium carbonate (mg/L or ppm $CaCO_3$). A total alkalinity of at least 20 ppm is required for good pond productivity. Ponds located within pine-forested watersheds are especially susceptible to low alkalinity.

In ponds with low alkalinity, pH can vary widely throughout the course of the day, causing unnecessary stress on fish populations. In this situation, it is often difficult to establish a phytoplankton bloom (see Fertilization section), which is the base of the pond's food chain. If you plan to fertilize, you should have the alkalinity checked. If alkalinity is less than 20 ppm and you want to fertilize, agricultural lime can be added to increase alkalinity. Do NOT use hydrated or quick lime, as rapid pH changes could cause a fish kill. Agricultural lime is often available in bulk quantities and can be delivered to your site. Common application rates range from one to four tons per surface acre. The lime should be applied as uniformly as possible over the surface of the pond to ensure coverage. Distributing the lime from a plywood platform on the front of a boat is a common application method. Check with local authorities or review the information found in the accompanying references to decide if liming is something you need to consider.

Water Fluctuation. Ponds in different parts of the state experience varied annual rainfall and evaporation rates. While East Texas farm ponds are usually full most of the year, South and West Texas ponds may experience drastic draw-downs during the summer months. These draw-downs concentrate fish in small areas and can reduce populations through either predation or oxygen depletion. You can minimize the impact of such draw-downs by providing deep water (12 to 16 feet) in part of the pond, sizing the pond appropriately to the drainage area of the watershed, and constructing a good quality dam (see Pond Construction Planning section). Some pond owners combat unwanted water-level reductions by pumping in groundwater from a well, but caution should be used as well water is low in dissolved oxygen. Providing structure in deeper areas of the pond ensures that fish habitat will be available regardless of water level. An aeration system can be used to help prevent fish kills during low water months when fish are crowded (see Aeration section). Porous soils and leaks under or through the dam can cause water levels to drop rapidly or maintain water below desirable levels. In some cases, walking behind the dam can reveal soggy or wet soils that may indicate a leak in the dam.

In certain situations, planned or manual water-level manipulations can be beneficial. Scheduled draw-downs can assist with aquatic vegetation control by allowing shallow bottom sediments to be subject to freezing or desiccation (drying out). Low water levels provide favorable conditions to repair damage to shorelines caused by erosion or cattle trampling, and to re-shape shallow bank slopes to 2.5:1. This may also be a good time to excavate silt deposits. Also, draw-downs can be used purposefully to reduce water volume if rotenone is applied to reclaim a pond for restocking. The References section of this manual can assist pond owners with information to prevent and fix leaky ponds.

Fertilization. The application of commercial inorganic fertilizer can result in up to a four-fold increase in pond fish production. Fertilization stimulates the growth of phytoplankton (microscopic single-celled algae) that forms the base of the pond's food chain. When properly managed, fertilization can also control submerged aquatic vegetation in water deeper than three feet. However, a poorly executed fertilization program will provide little benefit, and can easily cause fish kills if too much fertilizer is used.

Water-soluble granular, powdered, or liquid fertilizer may be used. All of them work, but usually one will best meet the specific needs of an individual pond or applicator. Whichever fertilizer you choose, make sure that it is the correct formulation, usually expressed as three numbers. The first number refers to the nitrogen component in the product, the second refers to phosphorous, and the third, potash. Common formulations are 20-20-5 or 18-46-0 (granular), 12-61-0 (powdered), and 10-34-0 or 11-37-0 (liquid). For most Texas ponds, a high phosphate formulation with no potash and a small amount of nitrogen is commonly used. For this reason, the 20-20-5 granular is generally not recommended, and nitrogen may not be needed in some older ponds.

Apply bulk granular fertilizer on a platform or from a plastic bag in shallow water. Granular fertilizer in specialized bucket dispensers are now available commercially. Applying the fertilizer is as easy as tossing the bucket in the pond. Another recent market innovation has been the appearance of quick-dissolve powdered fertilizer. These can be broadcast dry over the surface of the pond or dissolved in water before applying. Liquid fertilizer should be diluted 10 to 1 with water and applied to the surface of the pond by pumping the dilution into the propwash of an outboard or electric trolling motor. Either electric bilge pumps or "Venturi" (siphon-style) pumps will work. For larger ponds where greater amounts of fertilizer are required, liquid fertilizer may be the most economical choice. However, liquid fertilizer can be messy to handle without proper equipment for storage, transport, and application.

Begin fertilization in the spring when water temperatures consistently stay above 60 degrees. Depending on your location, this usually varies from early to late March in Texas. Check the response with an 8-inch diameter disk made of metal or plastic and painted black and white in alternate quadrants (called a "secchi disk"). Attach the disk to a string or yardstick and submerge it in the pond. The depth at which the disk is no longer visible is referred to as the secchi disk reading. Before fertilizing, secchi disk readings of 72 inches or more are common. Make an initial fertilizer application and, if needed, follow up with two more at two-week intervals.

Application rates vary among fertilizer products. For the initial application, use 8 to 16 pounds per surface acre of granular or powdered or 2 to 3 gallons per surface acre of liquid. Subsequent applications are usually 4 to 6 pounds per surface acre of granular or powdered or 1 gallon per surface acre of liquid. Monitor with the secchi disk and wait for the bloom to develop. The lag time between an application and a response may be as much as two weeks. An ideal phytoplankton bloom will result in secchi depths ranging from 18 to 24 inches, assuming water clarity is most influenced by plankton (as opposed to turbidity; see Muddy Water section). If the disk disappears at less than 12 inches, you have applied too much fertilizer and should cease further applications temporarily. At secchi readings less than 8 inches, emergency aeration should be considered. Apply fertilizer again once the secchi disk reading exceeds 24 inches. Continue fertilizing until late September for best results. Usually, between four and seven applications of fertilizer are required during that time period. In all cases, if the fertilizer product you purchase has instructions, follow their recommended application rates and intervals for best results.

Do not fertilize muddy ponds, ponds infested with aquatic weeds, ponds with low total alkalinity, or ponds that are flushed with large volumes of water until these problems are corrected. Ponds stocked only with catfish, and are fed more than three times per week, should not be fertilized. Several available publications (listed in the References section) give detailed instructions for pond fertilization. Consult them before beginning a fertilization program for your pond.

Aeration. Aeration can help to prevent low dissolved oxygen (DO) levels from negatively impacting pond fish populations. In addition, certain types of aeration equipment can effectively mix the water in a pond to prevent water-layer stratification, which can occur in deeper ponds (see Pond Habitat section) during warm months. Low DO levels can stress or even kill fish, whereas water stratification can limit fish use of cooler, deeper pond areas because of poorly oxygenated water. Anoxic (i.e., lacking oxygen) water does not permit bacteria to adequately process waste products, which then build-up on top of the pond's bottom sediments.

DO in ponds is naturally affected by photosynthesis, temperature, salinity, wind, supplemental feeding of fish, fish density, and pond depth. The natural sources of dissolved oxygen are photosynthesis by aquatic plants and diffusion from the air. Photosynthesis is the process by which plants (especially algae) use sun light to manufacture food. One of the byproducts of this process is oxygen. In a pond, DO is also consumed through respiration by fish, aquatic plants and algae, plankton, bacteria, and a host of other organisms. The most common DO problem occurs when the consumption of oxygen through respiration exceeds production through photosynthesis and diffusion. During summer, calm and/or cloudy days may reduce oxygen production by plants while fish continue to respire, and at higher rates as water becomes warmer. On occasion, algae or submerged plants in the pond die suddenly and no longer produce oxygen. As the algae or plants decay, bacteria grow and consume even larger amounts of oxygen. In deeper ponds, fall destratification (turn-over) can cause the DO level to crash as deep, anoxic water mixes with surface water. Although pond fish can survive short periods of low DO concentrations, prolonged exposure can cause stress or even death. DO can be measured using a chemical kit or an electronic oxygen meter. The preferred times to monitor DO are at daybreak and nightfall.

The general rule of thumb in determining the need for an aeration system is whether the pond contains greater than 1,000 pounds of fish biomass per surface acre. In most bass/sunfish ponds this carrying capacity is rarely exceeded. However, in fed catfish ponds, this threshold is occasionally exceeded by unknowing pond owners who do not harvest fish appropriately. Often, pond owners derive such pleasure from watching their "pets" grow and feed that they fail to harvest sufficiently to keep biomass within the 1,000-pounds-per-acre limit. For example, a pond owner who stocks 250, 6-inch channel catfish in a 1-acre pond, and feeds regularly, is safe within the limit. But in a couple years when those same 250 fish average 4 pounds each (total biomass = 1,000 pounds), a cloudy, summer morning could spell disaster. Aeration can serve as a pond owner's insurance against such occurrences.

A variety of aeration and destratification systems exist to assist the pond owner. Pump sprayer aerators, surface spray aerators, paddlewheel aerators, diffused air systems, and propeller-aspirator pump aerators each bring advantages and disadvantages to each specific pond environment. A thorough review of the sources found in the References section will greatly assist the pond owner in deciding which system best fits any particular pond or budget.

Aquatic Vegetation. While plants are the base or start of all food chains, uncontrolled rooted aquatic vegetation (macrophytes) and macro-algaes create numerous sportfish management problems. These plants tend to cover large areas of most ponds because of the abundance of relatively shallow water (< 8 feet). Few aquatic animals directly consume macrophytes or macro-algaes and so these plants tie up valuable nutrients and retard the flow of energy through the food chain to fish. Often the high densities of these plants allow prey to hide effectively and lead to stunted fish populations. Other common problems created by macrophytes include: limiting access to the water, increased evaporation rates, creation of environments for disease bearing insects (mosquitoes) and parasites, and degraded water quality.

Aquatic plants are usually grouped into 4 categories: 1) algae, 2) true floating plants, 3) submerged plants, and 4) emergent plants (see

Reference section). Algae are very primitive plants that have no true roots, stems, or leaves and do not produce flowers or seeds. Microscopic algae are important in the aquatic food chain and can be promoted through fertilization (see fertilization section). Filamentous and macro-algaees (like chara) often cover large areas and need to be controlled to improve access and reduce oxygen depletions. True floating plants (duckweed, salvinia, water hyacinth, etc.) increase evaporative water loss and can cause oxygen depletions and fish kills if they cover the entire pond surface. Submerged plants (bushy pondweed, coontail, milfoil, etc.) are extremely dense which allow prey species to hide and escape from predator species. The enormous biomass produced by submerged species often cause oxygen depletions and fish kills. Emergent or shoreline plants (cattails, lotus, primrose, etc.) reduce access, increase evaporative water loss, and often give prey species numerous places to hide.

Nuisance aquatic plants need to be controlled through an Integrated Pest Management (IPM) approach. The IPM approach includes prevention or 1) mechanical, 2) biological, or 3) chemical control. The best prevention is constructing the pond with rapid slopes to 2.5-3 feet and following a good fertilization program (see Pond Construction Planning, Pond Habitat, and Fertilization sections). Stocking with grass carp at five to seven per surface acre before any weed problem appears can also prevent many submerged weeds from establishing. It is prudent to start management programs before the noxious weeds cover large sections (> 20 %) of the pond.

Mechanical control is daunting and not often practiced. If weeds are mechanically cut they usually need to be removed from the pond so the decomposition will not cause oxygen depletions. Mechanical control is best practiced immediately when weeds first invade the pond. Physically removing the first/pioneer cattail or willow stops their immediate spread and saves time and expense on future treatments.

Biological control of submerged weeds is possible through the use of triploid grass carp. Permits for triploid grass carp must be obtained from Texas Parks and Wildlife Department. Stocking rates for grass carp should be based on the species of weed to be controlled and the percent or amount of the pond coverage (see Reference section). Triploid grass carp are usually effective at controlling submerged weeds for five to seven years but usually live to be 10 to 12 years old. Therefore, they have to be restocked periodically to maintain control.

Chemical control through the use of EPA registered herbicides is species specific and requires careful attention to application techniques and water use restrictions (see Reference section). Often when herbicides are not applied correctly, the massive amount of weeds killed leads to rapid decomposition and oxygen depletions. Oxygen depletions (see Aeration section) usually result in fish kills or stress that leads to parasite and disease outbreaks. Chemical treatment of algae, floating, and submerged plants is best done in the early spring before the plants have time to build up large biomass and while water temperatures are cool and dissolved oxygen levels high. In contrast, chemical treatments of emergent plants are often best in the fall before plants go dormant for the winter. Where possible, most chemical treatments of heavy weed infestations should be applied in only a portion of the pond and not over the entire area. Treating one-quarter to one-third of the pond at a time, then allowing two weeks for decomposition before another treatment, will reduce the chance of an oxygen depletion and fish kill.

The key to aquatic weed control is correct identification of the noxious weed species and selection of the best management option for that individual plant or alga and specific pond conditions.

Desirable Fish Species

Channel and Blue Catfish. These species do well in most pond environments and can be stocked alone in ponds of any size or as a supplement to bass and forage populations in ponds larger than 1 acre. Channel catfish (below) are more available for

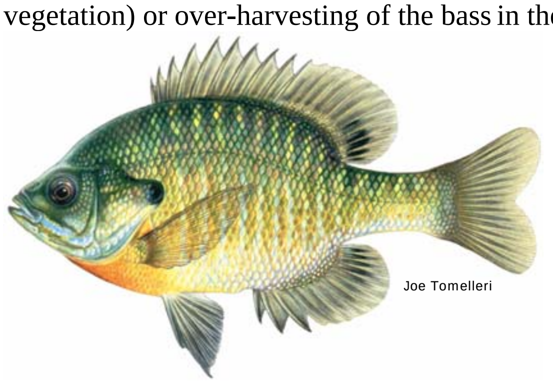
stocking, and can grow quickly to harvestable size when fed commercial feed. Pond owners desiring excessively large catfish can stock blue catfish.

However, expect them to become the dominant predator in the pond, not in numbers, but in size. Large blue catfish primarily consume fish and will compete with other sportfish for prey. In ponds primarily managed for bass fishing, channel catfish are the preferred species.

Largemouth Bass. This species is the most sought-after sport fish in Texas and, in almost all multi-species pond environments, is the primary predator. The northern largemouth bass subspecies is native to Texas and has been widely stocked since the turn of the century. Although the Florida subspecies grows to a larger size, it is more sensitive to very cold temperatures and more difficult to catch than the native (northern subspecies) bass. Because of its sensitivity to cold, Florida largemouth should not be stocked in ponds in the Texas Panhandle.

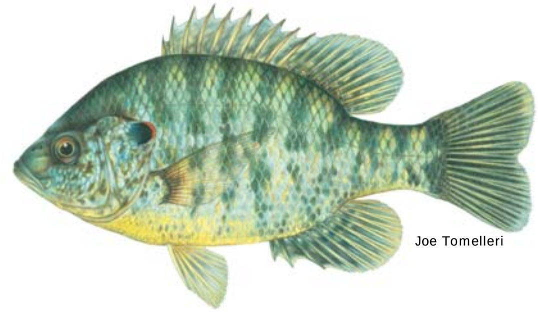
The native bass and Florida bass are often crossed to produce an intergrade offspring, commonly referred to as the F1 “hybrid.” The F1 may provide some of the advantages of both species. Florida largemouth bass will interbreed with natives, so if both subspecies are stocked in the same body of water, a mixture of Floridas, natives, hybrids, and back-crosses of various mixes will eventually occur.

Bluegill. Many pond owners are reluctant to stock ponds with bluegill because of the fish’s reputation for overpopulation. The bluegill is, however, a fine sport fish and the only fish species which can produce the large numbers of small fish needed to provide food for bass. Without them, a quality bass population will probably not develop. Overpopulation of bluegill most commonly occurs because of excessive escape cover (aquatic vegetation) or over-harvesting of the bass in the



first season of fishing—both of which reduce predation on the young bluegill (See Proper Harvest Section). The coppernose bluegill is a unique strain that, in Texas ponds, can reach larger sizes than do other varieties. If you have a strong interest in bluegill fishing, consider stocking this species.

Redear Sunfish. Redear sunfish can be stocked with bluegill in Texas ponds as supplemental forage. This species is also a fine sport fish and can increase angling opportunities. Because they eat snails they may also reduce fish parasites within a pond.



Hybrid Striped Bass. Hybrid striped bass are another sport fish that can be stocked in any size pond to provide additional sport fishing. They will readily accept artificial feeds, but will not reproduce in ponds. Hybrids can be stocked alone, with fathead minnows or sunfish, or in bass-bluegill ponds. Consult a biologist if you plan to stock these fish.

Fathead Minnow. The fathead minnow is a relatively slow swimmer (very vulnerable to predation), and therefore offers no long-term benefit when stocked in ponds containing established bass

populations. However, they are very useful when stocked with catfish that are not being fed regularly or in new bass-bluegill ponds to increase first-year growth of the bass and bluegill.

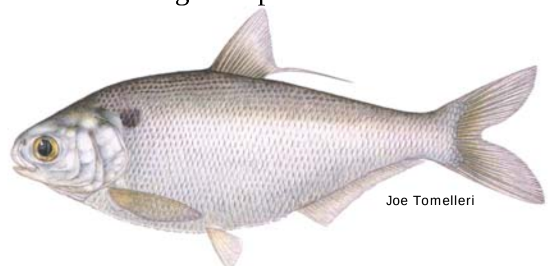
Grass Carp (White Amur). This species, when stocked in proper numbers, can provide long-term, cost-effective control of submerged aquatic vegetation in ponds; however, only specially produced sterile (triploid) grass carp are legal in Texas ponds, and a permit is required. Contact the Texas Parks and Wildlife Department for details.

Threadfin Shad. This species is an excellent supplemental forage species for bass; however, like the fathead minnow, generally cannot withstand bass predation for an extended period of time in a small pond. They are also sensitive to cold temperatures and perform best in South Texas, but can survive mild winters in North, East, and Central Texas. A fertilization program will greatly increase the success of threadfin shad introductions by reducing water clarity and increasing productivity.

Undesirable Fish Species

Many other species of fish have been stocked in Texas ponds, but none have been as consistently successful as largemouth bass, channel catfish, bluegill, redear sunfish, fathead minnows, or combinations of these fish. While other species may do well in streams, lakes or reservoirs, they often cause problems in ponds or are not suited for pond environments. Do not stock the following species or any species not listed without first consulting a fisheries biologist.

Gizzard shad can rapidly grow too large for most sportfish to consume. Without predation on large adult gizzard shad, they become overpopulated. Research has also proven that at high densities, gizzard shad can decrease production of young bluegill through interspecific competition for zooplankton resources. Never stock gizzard shad into a pond with newly stocked bass and bluegill populations. The only scenario where gizzard shad are desired is in ponds with existing bass populations that are managed for trophy-sized fish. In this scenario, large bass are able to benefit from the availability of larger prey and the pond owner is aware of the potential risk of a negative impact on bass and bluegill recruitment of young fish to adult sizes. Consult a professional fisheries biologist before stocking this species.



Golden shiners are occasionally stocked in established ponds to increase forage for bass. They should not be stocked in new ponds as they are heavy consumers of fish fry and eggs and could prevent the successful reproduction and establishment of the newly stocked game fishes.

Crappie are also very undesirable for stocking in ponds. They compete with bass for food, eat small bass, and tend to overpopulate and become stunted.

Flathead (opelousas or yellow) **catfish** are often stocked in ponds by the pond owner or well-meaning anglers, but this is a big mistake. This predator consumes large numbers of all species of fish, including largemouth bass.

Hybrid sunfish are often touted as a “superfish”; however, the crosses used to produce these hybrids are not good forage fish and should not be stocked alone for bass prey. Hybrid sunfish perform best when stocked with channel catfish and fed regularly with a commercial catfish ration. Some reproduction can be expected, but the offspring will not be as desirable as the original hybrid. Eventually, pond renovation and restocking become necessary because of overpopulation and stunting.

Stocking largemouth bass into a hybrid sunfish pond may greatly reduce the production of second-generation hybrid sunfish through predation. In this scenario, do not harvest any bass and allow this population to become as abundant as possible. As long as no other prey species are available, an abundant bass population may successfully limit the survival of the less desirable hybrid sunfish offspring. This could eliminate the need to renovate a pond and potentially ruin a developed catfish population. This scenario can only succeed when no other bass prey exists in the pond and bass abundance is high. This scenario will require periodic restocking of hybrid sunfish to maintain the population. Because this scenario involves many factors, consult a professional fisheries biologist if you are considering hybrid sunfish for your pond.

Carp, bullheads, and green sunfish often are inadvertently stocked or enter the pond from

adjacent water bodies through means such as flooding. Carp and bullheads are bottom feeders that can stir up the pond bottom and cause muddy water. Bullheads and green sunfish are notorious for overpopulating, particularly if bass populations are reduced.

Planning For Stocking

Small Ponds. Impoundments and reservoirs less than 1 surface acre in size are considered “small ponds” for the purposes of this publication. Most ponds in Texas are less than 1 acre in size, and many are less than ½ acre in surface area. These waters are almost always used for livestock, and fish management is usually not considered when the pond is built. But, after the pond is full of water, the owner often becomes interested in stocking fish.

Before stocking your small pond, remove any existing fish. New ponds should present no problems. Older ponds may have many different combinations of fish that will interfere with production. Avoid management hassles—clean out the pond. Consult the References for information on using rotenone to renovate ponds. Catfish are recommended for stocking in small ponds, since they provide the most fishing recreation and food for the table.

If you are feeding catfish, feed them daily during the growing season (April through November), giving them the amount of feed they will eat in 10 to 15 minutes, but not more than 10 pounds per acre per day. To avoid poor water quality resulting from feed and fish waste processing, a feeding ration of less than 3 pounds per acre per day is recommended. An aeration system should accompany feeding rations at higher rates. Feed them once a week during the other months (December through March). A daily feeding program with a good-quality commercial feed can result in 1 pound of fish gain for every 2 pounds of feed and will grow catfish to a catchable size in the shortest period of time. If daily visits to the pond are not practical, you can use an automatic feeder. Commercial catfish feed is available from feed and seed stores. Choose a good commercial floating or sinking pellet with at least 30 percent protein. Floating feeds may be more expensive, but they allow you to watch the fish while they feed, which reduces waste and provides entertainment.

Do not encourage catfish reproduction in small ponds by adding spawning devices or structures. Spawning will result in stunted fish. The total weight of catfish should never be allowed to exceed the pond’s carrying capacity (a maximum of 1,000 pounds per surface acre). If your goal is to produce a larger catfish, decrease the stocking rates accordingly. The probability of losing fish because of oxygen depletion increases dramatically when the pond’s carrying capacity is exceeded.

Large Ponds. For this discussion, ponds larger than 1 acre are considered "large ponds." Many large ponds are stocked with largemouth bass and prey species. Species stocked primarily to provide forage for bass are bluegill, redear sunfish, minnows, and possibly threadfin shad. A well-managed farm pond should support 300 to 500 pounds of fish per surface acre.

Channel catfish can be stocked to provide additional support and will not interfere with the critical balance between bass and forage. Expect most or all of the catfish reproduction to be removed by the bass, particularly in clear ponds. Muddy ponds (and other large ponds, if desired) may be managed for catfish and fathead minnows alone, as recommended for small ponds.

Successful multi-species management in large ponds requires stocking combinations of species to achieve a balance between predators (largemouth bass) and their principal forage species (bluegill). A balanced pond will have:

- Annual reproduction by largemouth bass and bluegill.
- Bluegill of many different sizes to provide food for all sizes of largemouth bass.
- Sufficient growth of both species for satisfactory sustained catches by the angler.

Maintaining balanced bass and forage fish populations is important for good fishing. Proper harvest of intermediate-sized bass and proper stocking schedules are critical for maintaining this balance. Proper bass harvest is discussed in more depth elsewhere in this publication.

The stocking schedule depends mainly upon the size of the bass stocked. When you plan to stock fingerling (1- to 3-inch) bass, stock fingerling (1- to 3-inch) bluegill and redear sunfish, fathead minnows, and catfish larger than 4 inches in the late fall, followed by the bass fingerlings the next spring (usually May or June when fingerling bass first become available). This schedule ensures that:

- The forage species and catfish are large enough when the bass are stocked that the bass will not deplete the original stocking of the forage fish and catfish.
- The forage species will have had an opportunity to spawn, creating a food supply for newly stocked bass.

If adult (longer than 3 inches) bluegill and redear sunfish are used, you may stock them either simultaneously with the fingerling bass or in the late fall followed by the fingerling bass the next spring.

Stocking fingerling bass between July 1 and September 1 is risky due to problems associated with transporting and stocking fish during elevated water temperatures. If stocking fingerling bass is not possible in late spring, an alternative stocking strategy is available. Bluegill, redear sunfish, and fathead minnows can be stocked in the spring and larger bass fingerlings (4 – 8 inches) can be stocked in the fall when water temperatures begin to cool.

Large bass (> 10 inches) and bluegill (> 5 inches) are sometimes used to stock new ponds, but this practice is not recommended because it makes achieving a proper balance less certain.

Stocking Guide

Recommended numbers of fingerling fish to be stocked in small or large ponds are shown in Table 1 (next page).

Proper Harvest

Bass. Improper harvest of largemouth bass ruins future fishing in Texas ponds more often than any other cause. Pond owners and other anglers often overharvest bass in the first season of fishing, allowing bluegills to overpopulate. No bass should be removed during the first 2 years after stocking.

You can reduce the chances of overharvesting bass by making your pond off-limits to everyone; however, this is not recommended since underfishing can lead to as many problems as over-fishing. Although you control access to your pond, don't deny entrance to a responsible angler willing to follow a few simple rules regarding catch-and-release of certain sizes of fish. Encourage all anglers to record their catch by species and size (see Appendices for more information on using these records). This record-keeping system provides you with an estimate of the size composition and relative abundance of game species over time.

The most sensible way to prevent bass overharvest is to establish a minimum length limit of 18 inches for the first 3 years after stocking. If anglers abide by this restriction and release all bass smaller than 18 inches, the pond should begin producing good fish of all species. The bass that were originally stocked have the greatest potential for growth and will have to support the majority of the catch for 2 years, so they have to be used wisely.

Table 1. Recommended Numbers of Fingerlings to Stock for Various Management Options in Texas Farm Ponds.

Pond Size	**Fish Species**	**Number per Surface Acre to Stock** Un-Fed: Fertilized	Un-Fed: Unfertilized	Fed[1]
Any Size	Channel Catfish or Blue Catfish	Up to 300 + 3 pounds fathead minnows	Up to 150 + 3 pounds fathead minnows	Up to 1000[3]
More than One Acre	Largemouth Bass	100	50	
	Bluegill	1,000	500	
	Fathead Minnows	10 pounds	5 pounds	
	Channel Catfish[2]	100	50	
	Largemouth Bass	100	50	
	Bluegill	750	375	
	and	and	and	
	Redear Sunfish	250	125	
	Fathead Minnows	10 pounds	5 pounds	
	Channel Catfish[2]	100	50	

[1]Do not fertilize catfish ponds where catfish are being fed.
[2]May be stocked to increase fishing opportunities.
[3]Above 700 fish, harvest is mandatory at 2 to 3 pounds;

After 3 years, you need to make a decision about the kind of bass fishing you want to promote for your pond. Bass will have reproduced two or three times during this 3-year period, and the pond may have large numbers of young bass. If the young bass are under-harvested, they will have to compete for the available food and their growth rates will be poor. The result will be a bass population consisting mainly of fish less than 12 inches long. All these small bass will reduce the number of small bluegill, and the pond will have a surplus of 7- to 8-inch bluegill.

If you are interested in catching bass larger than 12 inches long, 8- to 12-inch bass must be harvested. Harvest about twenty-five 8- to 12-inch bass (weighing a total of 10 to 15 pounds) per acre each year after the third year from stocking. Removing these small bass reduces competition and allows some fish to grow to larger sizes. Other factors that affect largemouth bass growth rate include genetics, water quality, habitat, and prey availability.

Average growth for bass in Texas are:

Age I	8 inches
Age II	12 inches
Age III	15 inches
Age IV	17 inches
Age V	18 inches

Lengths above represent averages for both sexes combined, and can vary considerably among pond bass populations and fish gender. It is worth noting that a properly managed bass population with adequate prey supply should exhibit faster growth rates than those previously described. Table 2 shows average weights for bass of various lengths. These statistics are useful for estimating the total poundage removed per surface acre per year.

Table 2. Average weight for largemouth bass of various lengths.

Largemouth Bass Length (inches)	**Average Weight (pounds)**
8	0.25
9	0.35
10	0.50
11	0.70
12	0.90
13	1.10
14	1.50
15	1.80
16	2.25
17	2.70
18	3.30
19	3.90
20	4.50
21	5.40

To keep bluegill in good condition, incorporate a “slot limit” for releasing 12- to 15-inch bass after the third year. Releasing bass of this size will also ensure that some bass will grow to more than 15 inches. Keep the harvest of bass longer than 15 inches to a minimum so that some larger, quality bass will survive.

If bass have not been harvested properly, you may need to make adjustments to the fish community. It is likely that the bass have been overharvested if anglers are catching mainly 3- to 5-inch bluegills and a few or no bass. This problem can be corrected by stocking 8- to 12-inch bass at forty per acre. Until small bass become abundant, make sure that all bass caught are released. Then, bass smaller than 12 inches and larger than 15 inches can again be harvested.

If many small bass and only a few large bluegill are caught, the bass have been underharvested. In this case, stock 30 bluegill, at least 5 inches long, per acre. Harvest about twenty-five 8- to 12-inch bass per acre each year thereafter. Again, bass 12 inches long and larger should be released.

Some pond owners want to maximize production of quality-size (15 – 20 inches) or larger bass, especially in ponds greater than 10 acres. Under this scenario, bluegill growth and high angler catch rates are sacrificed for the opportunity for anglers to catch fewer, but larger bass. Pond owners may consider utilizing a 14- to 18-inch or even a 15- to 22-inch slot length limit, and attempt to remove twenty-five 8- to 15-inch bass (weighing a total of 15 – 40 pounds) per acre each year. Total number and sizes of bass removed each year also depends on numbers of young bass recruiting to catchable size and available prey-fish supply.

If you decide to stock a new pond with limited numbers of advanced bass and bluegill rather than fingerling fish, the few bass must be returned to the pond and carefully protected. You cannot afford to lose the original fish, as they are present in limited numbers.

Catfish. You may begin harvesting catfish whenever the fish reach an edible size. Check catfish of catchable size for body condition. Numerous "skinny" catfish could be caused by overcrowding (corrected by increased harvest) and/or inadequate food supply (corrected by increased feeding frequency).

Catch records are important for determining when supplemental stocking is needed. In catfish-only ponds, at least half of the original fish should be caught before restocking. The total weight of catfish in these ponds should not exceed 1,000 pounds per surface acre during the warm months to decrease the risk of fish losses from oxygen depletion. In ponds where catfish were stocked in combination with largemouth bass and forage, occasional restocking may be needed to maintain the catfish populations over time. In these ponds supplementally stock catfish at least 10 inches in length at the rate of 25 to 50 per surface acre at 2- to 4-year intervals. The total weight of catfish in "combination" ponds, however, should not exceed 250 pounds per surface acre to reduce potential competition for food between species.

Identifying Fish Species

Identifying major sport, forage, and rough fish species is essential for interpreting assessment information. While it is neither practical to include every species and subspecies found in Texas in this publication nor necessary for you to know them, being able to identify the species discussed here will enhance your management efforts.

Assessment Techniques for Analyzing Fish Populations

Poor-quality fishing in most farm ponds is caused by unbalanced and/or undesirable fish populations. To determine the status of a fish population, you must take samples to assess the species composition and size distribution in your pond. You can use one of several methods to sample fish populations, including partial rotenone treatments, electroshocking, gill netting, trap netting, shoreline seining, and angler catch records. Although the first four techniques can provide excellent information, they are not practical for most pond owners. So, most pond owners rely on shoreline seining and angler catch records for making management decisions.

Shoreline Seining

Shoreline seining (Figure 1) is a good technique for assessing the status of many fish populations. Seine during June. A 15-x-4-foot minnow seine with a ¼-inch mesh is good for most ponds. Seining provides information on the presence and reproductive success of largemouth bass and

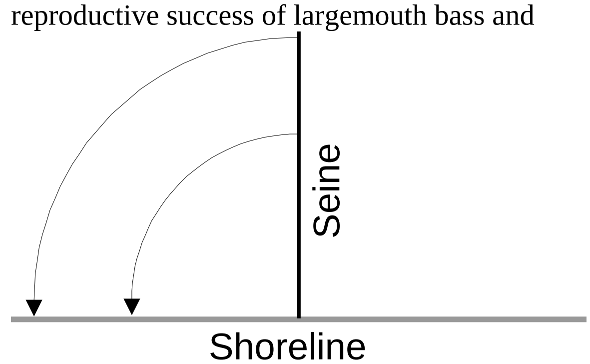


Figure 1. Quadrant seine haul technique.

bluegill. Excessive aquatic vegetation and brush will make seining difficult. Make a minimum of three quadrant seine hauls (more in larger lakes) in different areas to collect a representative fish sample from shoreline habitat. Record the numbers and sizes of each species collected for each seine haul.

Angler Catch Records

You can also gather assessment information from angler catch records, which often provide information on species not easily collected by shoreline seining. It sounds like fun, but to collect meaningful information, anglers should fish regularly with a variety of lures and baits (to catch as many of the species as possible) or fish consistently with similar gear from year to year (to identify changes in length and abundance). A sample record form (see Appendix B.) has been included to indicate pertinent information to be recorded.

Assessment using angler catch records is only as good as the information collected; therefore, make an extra effort to record the numbers and lengths of all species caught, along with other pertinent observations. Definite trends in harvest composition will become apparent over time, providing you with reliable information necessary for making management decisions.

A recent research study found a strong correlation between sport fishing and electrofishing data in largemouth bass populations, when Proportional Stock Density (PSD), Relative Stock Density (RSD), and relative weight (Wr) values were compared. See Appendix A for more information on PSD and RSD.

There was a weaker correlation between sport fishing and electrofishing data for sunfish populations when values for PSD, RSD-8, and Wr were compared. The fishing method described below for largemouth bass was used in that study. The method described for sunfish should increase the strength of that correlation.

The objective of these fishing methods is to catch fish that represent the proportion of different sizes present in the pond.

A. To collect largemouth bass:

1. Use artificial lures in three length categories: 1- to 2-inch, 2- to 4-inch, and 4- to 8-inch. The combination of these lure lengths allows you to target all sizes of bass in the pond.
2. Fish each lure for 30-minute intervals until you have caught 20 largemouth bass 8 inches or longer
3. Be sure to fish all three lures an equal amount of time before you stop fishing.
4. Fish all areas of the pond.

The fish caught in each 30-minute interval should be kept alive until the end of the interval and then weighed and measured. If you are returning them to the pond, clip their fins (one pelvic or pectoral fin) so you can be sure not to count them again in the analysis. Be aware that, in muddy ponds (secchi disk values 12 inches or less), this fishing method may overestimate the proportion of large fish in the population.

B. To collect sunfish:

1. Use 1 or 2 segments of a Berkley Power Wiggler or some other small lure on a #8 hook, #1 split shot, and light line.
2. Fish each bait type for 30-minute intervals until you collect 100 sunfish.
3. Fish each lure an equal amount of time.
4. Fish all areas of the pond.

With these fishing methods, you can use the data you collect to calculate population structure indices for largemouth bass and sunfish in ponds. However, this method is not a substitute for having an experienced biologist sample your pond and make management recommendations.

Interpreting the Results

Once you have collected assessment data for your pond, you must interpret it to make management decisions. Interpretations are based on the species composition and sizes for bass-bluegill populations.

Species Composition. The first factor to examine for all ponds is the presence or absence of certain key species. If undesirable fish have been stocked or have entered the pond, you must assess their impact as competitors or predators of the desirable species.

Species like gar, bowfin, flathead catfish, or chain pickerel compete with largemouth bass for available forage. Green sunfish, hybrid sunfish, and warmouth produce small numbers of young and compete for forage with small largemouth bass. As a result, largemouth bass do not perform well in ponds with only those species. The presence of these species in a pond with an adequate bluegill population, however, poses little threat to bass populations.

Crappie also compete with largemouth bass for forage, and their high reproductive rate may create stunted, starving crappie populations in small impoundments.

Other undesirables, regardless of the size of the pond, include black or yellow bullhead, common carp, carpsucker, buffalo, and Rio Grande cichlid. These species compete with desirable species for food and space. Several of these species can create muddy conditions in ponds.

In ponds managed for catfish only, any predator capable of feeding on catfish (such as largemouth bass, gar, or flathead catfish) should be avoided. Likewise, species that compete with the catfish for food (like green sunfish, golden shiners, and black or yellow bullheads) are undesirable.

Bass-Bluegill Population Structure. After you have determined which species are present, seine to determine the presence or absence of bass and bluegill reproduction. These two species provide the basis for predator-prey relationships in Texas farm ponds. The seine is the best method for gathering information on overall pond balance. Use Table 3 to evaluate the data collected by the quadrant seine haul technique. The presence or absence of bass and bluegill reproduction should almost always provide the information required for pond management decisions. Supplement this information with angler catch records whenever possible to provide information on the sizes of adult sport species in the pond. Some pond owners can use accurate records of numbers and sizes of fish caught by anglers for more in-depth assessment and management. A detailed description of the methods is contained in the Appendix.

Catfish Population Structure. Since shoreline seining will not provide much information on catfish, base your assessment of catfish populations on catch records and the general condition of the fish caught. Although these techniques apply specifically to catfish-only ponds, they can be useful for catfish assessment in multi-species ponds as well. At appropriate stocking rates (see Table 1), survival of stocked catfish will approach 100 percent. Knowing how may catfish have been removed will allow you to calculate how many remain in the pond. Under no circumstances should the total weight of catfish exceed 1,000 pounds per surface acre during the warm months.

Although some pond owners do not regularly feed their catfish, occasional feeding (at intervals of 1 to 3 weeks) with floating pellets allows you to determine whether the population has declined. If the number of catfish coming to feed drops markedly and remains low even in a variety of weather conditions, the population has probably been reduced by disease or vandalism. When you collect the catfish for population assessment, also make note of their body condition (plumpness). Since a distended gut can be misleading when you are making visual appraisals, concentrate on the thickness of the flesh when you observe the fish from above. If the catfish are overstocked and/or the food supply is insufficient, the fish will become "skinnier" over time. This sometimes happens if unexpected natural spawning occurs. In contrast, as the fish population declines because of fishing (or other mortality), the flesh will become thicker and "fatter."

Corrective Management

Three techniques can be used for correcting unbalanced or undesirable fish populations: renovation, harvest manipulation, and supplemental stocking. However, if unsatisfactory fish populations are the result of poor water quality, improper pond design, or an overabundance of aquatic vegetation, these techniques used alone may not be successful.

Renovation. Consider total renovation using rotenone if species such as gar, bowfin, flathead catfish, chain pickerel, black bullhead, common carp, buffalo, and carpsucker are present. If crappie are present, stunting (poor growth) and overpopulation can sometimes occur, and renovation may be necessary. The presence of warmouth and green sunfish does not require renovation if bluegill are present or can be supplementally stocked.

Harvest Manipulation. Angler harvest is an important management tool for adjusting the population structure of sport species. For bass and bluegill ponds, harvest recommendations are determined by the relative abundance of the two species and their size distributions (Tables 3 and 4 on next page). Harvest recommendations for balanced bass-bluegill populations are given in the Proper Harvest section.

Table 3. Assessment of Fish Populations and Management Recommendations Based on Seining June to October.

Seine Contents	**Status**	**Recommendations**
Young bass[1] present; many recently hatched bluegills[2]; few intermediate[3] bluegills	Population balanced	Use 12" to 15" slot or other goal-oriented harvest regulation
No young bass[1]; no recently hatched bluegills[2]; many intermediate bluegills[3]	Bluegills overcrowded	Stock 20 to 40, 8" to 12" bass per acre; stop bass harvest for 1 year or completely renovate and restock pond
No young bass[1]; many recently hatched bluegills[2], and very few intermediate bluegill	Bass badly overcrowded	Remove 25 to 40 bass of overcrowded size per acre; return larger bass
No young bass[1]; no recently hatched bluegills[2]; few intermediate bluegills[3]	Competition from undesirable fish species	Renovate with rotenone and restock

[1]Less than 4 inches long [2]Less than 2 inches long [3]3 to 6 inches long

For blue or channel catfish, maintain harvest records to determine the number of the original stocking removed. Balanced bass and bluegill populations may limit catfish reproduction even if spawning habitat is provided. If the catfish seem to be in poor condition (they look skinny), increase the harvest substantially to reduce competition for the food supply.

All other species caught should be removed from the pond regardless of size and number. These include gar, bowfin, flathead catfish, chain pickerel, bullhead, Rio Grande cichlid, common carp, buffalo, carpsucker, green sunfish, and warmouth.

Supplemental Stocking. Sometimes, pond assessment evaluations determine that supplemental stocking is needed to restore balance or establish a fishery. If shoreline seining and angler records reveal that bass are not present, a population could be established by stocking twenty 8- to 12- inch bass per surface acre, if forage is available. If bluegill are abundant and stunted at about 3 inches, increase this rate to 40 bass per surface acre. If you stock smaller fingerlings, they usually will not survive in a pond with an established population. A common but unwise practice of many avid bass anglers is to add more bass just because bass are what they like to catch. But if the bass are already unable to sustain their numbers because of poor water quality or inadequate forage, adding fingerlings will not correct the situation.

The only time you should stock bass on top of an existing balanced bass population is to introduce Florida bass genetics to a native population. The resulting F1 cross of the two subspecies may grow faster and larger than the parents, if proper forage, habitat, and water quality are present. Stocking 20 advanced (6- to 8-inch Florida bass fingerlings per

Table 4. Harvest Recommendations Based on Angling Proportional Stock Density (PSD)

Catch Composition	**Angling PSD**		**Harvest Recommendations**
	Bass	Bluegill	
Bass average 12" to 15"; bluegill range 3" to 6" or larger	40-70	40-60	Balanced pond-release 12" to 15" bass
Bass average 12" to 15"; bluegill caught are smaller than 5"	20-60	less than 40	Bluegill reaching overcrowded condition- harvest more bluegill; release 12" to 15" bass
Most bass are 12" or larger; bluegill caught are smaller than 5"	greater than 70	less than 40	Bluegill overcrowded- harvest more bluegill; release all bass
Bass are easy to catch. Most are smaller than 12"; bluegill 3" to 6" or larger	less than 20	50-80	Bass reaching over-crowded condition-harvest more bass smaller tan 12"; release 12" to 15" bass and all bluegill
Bass are easy to catch. Most are smaller than 12"; bluegill (6" plus) abundant	less than 20	more than 80	Bass overcrowded. Harvest more bass smaller than 12"; release 12" to 15" bass and all bluegill
Undesirable species			Consider renovation

surface acre should establish a breeding population in most ponds. However, you should first consult with a fisheries biologist before you supplementally stock Florida bass. If your assessment indicates that bluegill are not present, you should stock advanced bluegill fingerlings (3 inches and larger) at a rate of 40 per surface acre. This is often needed in ponds where warmouth and green sunfish are the only forage species available for bass. Several species can be stocked with the bluegill to further increase forage availability. Threadfin shad are often stocked at 200 to 500 per surface acre, although restocking is sometimes needed in small shallow ponds because of die-offs due to this species' sensitivity to water temperatures below 42°F and/or over-predation by the bass. This species is a relatively slow swimmer and will often be rapidly eliminated.

In established multi-species ponds, you can stock channel and/or blue catfish (if none are already present) at the rate of 100 per surface acre. Fingerlings should be no smaller than 10 inches to avoid predation by adult bass. Restocking may be needed every 3 to 5 years at rates of up to 100 fingerlings per surface area, since bass and bluegill populations often limit the natural reproduction of catfish. Do not restock catfish-only ponds until half of the original number have been removed. The total weight of catfish present should never exceed 1,000 pounds per surface acre during the warm months. The stocking rate you use should be based on the size of the pond, the condition and total weight of the catfish present, and the frequency of feeding. Fathead minnows are often supplementally stocked in catfish-only ponds at the rate of 500 to 1,000 per surface acre to provide additional forage. Although catfish do not normally spawn in small ponds, catfish stocked alone should not be encouraged to reproduce by adding spawning habitat since reproduction cannot be controlled and overpopulation and stunting may occur.

Other Management Considerations

Some aspects of pond management are not covered in detail in this publication. Published material on other important aspects of pond management are listed in the References section. Remember, appropriate stocking is only one step toward enjoying good farm pond fishing. Many of these additional management techniques are also necessary.

Summary

This publication provides management information to pond owners to increase the recreational value of their sport fishery. The information here should help you to effectively stock and manage your pond under most conditions. Even after the pond has been properly stocked, an assessment made, and necessary corrective actions taken, you should continue to monitor fish populations. Shoreline seining and accurate catch records will provide good assessment information for your future management decisions. If you encounter special problems or conditions, advice is available from qualified fisheries biologists with consulting firms, fish farms, universities, and state and federal agencies.

Proper management of fish in a pond is as much an art as a science. As research continues and the results are developed into recommendations, pond management will become more successful. Management will always be a necessity. Even if all the science needed for pond management were available in this publication, you would still need to be able to choose the best combination of factors to deal with your particular problems. Experience, learning from mistakes and successes, is the only way to develop the art of management.

Acknowledgments

The Texas Chapter of the American Fisheries Society Pond Management Committee worked diligently through the latest revision process to provide the best and most useful information available to pond owners, pond managers, and natural resource agency staff.

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References (by subject)

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College Station, TX 77843-2258
(979) 845-7473
http://texasextension.tamu.edu

Texas Parks & Wildlife Department
4200 Smith School Rd
Austin, TX 78744
(800) 792-1112
http://www.tpwd.state.tx.us/fish/infish/ponds

U.S. Department of Agriculture
Natural Resources Conservation Service
101 South Main Street
Temple, Texas 76501

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http://www.pondboss.com

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http://www.sdafs.org/tcafs/manuals/pond/ponds.htm

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Southern Regional Aquaculture Center Publications
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Texas Cooperative Extension
http://wildlife.tamu.edu

Texas Parks and Wildlife Department
http://www.tpwd.state.tx.us/fish/infish/ponds

Appendix A.

Assessing Population Size Structure

A technical index commonly used to analyze the size distribution of bass-bluegill populations from catch records is Proportional Stock Density (PSD). To determine the angling PSD for bass, the number of quality bass (12 inches and longer) is divided by the total number of bass and then multiplied by 100. A balanced bass population should have an angling PSD between 20 and 60 percent.

Example: Catch records indicate that 100 bass were caught, 33 of which were 12 inches or longer. The PSD would be:

$$\frac{33 \text{ (bass 12 inches and longer) x 100}}{100 \text{ (all bass)}} = 33\%$$

A PSD (bass) of 33 percent means that, of all the bass caught, one-third were at least 12 inches long.

For bluegill, the number of quality bluegill (6 inches and longer) is divided by the total number of bluegill and then multiplied by 100. A satisfactory bluegill angling PSD range is 50 to 80 percent.

Example: Catch records indicate that 40 bluegill were caught, 20 of which were 6 inches or longer. The PSD would be:

$$\frac{20 \text{ (bluegill 6 inches and longer) x 100}}{40 \text{ (all bluegill)}} = 50\%$$

A PSD (bluegill) of 50 percent means that, of all the bluegill caught, one-half were at least 6 inches long.

Relative Stock Density (RSD) can also be used to further analyze fish population structure. The calculation used for RSD-15 is identical to PSD except that the number of bass 15 inches or larger is divided by the total number of bass caught and multiplied by 100. This index, in conjunction with PSD, provides a more detailed description of a fish population's size distribution. The target range for RSD-15 is 10 to 40 percent. Similarly, 8 inches can be substituted for 6 inches in the bluegill PSD calculation. An acceptable bluegill range for RSD-8 would be 5 to 20 percent.

To achieve balanced populations, you should strive to maintain PSD values for both species within these suggested ranges. Table 4 shows evaluations based on angling PSD. The values that fall outside the suggested ranges may indicate a need for corrective management. Be sure to fish with a variety of lures and baits, with your angling efforts spread throughout the year.

Appendix B.

Angler Catch Record Chart

Date	Number Fishing	Hours Fished	Bass						Bluegill				Catfish			Other
			8 – 12 in.		12 – 15 in.		15+ in.		3 – 6 in.		6+ in.		Length	K	R	Number Species
			K	R	K	R	K	R	K	R	K	R				

K = fish kept and removed from the pond.

R = fish released alive back into the pond.