State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME
1416 Ninth Street
Sacramento, Ca 95814

Inland Fisheries - Informational Leaflet No. 23

FARM FISH POND MANAGEMENT IN CALIFORNIA[1]

Farm ponds are an important resource in California, used for stock watering, fire protection and recreation. Despite their potential benefits, farm ponds are subject to water quality problems, excessive growth of aquatic vegetation and other problems. Special care is required to effectively manage farm ponds so that they are esthetically pleasing and they achieve their full potential. Most ponds are located on private lands, and the landowner is responsible for pond management. This informational leaflet is intended to provide private pond owners with a summary of the basic information needed to construct and manage a pond for recreational fishing and other purposes.

Information contained in this leaflet is found under the following headings:

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PERMITS

It is important to you to obtain all required State and local permits before constructing a pond. Requirements differ from county to county, but required permits may include:

County Grading Ordinance

Check with the public works department for specific requirements in your county.

Water Rights

Be sure that you have legal rights to the water for your pond before construction of the dam. (This may not be an issue for springs or wells originating on your property.) The Natural Resources Conservation Service(NRCS; formally Soil Conservation Service) and Agricultural Stabilization and Conservation Service (ASCS) require verification of water rights from the State Water Resources Control Board before providing consultation or program assistance other than general information.

Department of Water Resources

Before building a dam, you must obtain a permit from the Department of Water Resources if the dam exceeds certain limits. The following dams are exempt from 1983 regulations:

(a) All dams 6 feet or less in height, regardless of storage capacity.
(b) All dams storing 15 acre-feet (An acre-foot of water will cover 1 acre, 1 foot in depth) of water or less, regardless of height.
(c) All dams less than 25 feet high which have a storage capacity of less than 50 acre-feet of water.

Department of Fish and Game (DFG)

(a) You may need a permit from the Department to stock fish (see Inland Fisheries Informational Leaflet No. 6, Regulations Governing Private Stocking of Aquatic Plants and Animals*).
(b) You may want to become a registered aquaculturist. Registration allows you to seine and trap fish in the pond as well as sell fish reared in the pond (see Inland Fisheries Informational Leaflet No. 35, Aquaculture in Inland Waters of California*). Registration also allows private or fee fishing without regard to season, limit or the need for a fishing license.
(c) Importation of live aquatic animals requires an importation permit (see Inland Fisheries Informational Leaflet Number 36, Importation of Live Aquatic Plants and Animals*).
(d) A permit is required (form FG 793*) for a private pond owner who is not a registered aquaculturist to seine fish, drain a pond to destroy fish, or to use a fish toxicant (required by Section 226.5, Title 14, CCR).
(e) If your water supply or the location of the pond involves work within a streambed, a Streambed Alteration Agreement*.

*** Available from DFG offices (see page 2).**

State Reclamation Board

You must obtain approval from the State Reclamation Board if the pond will be built within a designated floodplain of a river.

POND CONSTRUCTION AND DESIGN

Introduction

The design of the pond, dam and spillway are critical to the success of a farm pond. There are numerous excellent publications on this subject: Agricultural Handbook No. 590 and Farmer' Bulletins No. 2250 and 2256, and University of California Circular 467 (See Reference Material for sources).

Types of Ponds

There are two basic types of farm ponds: excavated and embankment. The choice of which type of pond to construct depends on the topography of the area. Use the excavated pond on relatively flat areas. This is a pit dug out and surrounded by the excavated dirt. Excavated ponds are commonly used to store irrigation water. The embankment-type pond is common to the foothill areas and consists of an earthen dam constructed across a ravine to impound

water.

Agricultural Conservation Program

The Agricultural Stabilization and Conservation Service (ASCS) may reimburse you up to 50% of the cost of the dam, to a maximum of $3,500. The ASCS is listed in the white pages of the telephone book under U.S. Government, Department of Agriculture. Applications are accepted for only about three weeks each year due to limited funding. You must have a water rights permit (when required) before applying. The NRCS can advise you as to whether a water rights permit is required for your pond. To receive reimbursement, you must have an approved application before starting construction. Contact the nearest ASCS office should to determine when the filing period is open in your county.

Site Selection

There are many factors to consider when selecting a site for pond construction. The main consideration in selecting a site for an excavated pond is soil type. Select an area that will not allow excessive amounts of water loss due to seepage through porous soil (consult with NRCS). Take steps to seal the pond before filling with water if seepage is anticipated to be a problem (see What to do about a Pond that Leaks).

Selecting a site to construct an embankment type pond is more complicated. Consult a NRCS engineer for advice on selecting the location.

When selecting sites for an embankment type pond, an important factor to consider is the size of the drainage area supplying runoff to the pond. If the drainage is too large, you risk losing the dam. If the drainage is too small, the pond may go dry during the summer. Agricultural Handbook No. 590 has some guidelines for calculating drainage area. Runoff rate and timing depend on slope, geology, vegetative cover and size of the drainage area.

The site selected for an embankment pond should be in a fairly narrow ravine. This reduces the size of the dam required and provides adequate pond depth. The choice of a relatively flat area increases the cost of the dam significantly, and the pond will contain more shallow areas. Shallow pond areas tend to have more aquatic weed problems and higher water temperatures.

Springs or wells are more reliable than runoff as water sources for your pond. Enough water must be available to fill the pond and replace any water lost through evaporation and seepage. Pumping water from a well may be expensive.

Watersheds that are cultivated or where vegetation is absent are usually poor choices for farm ponds. Such drainages will probably add large amounts of silt and nutrients to the pond, reducing the longevity of the pond and increasing aquatic weeds.

Finally, locate the pond in an area where failure of the dam would not result in the loss of life or property.

Constructing the Dam

Pond owners may be liable for any damages resulting from failure of the dam. We strongly recommend that you obtain the advice of a professional, such as your local NRCS representative. They can examine the soil type to determine if it contains enough clay to prevent excessive water seepage through the dam and the pond bottom. They can also provide advice on site selection, pond design, and pond maintenance.

Construct the dam with a clay core or "keyway". This will prevent excessive seepage of water through the dam (see Agricultural Handbook No. 590 for details). The "keyway" should extend from the top to the bottom of the dam and three feet into the subsoil. Use the best clay available to construct the "keyway" and compact it as it is backfilled.

Be sure to save all topsoil removed during pond construction. After pond construction is completed, spread the topsoil over all surfaces of dam, spillway and bottom of the pond. This rich topsoil will promote the growth of grasses that reduce erosion. It might be advisable to plant selected grass seeds (consult your NRCS representative). Do not plant on the dam or in the spillway any vegetation that has an extensive root system, such as willows. Roots can provide an avenue for water seepage, leading to erosion and even loss of the dam or spillway.

Depth

The recommended maximum depth of your pond will vary depending on its location. Deep water areas are necessary to give fish a refuge from warm temperatures. In the central valley of California, one-fourth of pond should be a minimum of 10 to 12 feet deep (see Agricultural Handbook No. 590, page 9). Design ponds to insure the edges, from the dam to about two-thirds of the distance to upper end of the pond, are at least three feet deep. Make the slope of the excavated banks three horizontal feet for every vertical foot (3:1). This reduces the chance of rooted aquatic plants from becoming established in the shallow areas of the pond. It costs more initially to reduce the amount of shallow areas in the pond, but reduced aquatic weed problems are well worth the investment in years to come. The area where water enters the pond should be relatively deep.

Size of the Pond

For commercial fish production, farm ponds should be a minimum of 1/2 surface acre in size. In smaller ponds, fish populations fluctuate drastically in response to changes in the environment. Small fish populations cannot support much fishing pressure and smaller ponds have a greater chance of going dry during summer months of drought years.

Clearing the Pond Site Before Filling

Remove most trees and brush before filling the pond. An abundance of such cover may interfere with pond management activities, prevent adequate harvest of gamefish and eventually lead to an overabundance of sunfish.

Remove stumps and rocks from all or at least part of the shallow end of the pond. This area will be used to evaluate the fish population. Removal of obstacles now will facilitate fish population management work in the future.

Use trees and brush removed from the bottom of the pond to construct brush piles at selected locations around the pond. Brush shelters provide hiding places for small fish, resting areas for adults and a substrate for aquatic insects that are eaten by fish.

Weight brush piles, or any other objects that may float, to anchor the structure to the bottom of the pond. Brady (1981) presents details on the construction and anchoring of brush piles.

Place brush shelters in areas accessible to shore anglers. The shelters can be used in conjunction with fishing piers of earthen peninsulas, which extend out into the pond and increase the amount of shoreline available to the angler. These combinations can increase harvest rates, especially for bluegill and redear sunfish.

Other materials, such as tires, rubble and old concrete pipes can also be placed around the edges of the pond as fish attractors. Be sure to locate these structures in areas that will not hamper management options or weed control.

Drain and Overflow Pipes

For safety and fisheries management reasons, install a drain pipe through the bottom of the dam during construction. This will allow complete draining of the pond. Fit the drain pipe with an anti-seep collar and valve. In coldwater ponds (see Classifying a Pond), you may want to install an alternative discharge to remove warm water from the top of the pond.

There are several advantages to removing the deeper layers of water from a warmwater pond. Removal of bottom water allows the warmer surface water to remain early in the spring and later in the fall. This gives the fish a longer growing season. Removal of bottom water reduces the chance of thermal stratification (which isolates the upper and lower layers of the pond which do not mix while stratified). It also allows the removal of water that may be low in oxygen or contain high concentrations of toxic material. The overall production of food organisms will be greater if the warmer fertile water layer remains in the pond and the less fertile bottom layer is removed.

It is desirable to install an overflow pipe to keep the level of the pond several inches below the emergency spillway. This reduces erosion of spillway due to waves, prevents the grass cover on the spillway from drowning and prevents small fish from escaping over the spillway.

Spillway Design

The location and design of the emergency spillway is probably the most critical aspect of the design and construction of the farm pond. This must be done right! A properly designed, built and maintained spillway can prevent failure of the dam under adverse runoff conditions. This requires consultation with your local NRCS representative or other expert.

Spillways should be large enough to adequately handle any anticipated flow. Wide spillways are desirable; the flow of water over the spillway should not exceed a depth of 6 inches. A shallow, slow flow is much less erosive than a narrow, fast flow.

Do not screen the spillway. Debris in water passing over the emergency spillway can accumulate against the screen and contribute to failure of the dam. Always keeping spillways clear of debris is part of good pond maintenance.

Design the spillway to prevent upstream movement of wild fish into the pond. Water leaving the spillway should pass over a sharp lip and drop at least three feet through the air onto a rock surface or into a shallow pool. Water from the spillway should not fall into a deep pool, because this increases the height most species of fish can jump, increasing the chance that they will enter your pond. Return the water passing over the spillway to the natural stream channel below the dam.

Establishing Vegetation

Planting grass in the pond basin before filling offers several advantages. Seeding the dam and spillway to reduce erosion has been mentioned. It may also be desirable to plant cover crops on the bottom of the pond and other areas that will eventually be flooded. This vegetation will hold the soil and reduce erosion as the pond fills, provide additional surface area for the production of aquatic insects, and as the material decays, contribute nutrients to the pond and increase overall productivity. Vegetation which can be used includes: rye, oats, wheat and barley.

Plant the banks of the pond to stabilize the soil and prevent silt from entering the pond. The vegetation should be a water tolerant grass (e.g. tiff green bermuda). Fence ponds, dams and spillways to exclude livestock. Fencing protects the dam and spillway from trampling damage and encourages the establishment of shrubs and herbaceous plants for wildlife food and cover. Water may be piped outside the fenced area to a trough for livestock watering.

Bushes, such as Atroplex can be planted around the perimeter of a pond to attract wildlife. Brush piles will encourage quail to use the area. For more details, see Producing Fish and Wildlife from Kansas Ponds, by Gabelhouse et al. (1982). Contact your local DFG (Appendix A) or NRCS office for additional suggestions.

FILLING THE POND

Pond construction should be complete before the winter rains so the pond can fill during periods of natural runoff. Fish are easier to transport in cool weather and are more likely to survive the stress of stocking. Warmwater fish species are most available for stocking during spring and early summer. Trout are available throughout most of the year.

What To Do About A Pond That Leaks

It is not unusual for a new pond to leak after construction, either through the dam or through the bottom of the pond. Normally a pond will seal itself within two years after filling. Fine particles in the water should eventually plug the small crevices. If the pond is not leaking badly, it might be easier to live with the problem than to try to correct it. Sealing a leaking pond

is time-consuming, expensive and often does not work.

There are several methods and additives to try, but first seek the advice of an expert, such as a NRCS representative. Materials commonly used to seal leaking ponds include bentonite, plastic liners and clay.

Bentonite - Bentonite is a clay-like material that expands when wetted. Apply bentonite to the bottom of a drained, dry pond at a rate of 1 to 2 pounds per square foot (See Ponds - Planning, Design Construction, Agriculture Handbook No. 590, page 47). Mix the Bentonite with the soil and then compact. Bentonite can also be applied to water but is more difficult to accomplish a good seal this way.

Liners - If the pond is not too large, plastic sheets may be used to line the bottom of the pond and face of the dam. This is expensive and, depending on the quality of the lining, may be good for only a few years. Consult an engineer before attempting to use plastic liners.

Clay - Clay is similar to bentonite and is applied in the same way and compacted. Saving topsoil during construction and then placing six inches of topsoil over the pond bottom will help prevent leaking.

ELIMINATING FISH PRIOR TO STOCKING

The success of any fishery depends partially on stocking the correct species, size and numbers of fish. Fishing ponds are seldom successful if undesirable species of fish are present. It is also important to determine if unwanted fish are present upstream from the pond. If the source of water is intermittent, well water, or directly from a spring, this should be no problem.

If undesirable fish are in the pond or the upstream water supply, it may be necessary to eliminate all fish present before stocking (removal of fish requires a permit from the DFG - Contact your nearest DFG office, see Appendix A). This will insure that the pond will contain only desired fish.

If the water source is a permanent stream, or if there are other farm ponds upstream, make an intensive search for unwanted fish species. Remove these fish from waters on your property after all permits and authorizations are received and before filling the pond. Contact the Department of Fish and Game for advice in this matter. If there are farm ponds on other properties upstream that contain fish that you do not want in your pond, consider selecting another site for your pond or screen the inlet water (i.e. run incoming water through a gravel filter).

The easiest way to eliminate unwanted fish from a pond is to drain it. Open the valve at the bottom of the pond, siphon or pump the water out of the pond. If it is impossible to remove all the water, allow remaining water to evaporate or seep into the ground.

If the pond cannot be drained, then it is necessary to use a piscicide (fish toxicant) to remove unwanted fish. The only pesticide that is registered in California for this purpose is commercial formulations of rotenone. The removal of fish from a pond, regardless of method, requires a permit (FG 793) from DFG. When using chemicals, it may be necessary to notify the Regional Water Quality Control Board. Rotenone based pesticides registered for restrictive use. This means they can only be applied by an applicator that is licensed by the State Department of Pesticide Regulation. If pesticides are used to remove fish from the pond, great care must be exercised. It is illegal to allow treated water to escape from the pond and kill fish in downstream waters. Contact your County Agricultural Commissioner for additional information on the use of rotenone based pesticides.

Rotenone requires a certain amount of time to detoxify before it is safe to plant fish. Suspend test fish in cages (live cars) at various depths and locations around the pond to insure that the rotenone is no longer toxic. Detoxification time varies depending on temperature, water quality, vegetation present, depth and turbidity. Chemicals can be used to detoxify rotenone, but they must be applied by trained personnel.

WATER QUALITY

The quality of water in a farm pond is measured in terms of amounts of dissolved oxygen, pH, nutrients and turbidity in the water. Good water quality is necessary to maintain the overall productivity and decrease the time required to manage a pond. One of the primary factors influencing a pond's water quality is condition of the watershed. The watershed must be managed to ensure that erosion is limited, even during periods of heavy runoff. It may be necessary to plant vegetation in barren areas to help stabilize the soil.

It is important that cattle or other livestock be prevented from grazing along the banks or wading in the pond. Large animals break down the banks, add unwanted nutrients and muddy the water. Pipe water for livestock some distance from the pond to a trough. If livestock access to the pond is necessary, then fence access to all but a very limited section of pond.

Muddy Ponds

Muddy water is undesirable in farm ponds because it reduces fish production and general appearance of a pond. Muddy water deposits sediments in the pond, reduces the pond volume, increases the proportion of shallow areas and encourages rooted aquatic weeds. Muddy water greatly reduces the amount of light that penetrates the water and inhibits the growth of plankton, a major source of pond food production. Large amounts of sediment may suffocate fish eggs, cause poor reproduction and eventually poor fishing. Lack of visibility helps conceal forage (food) fishes from larger game fish. When this happens in ponds with largemouth base and bluegill, it can result in unbalanced fish populations, with large numbers of small bluegill and fewer, slower-growing, bass.

If the pond remains muddy year-round, the problem may be a fine clay (colloidal) suspension. These are very fine particles that cannot settle out of the water column by gravity alone. An easy way to diagnose this is to place pond water in a glass container and let it stand

undisturbed for one to five days. If after this time the water remains muddy, then your problem is probably a colloidal suspension. Cloudy water may also occur and persist if Bentonite was used to seal the pond.

There are several methods for clearing muddy water caused by colloidal suspension:

1. Agricultural grade gypsum (hydrated calcium sulfate) - This is a fast and effective method, but requires large amounts of material. Apply 100 to 500 pounds of agricultural gypsum per surface water (12 to 60 pounds per 1000 cubic feet of water). The water should clear in about one week. Do not apply gypsum if the acidity of the untreated water is below pH 6.5. You can measure pH with a simple kit available where swimming pool accessories are sold.
2. Aluminum sulfate (filter alum) - Add 15 to 25 pounds of aluminum sulfate per surface acre. This should clear the muddy water within two to three days. If the water remains murky, it may be necessary to add an additional 15 to 25 pounds per surface acre. Aluminum sulfate has a tendency to lower the pH (become more acidic) of the water. We recommend 50 pounds per acre of hydrated lime be added if the acidity of the untreated water is below pH 7.0. Spread the lime evenly over the surface of the pond.
3. Cottonseed meal - Add cotton seed meal at a rate of 75 pounds per surface acre along with 25 pounds of superphosphate (or equivalent) fertilizer per surface acre. Apply evenly over the entire surface of the pond and allow 2 to 3 weeks for the water to clear. This may have to be repeated several times before the water clears.
4. Green hay or dry straw - Addition of green hay or dry straw promotes the growth of bacteria that cause suspended particles to form large clumps and settle out of the water column. Add 7-10 bails of hay or straw per surface acre of water. Break the bail open and scatter the material along the edges of the pond. The application of the hay or straw may have to be repeated at 7-10 day intervals until the water clears.

IMPORTANT: During summer months, never add organic material such as cottonseed meal, hay or straw to a pond. The rapid decay of this organic material may use enough oxygen to cause a fish kill. Use this type of material only during the cooler months.

If you do not want to go to the effort or expense to reduce the turbidity of your farm pond, then stock only channel catfish. Since high turbidity significantly reduces the microscopic plant and animal populations (phytoplankton and zooplankton), the overall productivity of the pond is reduced and there will be little food available for the younger stages of the fish in the pond. Channel catfish readily take food pellets and are not as dependent on the pond productivity.

During the spring and summer months, the water may appear cloudy due to an abundance of phytoplankton and zooplankton that are desirable components of the overall productivity of the pond. Plankton will give the pond that "pea green" color as compared to "dirty brown" color associated with a high turbidity. If you are unsure as to the cause of the turbidity, contact your local NRCS or county Agricultural Commission office for guidance.

STOCKING THE POND

Classifying a Pond: Warmwater or Coldwater

Before deciding what to stock, you must first determine if the pond is suitable for coldwater or warmwater fish. This is important because coldwater fish, like trout, will die in water which is too warm, and warmwater fish, like largemouth bass and channel catfish, grow slowly in cold water.

Coldwater Ponds

During the summer months, measure the temperature of your pond about 6 inches below the water surface at dawn (the coldest period for the pond). If the temperature is below 70^{O}F., then the pond could be classified as coldwater. Normally, the temperature will not rise more than 8-10 degrees Fahrenheit during the day. Also, if a supplemental water supply exists, the temperature and quality of that water will influence the fish stocked.

Warmwater Ponds

A warmwater pond is one in which the spring surface water temperatures reach the 50 to 60^{O}F and summer temperatures reach at least 80F.

Recommended Coldwater Fish

Rainbow trout (*Oncorhynchus mykiss)* - These are very desirable fish and are the fish most commonly used in coldwater ponds. Rainbow trout are also the most readily obtainable trout species. Rainbow trout should do well provided water temperatures do not exceed 75^{O}F for any length of time (Farmers' Bulletin No. 2249). They are stream spawners and will not reproduce in a pond unless a suitable stream flows into or out of the pond.

Depending on the strain of rainbow trout, spawning usually occurs in the spring. If successful spawning does not occur, It may be necessary to restock the pond with trout every few years. Unless all previously stocked trout are eradicated from the pond, restock with larger than 4 inch fish as smaller trout will be eaten by any large trout remaining in the pond.

Brook trout (*Salvalenis fontinalis*) - Brook trout have temperature requirements similar to those of rainbow trout. Brook trout will reproduce in ponds if springs or upwelling occur in the pond. They spawn in the fall. Because brook trout are so successful at producing large numbers of offspring, fish brook trout populations heavily to prevent overpopulation and stunting.

Brown trout (*Salmo trutta*) - Brown trout are fall spawners like brook trout, but require streams for spawning. They generally do not do as well as rainbow or brook trout in a pond.

Recommended Warmwater Fish

Fish recommended for stocking in warmwater ponds include largemouth bass, bluegill, redear sunfish, channel catfish and sometimes Sacramento perch.

Largemouth bass (*Micropterus salmoides*) - Largemouth bass are a very popular sport fish and do well in farm ponds. They are normally stocked with a forage species such as bluegill and/or redear sunfish. Bass are necessary to keep the numbers of sunfish under control and prevent overpopulation and stunting. Largemouth bass normally spawn in April or May when water temperatures are 60 to 65^{O}F. They reach 5 to 6 inches after one year and 10 inches after 2-4 years. Growth rates vary considerably depending on pond productivity and management.

Bluegill (*Lepomis macrochirus*) - Bluegill are primarily planted as food for bass, but in properly managed ponds, bluegill also provide good fishing. Bluegill begin to spawn when water temperatures reach the mid 70's (usually around June) and continue to spawn through August. They reach 3 inches long by late fall, although their size depends on which month they were spawned and the availability of food. If not harvested by bass or anglers, bluegill will overpopulate and stunt.

Redear sunfish (*Lepomis microlophus*) - Redear sunfish are often stocked instead of bluegill or in combination with them. Redear sunfish are not as prolific as bluegill, and therefore do not overpopulate and stunt as badly. Spawning begins when water temperatures reach 72 to 76^{O}F. and continues throughout the summer. Redear sunfish grow slightly faster than bluegill, sometimes reaching 5 inches by the end of their first year, 6 inches by the second, 7 inches by the third and 8 inches by the end of the fourth year of life.

Channel catfish (*Ictalurus punctatus*) - Channel catfish may be stocked with bass and bluegill but generally grow better when they are stocked alone. They eat insects, snails, worms and fish as well as commercially produced food pellets. Growth can be rapid with fish reaching 1 1/2 pounds by the end of the second season. Channel catfish will not reproduce in ponds unless provided with milk cans or other suitable nesting sites. If channel catfish are stocked in combination with other species of fish, many of the young catfish will be eaten soon after leaving the nest.

Sacramento perch (*Archoplites interruptus*) - Sacramento perch are the only native sunfish (Family Centrarchidae) west of the Rocky Mountains. Sacramento perch usually do not grow well in the presence of other sunfish. They are well adapted to survive in waters that are alkaline (pH greater than 7.0).

Mosquito fish (*Gambusia affinis*) - Mosquitofish can be stocked in farm ponds but usually do not provide any significant benefits. The other more desirable fish species stocked will also eat mosquito larvae.

Often Stocked, but Usually Undesirable Warmwater Fish Species

The following species are not recommended for stocking in farm ponds:

White catfish *(Ictalurus catus* - White catfish do not grow as rapidly as channel catfish. They do however, reproduce quite easily in ponds that can lead overpopulation and stunting.

Brown bullhead (*Ictalurus nebulosus*) - This is a very prolific species that tends to overpopulate in a pond and produce stunted populations unless adult bass are present in fairly large numbers and aquatic vegetation controlled.

Green sunfish *(Lepomis cyanellus*) - This species also overpopulates and stunts where adult bass are unable to properly utilize them.

Crappie (*Promoxis* Sp.) - Normally crappie do not do well in farm ponds. They tend to overpopulate, stunt and compete for food with largemouth bass. They should not be stocked in ponds less than 1 acre in size.

Carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) - These two species tend to stir up the bottom of the pond, keeping the water muddy.

Golden shiners (*Notemigonus crysoleucas*) or Fathead minnows (*Pimephales promelas*) - Golden shiners and fathead minnows are commonly used for bait. Adult minnows compete with other fish for food. Minnows have been used successfully in some pond management programs as a forage species for largemouth bass. If minnows are introduced, do not stock other forage species as bass feed on the minnows and tend to ignore bluegill or redear sunfish. This results in many stunted sunfish of little or no value to the angler. If minnows are stocked, monitor the fish populations closely to ensure that overpopulation does not occur and that many of large predators remain in the pond. A better idea is to rear minnows in a separate pond.

SOURCES OF FISH

Fish for stocking the pond must be obtained from a registered aquaculturist. A list of registered aquaculturists is available from DFG offices (Appendix A). A private stocking permit may also be required. Application and copies of pertinent regulations are found in Fish and Game Inland Fisheries Informational Leaflet No. 6, available from DFG offices (Appendix A).

STOCKING DENSITIES

Coldwater Ponds

Trout are the best species to stock in a coldwater pond. Any of the trout already discussed will thrive if water temperature is not more than 70^{O}F. in the summer (see Farmers' Bulletin No. 2249 - Trout Ponds for Recreation). Rainbow trout are the best choice. Unless heavily fished, brook trout overpopulate and stunt. Brown trout are harder to catch than other trout and are very predacious. They should not be stocked with other species of trout.

Fingerling trout may be stocked in either the spring or fall. Five hundred 2 to 4-inch trout per acre of pond stocked in the spring should yield 7 to 8-inch fish the first year. Half as many fingerlings stocked in the fall should give 10-inch fish the next year.

Fall planted fish reach pan size early in the following year. Unfortunately, a source of fingerling trout is often hard to find in the fall. In shallow ponds that freeze, winter kill may limit you to spring plants.

Trout are very sensitive to abrupt changes in temperature. Never release trout directly into a pond from the shipping container. First, pour out about half the water in the container and slowly add pond water. If the fish show any signs of stress (such as floating on their sides), stop and wait until they act normally again. When mixing is complete, slowly pour the fingerlings in the pond. Do not stock trout when water temperatures are above 65^{O}F.

Warmwater Ponds

Warmwater ponds have two main stocking options: (1) Channel catfish only, or (2) largemouth bass, sunfish (bluegill and redear sunfish) and channel catfish. Other fish species may be used, but additional species will affect the productivity and complicate the management of the pond.

Decide on the type of fishing you want before selecting fish for stocking. Ideally, you will keep careful records of the numbers and types of fish both stocked and removed from your pond. If bass and sunfish are stocked, bass harvest may have to be restricted. It is important that approximately 5 pounds of bluegill or redear sunfish be removed for every pound of bass taken. Not more than 25 pounds of bass per surface acre per year should be harvested from a fertilized pond. Otherwise, the bass reproduction will be unsuccessful and the sunfish will overpopulate and stunt.

If you are not willing to go to this effort and want the pond to maintain it self, stock channel catfish alone. In ponds 1/2 surface acre or smaller or with visibility of less than 12 inches, stock only channel catfish. Sunfish usually do not do well in these small ponds (see stocking the Pond).

It is important to stock the correct number and size of fish in your pond. This will result in good fishing in the shortest period of time. Stocking adult fish is not normally recommended as it may result in the production of too many offspring, eventually leading to overpopulation and poor fishing.

The proper stocking ratio of sunfish to bass is controversial and will vary from pond to pond and area of the state, but a good rule of thumb is 50 to 100 fingerling largemouth bass and 500 to 1,000 fingerling sunfish per surface acre in unfertilized ponds. Stocking fish as fingerlings and in the correct density will result in rapid growth and usually good fishing by the second summer in well-managed ponds. In well constructed and carefully managed ponds, some of these general principles can be violated, but consult with a fishery biologist before changing stocking criteria.

Redear sunfish are more desirable in pond management than bluegill because redears are less prolific and will not overpopulate the pond as readily as bluegill. If both bluegill and redear sunfish are to be stocked, then a ratio of 30% redear to 70% bluegill is recommended.

Channel catfish can be stocked along with the bass and bluegill. They should have little effect on the bass and bluegills since channel catfish occupy a different part of the pond. Channel catfish fingerlings should be stocked at a rate of 50 to 100 per surface acre. Table 1 outlines the recommended stocking rates for various combinations of largemouth bass, bluegill, redears and channel catfish.

Table 1 - Recommended Stocking Rates for Unfertilized Farm Ponds*

NUMBER OF FISH PER ACRE (FINGERLINGS)				
Type of Management	Bass	Bluegill	Redear Sunfish	Channel Catfish
Bass-bluegill	50	500	---	---
Bass-bluegill-channel catfish	50	500	---	50
Bass-bluegill-redear sunfish	50	350	150	---
Bass-bluegill-redear sunfish-channel catfish	50	350	150	50

* After Brady, 1981

If larger fish are stocked, reduce the stocking rate to 50, 8- to 12-inch largemouth bass, 250, 4- to 5- inch bluegill and 50, 8- to 12- inch channel catfish per surface acre. Stocking larger fish can give the pond a 1 to 2-year head start over stocking fingerling size fish and result in good fishing sooner. This method of stocking, using adult fish, is not normally recommended because too many young fish may be produced during the first summer assuming an unbalanced fish population and poor fishing.

Stocking Channel Catfish Only - There are several situations when only channel catfish should be stocked: (1) the owner wishes to have the pond "manage itself", (2) the pond is 1/2 surface acre or smaller in size, (3) visibility in the pond is 12 inches or less. There are several advantages to stocking channel catfish alone. They do not normally reproduce in farm ponds (unless spawning structures are added - see Catfish Farming, Farmers' Bulletin No. 2260, page 10). This means the number of fish in the pond can be easily controlled. Extensive research has been conducted on pond rearing of channel catfish and much information is available. This is a very tasty species and it takes commercial feeds readily. If only channel catfish are stocked in your pond, be sure to remove all trees and brush to prevent successful spawning. By controlling the spawn, management of the pond is much easier.

Stocking rates and sizes of channel catfish vary depending on your management goals. If the pond will be used for recreation purposes only, stock around 50 breeder-size (13 to 15- inch) fish per surface acre (equal numbers of males and females, see Pond Fish and Fishing in Illinois, page 21 for details on sexing catfish). Spawning boxes or milk cans will have to be added. After the fish have successfully spawned, remove the boxes.

A less expensive option is to stock your pond with fingerling channel catfish. Stocking density is highly variable and depends to a large extent on how much time you are willing to spend on the pond. Other variables include pond fertility and feeding rates. If channel catfish are being stocked for production ponds (commercial sales), rates depend on whether the ponds are fertilized and if the fish are fed. Table 2 summarizes suggested stocking rates for fingerling (about 2- inch) channel catfish under a variety of pond conditions.

Table 2. Suggested Stocking Rates for Fingerling Channel Catfish

Condition	Fish/Acre
No Feed or Fertilizer	100-200
Fertilized	200-400
Feeding Once Per Week	200-400
Feeding 2 to 3 times per Week	400-600
Feeding Daily	600-1000 (commercial operations only)

If spawning does not occur, the pond has to be restocked periodically. It is important to keep a record of the number of fish removed from the pond so that you know how many and when to restock.

When and How to Stock - You have three options as to when and how to stock warmwater ponds: (1) stocking adult fish, (2) stocking fingerling bass and bluegill in the fall, (3) stocking fingerling bluegill in the fall and fingerling bass the following spring or early summer. As mentioned earlier, stocking adult fish can be risky and is not normally recommended.
Stock fingerling bluegill, redear and channel catfish in the fall. A preferred option is to stock

fingerling bluegill, redear and channel catfish in the fall, and to stock fingerling largemouth bass the following spring or early summer. By stocking the bass the following season, some of the bluegill and/or redear sunfish should have spawned and provide forage about the time the bass are stocked. This latter method results in faster growth of the largemouth bass.

If only channel catfish are being stocked, they should be stocked in the fall of the year.

FEEDING FISH

If you want fast growth of your fish you may have to supplement natural foods with commercial feeds. Pelleted fish food is available for this purpose. Commercial foods are most successful for feeding channel catfish or trout. Bluegill may take pellets, but largemouth bass probably will not. When pelleted food is used, do not fertilize the pond, except for 2 or 3 applications during February or March of the first year.

Initially, feed fish at a rate of 2 pounds of feed per day per acre of pond. Once the fish begin taking the food, feed may be increased but should not exceed 10 pounds per acre per day. Do not feed more pellets than the fish will eat in 20 to 30 minutes. Be especially careful during warm weather since uneaten pellets will decompose and reduce the amount of oxygen in the water. It is not safe to feed trout when water temperature exceeds $65^{O}F$, unless water is flowing into and out of the pond. When trout are fed, water leaving the pond should come from the pond bottom.

HARVESTING FISH FROM THE POND

Fishing is an important tool for maintaining a balanced fish population. The rate and species of fish removed from the pond should be regulated. You should keep a record of all fish removed.

IMPORTANT: Licensing requirements, seasons, bag limits and other California angling regulations may apply to waters on private property in California, except ponds registered for aquaculture. Owners and invited guests do not need an angling license to fish ponds not hydrologically connected to any waterway of the state and not operated for profit.

Trout - Begin fishing when the trout are 6 to 8 inches long (about 6 to 10 months after stocking). If you fish these trout lightly, you should catch some 1- to 2- pound fish by the second year. Trout grow slowly after they reach this size and natural mortality increases. Plan to fish your pond heavily the second year and then restock with 4- to 5- inch or larger trout if fish from previous stockings remain in the pond.

Channel catfish - Channel catfish may be taken the first July or August after the initial stocking. Depending on the size and number stocked, the catfish will be about 3/4 pound by this time. Keep accurate records of the fish removed so that additional catfish can be added later if needed.

Sunfish and Bass - Do not fish sunfish (bass, redear and bluegill) before the second summer following stocking. The fish should have spawned by this time. Before harvesting fish, verify spawning success by inspecting the shallow areas of the pond. If no young bass and bluegill are visible, delay fishing until young fish are seen. The fish population should be approaching a balanced condition at this time. Bass should average about 1 pound and bluegill or redear 1/2 pound each.

The three most common causes of poor fishing in ponds stocked with a combination of bass and bluegill are: (1) overabundance of aquatic vegetation, especially submerged vegetation, (2) lack of adequate fishing pressure on the bluegill/redear sunfish populations, (3) removing too many largemouth bass over too short of a time period.

Do not return bluegill or redear sunfish to the water. This is probably one of the most frequent mistakes made in managing farm ponds. The panfish must be removed along with the predators, or they will overpopulate, stunt, prey on young largemouth bass, and compete with the young-of-the-year bass for food. Remove five pounds of forage fish (bluegill/redear sunfish) for every pound of bass.

Largemouth bass populations are easily overfished. When bass are depleted, bluegill and redear sunfish will overpopulate and stunt. The result is many small panfish and few small bass. As a general rule, you should harvest about 25 to 30 pounds of bass per surface acre per year and return all bass less than 11 inches long to the water. In a mature, well-managed pond, if numerous yearling bass less than 1/2 pound are being caught in the spring, reduce the bass population by increasing the harvest of these smaller fish.

Under fishing is also a common problem in farm pond management. This results in large numbers of small largemouth bass and a few very large (7 1/2 inch) bluegill and redear. Let others fish your pond, provided they follow your rules. Never allow anyone to use live minnows as bait. When the minnows escape, they become numerous, compete for food with bluegill, redear sunfish and small bass and eventually cause poor fishing.

The booklet, “Producing Fish and Wildlife from Kansas Ponds”, (Gabelhouse et al. 1982), presents five very interesting pond management options which include management techniques for either large bass (5 pounds plus) or large bluegill. The pond will only produce so many pounds of fish under a given condition, so if you choose to increase the pounds of one species, it will be at the expense of other species in the pond.

FERTILIZING THE POND

Pond fertility is a primary factor affecting the poundage of fish produced. By adding fertilizer to a pond, you can increase the pounds of fish it supports by as much as 4 to 5 times. Nutrients added to the pond increase amounts of microscopic plants (phytoplankton) which are the primary source of food for microscopic animals (zooplankton), aquatic insects and

small fish. It takes about 10 pounds of plankton to produce 1 pound of bluegill and about 10 pounds of bluegill to produce 1 pound of largemouth bass.

Another advantage of high fertility (and a good reason to fertilize a pond) is that dense phytoplankton blooms reduce the amount of sunlight reaching the bottom of the pond and prevent the growth of rooted aquatic plants. This method of controlling rooted aquatic plants is cheaper than herbicides, and increases food production.

Fertilize your pond in the spring when afternoon surface temperatures of the pond reach 65^{O}F. or higher. Plankton "blooms" will occur when water temperature reaches the low 70's. It is important to build up pond fertility quickly and early in the spring. If you fertilize too late in the season, you fail to get the full benefit of the fertilizer. Fertilization can be continued throughout the growing season to maintain a depth of visibility of 12 to 18 inches. Stop fertilizing about October 1, when most plant growth subsides. Never fertilize during the warm months, since this could reduce the oxygen level and result in a fish kill.

There are two types of fertilizer available: mineral and organic. Mineral fertilizers are best. Organic fertilizers such as cottonseed, manure and leaves, tend to encourage the growth of filamentous algae, which are not as desirable as other algae because they are unsightly, are more likely to cause oxygen depletion in the pond.

A satisfactory mineral fertilizer contains 8 pounds of nitrogen, 8 pounds of phosphate and 2 pounds of potash per 100 pounds of fertilizer. This is commonly referred to as 8-8-2. A stronger fertilizer, such as 16-16-4 to 20-20-5 may be used, however, use proportionally smaller amounts.

The amount of fertilizer required will vary from pond to pond depending on the natural fertility of the pond. Apply fertilizer at a rate of 40 pounds of 20-20-8 or 100 pounds of 8-8-2 per surface acre, but not more than 200 pounds of fertilizer during any one application.

The easiest way to apply the fertilizer is to slit open the bag and place the bag on a wooden platform in about 12 inches of water near the edge of the pond. You can also broadcast the fertilizer by hand from a boat. It is best not spread the fertilizer in water deeper than 4 feet. If less than 10% of the pond is 4 feet deep or less, it is usually not economically feasible to broadcast the fertilizer. The effects of fertilization should be visible in 3 to 7 days, when the pond develops a green or brown color.

Fertilize the pond three to six times at 10 day intervals. Once a fertilization program is started, it must be continued. Fertilizing the pond one time is a waste of money and may be a detriment to the fish population. As the plankton in the pond increases through fertilization, the total weight of fish the pond can produce also increases. Discontinuing fertilization may result in a drastic decline in the amount of plankton present. The result would be too little food for the number of fish and the fish population would decrease. Fertilization creates an artificial situation, and once started, it must be continued.

You can easily determine when to repeat fertilization. Nail a white disk to the bottom of a stick. Mark the stick 12 and 18 inches above the disk and slowly submerge the disk in the pond. The pond is fertile enough to feed 300 to 400 pounds of bass and bluegill per acre when the disk is no longer visible at about 12 inches below the water surface. If the disk is still visible when 18 inches deep, then the pond needs to be fertilized at the same rate as the initial application. Another method is to stick your arm into the water up to the elbow; if you can see your fingers, then fertilization is needed.

Care must be taken not to over fertilize. If the disk disappears at less than 12 inches, too much fertilizer has been added. This is usually not critical and is only a temporary condition. Watch the fish in the pond carefully for signs of stress and do not add additional fertilizer until the disk is visible at 18 inches. Discontinue fertilization when water temperatures fall below 65^{O}F. or exceed 72^{O}F.

Once you have a plankton bloom in your pond, you may want to experiment to determine if you can maintain it using less expensive fertilizers. During the summer months, a dense bloom of blue-green algae occurs naturally in many ponds. The blue-greens are able to use atmospheric nitrogen, so a fertilizer either low or lacking nitrogen might be substituted.

If after applying the right amount of fertilizer, a plankton bloom fails to occur, or after the bloom it can not be maintained, there are several explanations:

1. Soft Water - If the water is soft (less than 20 milligrams per liter total hardness) a plankton bloom often will not develop after fertilization. This can be corrected by adding agricultural limestone (calcium carbonate).
2. Excess Water Exchange - Most of the water must remain in the pond three to four weeks, following the addition of fertilizer, to provide the desired results. If water is released from the pond, it should be removed from the bottom (less fertile) water.
3. Muddy Water - Muddy water can reduce plankton blooms by shading out sunlight. If the water in the pond is muddy, it should be cleared (see section on clearing muddy water) before fertilization.
4. Rooted Aquatic Vegetation - Well established beds of rooted aquatic vegetation will use all or most of the nutrients added to the pond. Once the weeds are controlled, plankton blooms will help control vegetation by shading plants.

FISH POPULATION EVALUATION

One of the easiest ways to monitor the condition of the fish in the pond is to examine the catch. In a balanced population, bluegill should average 6 inches and largemouth bass 1 to 2 pounds. The presence of both young-of-the-year largemouth bass and bluegill indicates successful reproduction. However, if fishing becomes "poor", it is time to take a closer look at the fish populations in the pond. A summary of the status of fish populations evaluated from fishing records is presented in Table 3.

A lack of young bass and/or bluegill usually means a spawning failure the previous spring. Too many bluegills can interfere with successful largemouth bass reproduction and further complicate the out-of-balance condition. Largemouth bass are highly vulnerable to predation when less than 1 inch long. When panfish are overabundant, there is a high mortality rate for young bass. A reduction of the panfish population will usually be followed by the production of many young bass.

Table 3. Evaluating Fish Populations Based on Fishing Records[1/]

CATCH	STATUS OF FISHERY
1. Bluegills average 6-7 inches. Bass average 1 to 2 pounds (12-15 inches)	Balanced
2. Many small bluegills (less than 5 inches). Only a few bass caught, and most are 2 pounds or larger.	Bluegills overcrowded, resulting in poor survival of young bass.
3. Few bluegill caught, but those average 0.4 pounds (7.5 inches) or greater. Largemouth bass are less than one pound each.	Bass are overcrowded and causing a poor survival rate for young bluegills.
.Excessive numbers of undesirable fish (green sunfish, carp, bullheads)	Species have been introduced which are incompatible with the management of a bass-bluegill pond.

[1/] Modified from Brady, 1981.

A more accurate and informative means of evaluating the fish population in the pond is by periodic seining. **Note: Any use of a seine requires a permit from DFG (see page 2).** For the purpose of analyzing the status of the fish population, a 30 to 50-foot long seine, 6 to 8 feet deep and having 1/4 to 1/2 inch mesh is needed. If the pond has a muddy bottom and the lead line tends to roll, replace the lead with flat rocks or homemade cement weights. Make the weights using small paper plates as molds and placing small wire loops in the edge of the cement before it hardens. This will allow the bottom of the net to float over the muddy bottom and not roll-up. Another option is the use of a “mud-line” or unraveled hemp line, often referred to as a “many ends” line, on the bottom of the net. Pull the seine through the water moderately rapidly, being sure the lead or “many end” line remains in contact with the bottom of the pond. Be careful not to step in the muddy shallow area of the pond where the net will be pulled ashore. Foot prints made in the mud can provide an escape route for panicky fish as the lead line is pulled across the depression. Once the ends of the net reach shore, pull the ends all the way up on dry land. Pull in the lead line of the net, being careful not to lift the lead line from contact with the bottom of the pond. Bass greater than about 6-7 inches can usually

avoid the net or jump over the float line as they are crowded. Several people should hold the float line up in the air as the fish are crowded to prevent the larger fish from jumping over the float line. Be careful not to pull the lead line off the bottom. To evaluate the fish population in your pond, compare your catch with Table 4.

Table 4. Status of fish population Based on Sampling with a 50-foot seine[2/]

Contents of Seine	
1. Young bass and recently hatched bluegill are present. Medium-sized (4- to 5-inch) bluegills are present, but fewer than 20 are captured per seine haul.	Balanced population.
2. More than 20 medium-sized (4- to 5-inch) bluegills per seine haul. (Young bass and bluegill may be abundant or absent).	Overpopulation of bluegills.
3. No bluegills of any size in seine haul.	Shortage of bluegills
4. No young bass. Many recently hatched bluegills. Fewer than 20 medium-sized (4- to 5-inch) bluegills per seine haul.	Bass may be overcrowded or the young bass may have grown to a size where they can avoid the seine. If bass are overcrowded, angling should produce numerous 1/4- to ½- pound bass.
5. No young bass, few recently-hatched bluegills, and few medium-sized bluegills. Undesirable other species present.	Overcrowding by undesirable species.

[2/] Modified after Brady, 1981.

CONTROLLING AN OVERPOPULATION OF FISH

Bluegills - Indicators of overpopulation include:
1. Most of the bluegill or redear sunfish are of an intermediate size (3 to 5 inches).
2. Few largemouth bass are present, most of which are two pounds or larger.

Overpopulation and stunting of the forage species may be caused by several factors including:
1. Excessive aquatic vegetation in the pond - small forage fish are not available to the bass because they are afforded too much protection by the plants.
2. Over fishing the largemouth bass population.
3. Under fishing the bluegill/redear sunfish population.

Often it is a combination of all three factors that lead to an overpopulation of forage fish. To correct this condition, you must remove the bluegill. Cease bass fishing until the overpopulation of bluegills is reversed. Also, it may be desirable to stock adult bass (1/2 to 1 pound each) at a rate of about 10 to 15 per surface acre in an unfertilized pond; 20 to 30 bass per surface acre in a fertilized pond.

Largemouth Bass - An overpopulated, stunted bass population can best be detected in the spring when all the bass are at least one year old. If virtually all the bass are 4 inches long or smaller, the population is probably stunted. Indicators of largemouth bass overpopulation are:
(a) The largemouth bass caught are all less than 1 pound and are "skinny".
(b) The bluegills are 1/2 pound and larger (too large for the bass to eat).
An overpopulation an/or stunting of bass may be caused by several factors including:
(a) Not enough bass being harvested.
(b) Too few bluegill or redear sunfish were stocked initially or they are failing to reproduce and the bass population does not have an adequate food supply.
The easiest way to control an overpopulation of largemouth bass is by increasing the take of bass. This is an effective method of thinning the bass population providing recreation at the same time. It may take two to three years to bring the population back into balance. If forage fish are scarce, stock adult bluegill or redear sunfish (7 to 8 inches long). These fish will be too large to be eaten by the bass. The large panfish will spawn in the spring and produce a supply of forage.

Undesired Fish Species - While evaluating the population of fish in the pond, take note of any species present other than those you stocked. The additional fish compete for food with the stocked fish.

Try to determine the source of introduction of the unwanted fish. Be sure live minnows are not used for bait. Check the water supply to the pond and the outlet to be sure the fish are not entering there. It may be necessary to screen one or both of them (see Farmers' Bulletin No. 2244).

Eliminating undesirable species from a pond usually require that you remove all of the fish in a pond and restock with the desired species. Eradication of fish from a pond can be done by draining the pond, or by drawing down the pond and treating with a fish toxicant (see section below on "other Methods of Controlling Fish Populations"). **Note: A permit is required (form FG 793) for a private pond owner who is not a registered aquaculturist to seine fish, drain a pond to destroy fish, or to use a fish toxicant (Section 226.5, Title 14, CCR).**

Other Methods of Controlling Fish Populations - When fish are stunted or undesired fish are present in your pond, one or more of the following methods may also be used to correct the problem:

A. Seining or Trapping - Using a seine or trap allows the selective removal of specific sizes or species of fish. Physical removal of small redear sunfish or bluegill can be done with a 40'

x 6' seine with 1/2" mesh (stretch). The seine is pulled through the shallow area of the pond. Destroy all 2- to 5-inch bluegill or redear sunfish, and return both the larger and the smaller ones to the pond. Repeat this operation every week until the sunfish longer than 5 inches have grown to a desirable size. The seining should be done in the late summer or early fall.

B. Management Drawdown - Management drawdown is probably the easiest and most effective method for preventing an overpopulation of forage fish. It should be done annually, in conjunction with fall drawdown for aquatic weed control.

Draw the pond down to 1/2 of its normal surface area in July or August to force the small forage fish out from the protection of any aquatic vegetation or cover and into open water. This makes them available to the predators. Hold the pond at this level for a minimum of three months. When the pond is refilled during winter or early spring, both bluegill and bass should grow at a better rate.

C. Destroying Spawning Beds - You can destroy bluegill spawning beds periodically by raking over the beds or wading out and trampling through the nests.

D. Fish Toxicants - Fish toxicants can be used to thin excessive numbers of bluegill. Rotenone based pesticides are a restricted pesticide and must be applied by a State certified pesticide applicator.

The fish toxicant is applied to the shallow areas of the pond in late summer or early fall. This technique will kill primarily bluegill and not significantly affect the bass. These chemicals, however, will kill bass. The reason bass are not significantly affected is because they generally are not in the shallow portion of the pond at this time of the year. A limited chemical treatment is probably the least desirable method for thinning bluegill populations and should be used only as a last resort.

E. Predators - You can add adult largemouth bass to control an overpopulation of stunted bluegill or redear sunfish, although this is expensive.

F. Fish Heavy and Often - The lack of adequate fishing pressure is probably the most common cause of an unbalanced fish population... Be sure, however, to remove more bluegill than bass. Bluegill caught from a properly managed pond can provide an excellent angling experience as well as good eating.

FISH KILLS AND THEIR PREVENTION

Most fish kills occur in the summer. The most common cause is lack of oxygen. This occurs when the water is warm, there are large amounts of weeds or algae present and the pond is overcrowded with fish. There are several additional reasons fish kills are more likely to occur in the summer months. These include:

1. The water holds less oxygen at higher temperatures.

2. Fish require more oxygen at higher temperatures, because of a higher metabolic rate.

3. Bacterial decomposition of algae, aquatic weeds, or nutrients in the pond uses much oxygen and occurs more rapidly at higher temperatures.

4. Algae blooms often occur with increased sunlight and warmer water.

5. At night, a process in plants called respiration (which uses oxygen) occurs. Oxygen shortages are most acute at dawn and the situation is worsened by cloudy weather.

For the above reasons, it is important that a close watch be kept on the pond during the warmer months so that potential problems are recognized early. When fish start to die, it may be too late to take action. A pond with shallow areas that are choked with weeds is a good candidate for a fish kill. When large weed beds occur, you can expect fish kills due to oxygen depletion when aquatic vegetation begins to die during fall and early winter. If the inflowing water contains organic pollutants, such as runoff from fertilized farm land, feed lots or sewage, there is a good chance the pond will run out of oxygen. If a potentially dangerous situation is developing, take action before the fish start to die. Stop feeding fish during periods of low oxygen.

There are several ways to increase the amount of oxygen. Adding fresh water or aerated well water (sprayed or splashed) is probably the best. If possible, drain water from the bottom of the pond as new water is added. Using portable aerators and recirculating pump is another technique that is sometimes effective. Be sure to pump water from the top 2 feet of the pond. The water at the bottom of the pond may have no oxygen or contain high concentrations of carbon dioxide, hydrogen sulfide and/or ammonia - all of which are toxic to fish. Bringing this water to the surface with a recirculation pump can cause a fish kill.

An outboard motor on a stand can be used to aerate the water in small ponds. Check the water being discharged from the bottom drain pipe to see if there is a bad (rotten egg) odor. If so, the bottom water contains toxic material and you should not use an outboard motor since mixing bottom water will probably result in a fish kill.

Finally, you can apply 50 to 100 pounds of superphosphate fertilizer per acre broadcasted over the surface of the pond is an emergency measure, however, it must be used with great care. The superphosphate acts as a chemical buffer against the toxic effects of the carbon dioxide and ammonia. It also stimulates the phytoplankton to produce more oxygen.

Take special care when using pesticides around a pond. Rain or wind can carry the chemical into the pond and cause a fish kill. Fish also die of natural causes, especially in the spring of the year. This is due to old age or stress associated with spawning.

CONTROL OF AQUATIC PLANTS

Large amounts of aquatic plants create many problems. Rooted plants use up nutrients, interfere with angling, contribute little to the growth of fish, may give fish an unpleasant taste, and sometimes contribute to the overpopulation of forage fish species. As plants die and decompose, they use up oxygen, causing fish kills.

A permanent solution may require, draining the pond and deepening the weed bed area. If deepen the pond is not feasible, you may have to periodically remove the aquatic plants physically or control them with chemicals.

It is important that the problem plants be correctly identified so that an appropriate control technique can be selected. Consult with your local County Agricultural Commissioner's office or the Agricultural Extension Service of the University of California. Aquatic plants are classified into one of four categories based on how they grow in the pond:

1. Emergent plants - These are plants that are rooted to the pond substrate and extend out of the water. Common examples are cattails, lotus, waterlilly and smartweed.
2. Submerged plants - These plants are usually rooted to the bottom of the pond and grow towards the surface of the water. Some have leaves that float while others are entirely under water. Examples are pondweed, coontail, milfoil, Elodia and naiad.
3. Floating plants - This group of plants are not rooted to the bottom of the pond and are free to float about the pond. Common examples are duckweed and water hyacinth.
4. Phytoplankton - Phytoplankton are primitive microscopic plants that lack true leaves or flowers. They often make the water look soupy green or brown.

Controlling aquatic plants begins with careful pond design. It is much easier and less expensive to prevent aquatic weeds from starting than it is to try to control them. A properly designed pond has very little or no rooted vegetation in it. There are three methods for controlling established aquatic plants in a farm pond:

1. Mechanical - Cutting weeds and removing the cuttings from the pond is a satisfactory method if used when the weeds first appear. Remove well established rooted weeds by dragging a heavy cable across the bottom of the pond. Mechanical cutting devices that fit onto the front of a boat are also available commercially. These techniques, however, are expensive, and cutting can result in the spread of certain plant species.

2. Fall Drawdown - This is an easy, safe and economical tool for controlling rooted aquatic plants. Further, it can coincide with fall drawdown for control of forage fish. Reduce the surface area of the pond to about 1/2 the area when full. This exposes aquatic plants to drying

effects of sun and wind. It is best to scrape the exposed bottom before refilling in the winter. If the pond is completely choked, drain it completely, let it dry out, and disc the entire pond bottom. You may want to apply a herbicide at this time.

3. Weed-eating Fishes- Grass carp (*Ctenopharyngodon idella*) are very effective for the control of some species of nuisance aquatic vegetation. However, because they also have the potential to cause environmental damage if used improperly, their use is strictly regulated in California. State law as of January, 1998, allows the use of triploid (sterile) grass carp only in Kern, Los Angeles, Ventura, San Diego, Orange, Santa Barbara, Riverside, San Bernardino and Imperial counties. Information about Triploid Grass Carp Permits may be obtained from the DFG San Diego Field Office (see page 2).

Sacramento blackfish--filter feeders--may have some value in reducing phytoplankton, but their use is restricted in most of the State outside the central valley.

Tilapia (several species) are sometimes advertised and sold for aquatic weed control, but are prohibited in California north of Los Angeles County. Their value for control of nuisance aquatic vegetation is questionable, and they are not recommended anywhere.

4. Chemical Control - The advantage of using chemicals is that they are applied quickly with a minimum amount of labor and fast results. The disadvantages are that chemical treatments are expensive, repeat applications may be required, and there are dangers associated with their toxicity. A good reference for chemical control of unwanted aquatic plants is Farmer's Bulletin 2181 "Waterweed Control on Farms and Ranches".

Consult with your County Agricultural Commissioner's Office or the Agricultural Extension Service of the University of California. They can properly identify the problem plant and make recommendations as to which chemicals to use. It is important to use the appropriate herbicide to control the problem plant. It is also important that you READ AND FOLLOW THE DIRECTIONS ON THE LABEL. BE CERTAIN THAT CHEMICAL AND DOSAGES TO BE USED ARE NOT TOXIC TO FISH.
In most cases, treated water cannot be used for irrigation or domestic purposes for some time. Some herbicides should not be applied to stock or domestic water supplies. Herbicides are most effective when weeds are young and growing rapidly. If a large portion of the pond contains aquatic plants, do not treat more than 1/3 of the pond at a time. Large amounts of decomposing plant material can cause oxygen depletion in the pond.

FISH DISEASES

Fish can have a variety of diseases and parasites. Infections are most likely when fish are stressed by crowding, poor nutrition, high temperature and low oxygen. The most critical period is usually in the spring, as fish are generally in poor condition after winter. Another period of stress is during spawning.

Fish diseases are difficult to diagnose and expensive to treat. Fortunately, they sometimes disappear without special treatment. If you decide to treat a disease, begin as early as possible. It is best to have a fish disease diagnosed by a laboratory and tested for resistance to various antibiotics. Many common antibiotics used in the livestock and poultry industry can be purchased at feed stores.

Most wild fish populations have parasites. Parasites are not usually fatal, if the fish are in good condition. Most parasites do not affect humans who consume the fish, if the fish is thoroughly cooked. Fish in farm ponds can be kept healthy by maintaining good water quality and preventing overcrowding.

The following guide "What's Bugging that Fish" was prepared for the Nebraska Game and Parks Commission, but is applicable to farm ponds in California. If you need assistance in identifying a fish disease, contact the nearest DFG office (Appendix A). For information on the safety of consuming an infected fish, call your local public health agency.

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