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Raising Fresh Fish in Your Home Waters

by: Brenda Bortz, Jack Ruttle, and Marc Podems

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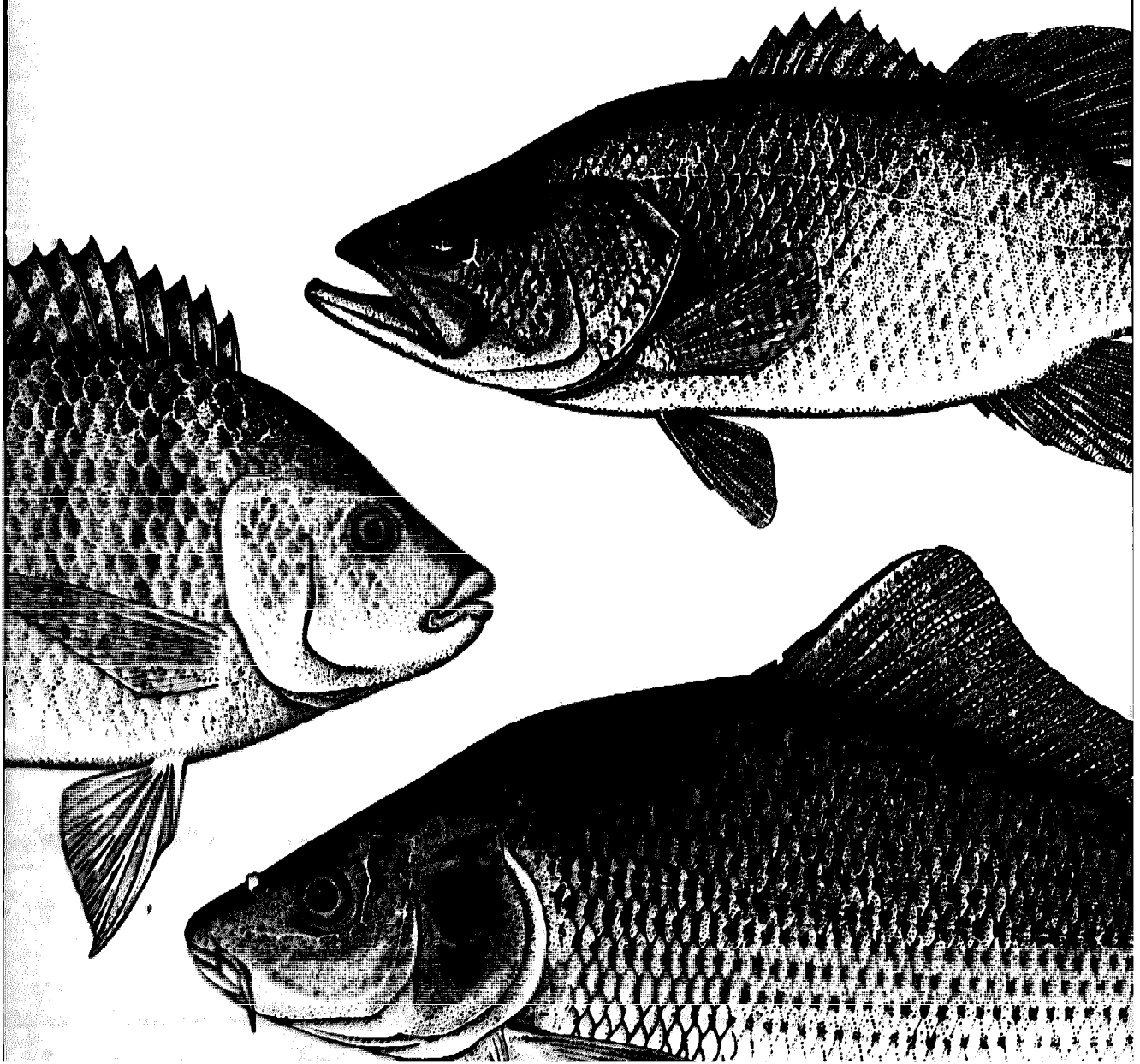
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RAISING FRESH FISH IN YOUR HOME WATERS.

Brenda Bortz

Jack Ruttle

Marc Podems



WHY BE A FISH FARMER

Not many people think of fish as a potential crop. But that's just what carp, catfish, trout, and bass are. Till recently, fish has been a wild food in this country—hunted and caught in open waters, then taken home or to market. But all that is changing. Wild stock is being depleted by overfishing and contaminated by industry, and the cost of fresh and frozen fish keeps climbing.

Luckily, there's a happy ending to this fish story. In other lands people have been stocking, breeding, feeding, and harvesting fish for centuries. And more recently, American scientists have begun to domesticate desirable native species like trout and catfish.

Putting this knowhow to work, commercial farms now raise huge numbers of fish much like agribusiness grows cattle and chickens. At the other extreme, country people still enjoy the farm pond—stocked for recreation and occasional meals, but not truly cultured.

Now, though, there's a middle ground. It's a backyard fish culture, a method that lets you grow fish like a garden crop. Like the foods you grow in soil, the fish in your water garden will need regular attention and feeding or fertilization. Cared for in this way, a pond the size of a modest swimming pool can supply enough fish for a family. And a typical farm pond can yield enough to have plenty left over for sale.

Backyard fish vs. barnyard animals For many people, a crop of fish can also turn out to be the best choice in livestock. Highly digestible and low in fat, fish are rich in protein. And their protein comes closer to meeting the body's needs than meat protein does.

Since fish are cold blooded, they

don't burn food just to keep warm. Which means they are one of the most energy efficient livestock around. And unlike barnyard animals, they're absolutely quiet and odorless. Since there's no pen or manure pile to offend the neighbors, raising fish is an almost invisible way to grow some of your own meat in town or in the suburbs.

CREATING A BALANCED AQUATIC HABITAT

Just like organic gardening, fish culture involves working with a whole living system. The water that will be your growth medium is much more than the equivalent of nourishing garden soil. It's also the atmosphere that provides life-giving oxygen. Many forces interact in this total environment, and as a beginner in aquaculture you'll want to know about those that directly affect fish.



Swimming silently in small, gem-like ponds, fish are welcome neighbors just about anywhere.

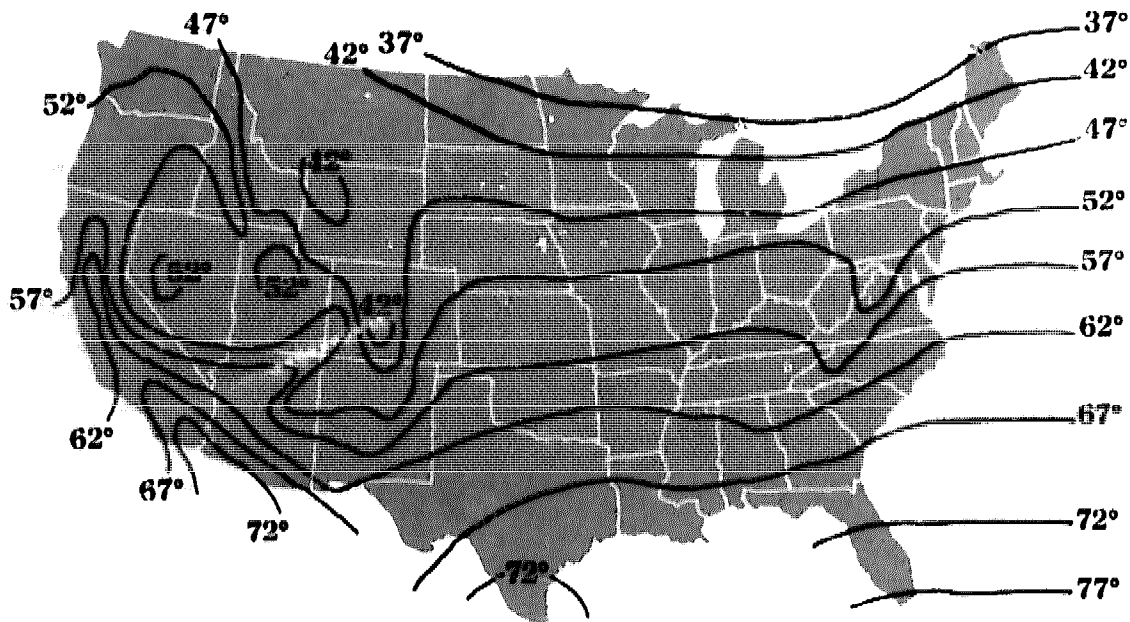


Figure 1. Approximate temperature of groundwater in the United States at depths of 30 to 60 feet.

Clean water is a must in fish culture, and fortunately the water in most farm ponds, rural streams, springs, and wells is naturally clean. Keep in mind, though, that the kind of water best for fish farming is far from crystal clear. A healthy bloom of algae is vital to a high-yielding system, and these microscopic pea green to ruddy brown plants can make water look soupy.

If you suspect, however, that your water source contains man-made pollutants, you should have it analyzed. Your county Agricultural Extension Agent or your state's Fish and Game Commission people can tell you how to do this.

You must also be alert to natural sources of trouble. Even ordinary soil aided by erosion or the rooting of ducks can foul water too much for the fishes' liking. In heavily stocked ponds, droppings from the fish themselves can get thick enough to clog their gills with tiny particles. Unconsumed bits of food can do the same thing. Happily, these problems aren't

common—especially when other organisms in the pond are doing their work.

Temperature is crucial. Because fish are cold blooded animals, they can be grown only when and where the climate and water supply cooperate to provide water temperatures within their growing range. Moreover, each kind of fish favors a specific temperature range. Some flourish only in cold waters. Others won't grow and reproduce well unless the water is very warm.

The water temperature you will have to work with can be closely tied to the temperature of your water source. If your source water flows fast from an underground supply, its temperature will be roughly the same as that of the groundwater in your area. (See Fig. 1.) On the other hand, if your source water trickles from below ground rather than gushes, it will be warmed somewhat as it passes slowly through the ground below the frost line.

Air temperature also greatly influences pond water temperatures. As a rule of thumb, water temperature in a pond tends to approach the average air temperature. To get a good idea of what that is, scan the table of average monthly temperatures for your area. (Get this from the nearest U.S. Weather Bureau. Or look it up at the library in *The Climatic Atlas of the United States* or in a good almanac or encyclopedia.)

Since pond water responds slowly to changes in air temperature, the water temperature in your pond will be slightly behind the temperature rise in spring and the drop in fall. For the same reason, pond water is usually cooler than the hottest air during the day and warmer than the coolest air at night.

The deeper the pond, the less the change in water temperature between night and day. In small ponds, however, water temperature can change a fair amount on a summer's day and will follow seasonal changes in air temperature more closely. This means that to be on the safe side in choosing fish, you should know both average monthly air temperatures and the approximate highest temperature your pond water is apt to reach in the summer. (Fish Commission people can help you with that estimate.)

As all this suggests, each region has a growing season for fish. Though pond size, source-water temperature, and climate affect the length of this season, it will correspond roughly to the frost-free period for gardening in your area. How close it comes you'll have to determine from experience.

Growing season aside, the natural life that establishes itself in your pond will go on to some extent all year round. Though any fish will be dormant in winter, algae will grow a lit-

tle. Water temperature will control the rate of all activity at any time. A very rough rule is that the speed of life processes in fish and algae doubles with each 15°F rise in temperature.

Oxygen is vital to high yields in fish culture. Unlike air, water has very little ability to hold oxygen. In 5 parts of air, 1 part is oxygen. But in 1 million parts of water, only 10 are oxygen. And so the availability of oxygen is often what puts a limit on how much life a pond can support.

Some of the oxygen used up by pond life is replaced from the air. Cooler water will hold more oxygen than warm water. So when oxygen levels fall below the norm at a given temperature, oxygen molecules move into spaces in the water from the air above it. At 50°F water will hold 11.3 ppm (parts per million) of oxygen. At 60°F the saturation point is 9.6 ppm, at 70°F — 9 ppm, at 80°F — 8 ppm, and at 90°F — 7.4 ppm.

Now it's much easier for relatively shallow ponds of 3 to 5 feet in depth to maintain these full oxygen levels naturally. That's because shallow ponds have a large surface area compared to volume, so a larger portion of water is in contact with the air.

Wind also can help greatly. First, by making ripples or waves, it magnifies the surface area of a pond. Second, wind steadily brings fresh air into contact with the water, thus stepping up the rate of oxygen exchange from rich to depleted areas. (Larger ponds take advantage of wind best, because they give moving air more chance to kick up waves.)

In addition to air, another source charges water with oxygen. It's the process of photosynthesis. Whenever oxygen is used up in the water by bacteria breaking down organic matter — or by higher forms of animal and plant life — carbon dioxide

is produced. This abundant gas, together with sunlight and water, is used by plants to make their food via photosynthesis. And so for each molecule of carbon dioxide plants take in, they return a molecule of oxygen to the water.

The most important plants contributing oxygen to water are algae, and under ideal conditions algae and still or moving air will keep a pond supplied. But the amount of oxygen a cultivated pond will need depends on how much fish you plan to grow in it. Theoretically at least, your goal in fish farming ought to be first, to find the amount of fish that the oxygen in your water can support, and beyond that, to find ways to make the algae population healthier so it can donate more oxygen.

But all this is easier said than done, for many factors make it difficult to

count on a fixed amount of oxygen from algae. Each of the many types makes oxygen at a different rate. Too, it's impossible to control which species will get into your pond, or to tell how to create the conditions that desirable types will like. Moreover, for no apparent reason the dominant species in your pond may change slowly as the season progresses.

Another variable is the weather, for the rate of photosynthesis depends directly on the sun. Typically, the oxygen levels in your pond will change even on a clear day. By mid-morning the algae will be hard at work, and there will be plenty of oxygen. By early afternoon the dissolved oxygen will be at maximum concentration. Your pond should stay saturated with oxygen nearly to sunset. When the temperatures are right at those times, you can be sure the fish



A relatively shallow pond fully exposed to sun and wind has a good chance of maintaining high oxygen levels.

are feeding active, and growing well, even though you can't see them in the pea soup-green water.

At sunset, natural oxygen production stops, but oxygen use by all pond life goes on. By the next morning, oxygen levels will be low but tolerable for the fish, and at sunrise the water again will begin to be charged by the algae.

On a cloudy day, of course, the algae will generate much less oxygen, and there will be much less to tide over the pond population at night. Cool weather also will slow photosynthesis slightly.

The food chain is another major force at work in the aquatic environment. As the term implies, all life in the water is linked together. And every plant and animal is destined to be eaten by the being on the next higher level of the chain. Interestingly, a creature's source of food rather than its size is what fixes its position on the food chain. Because algae make their food from gas, light, and water, they are at the first level. And because some very large fish feed directly on algae and tiny animals called zooplankton, these big fish are themselves quite low on the food chain.

In a farmed pond, it's these plankton feeders that will grow best with the least attention to supplementing the natural foods in the pond. That's because like grass in a pasture, cropped-off algae can grow back rapidly, whereas amphibians and other forms of higher life eaten by nonplankton feeders are replaced much more slowly.

Pond fertility is determined not just by oxygen and temperature levels, but by the amounts of mineral nutrients available to support algal growth. If your system contains a well-balanced supply of nitrogen, potassium, phosphorus, and other minerals in the form of fertilizer

supplied by nature or by you, there will be a rich bloom of algae. And the algal population will expand until all free nutrients are absorbed in balanced amounts.

But there can be an excess of nutrients. For example, algal growth can get so thick that the surface layer keeps light from algae below and starves it. When this happens, decay organisms thrive on the dead algae, increasing until they exhaust the oxygen supply. Then more dieback occurs, other organisms are favored, and the cycle can continue.

Working with the food chain is a big must in raising fish in quantity. In a mature pond left on its own, life will reach a balanced state. Changes in dominant species and in oxygen levels will be gradual. But that is not the case in fish culture.

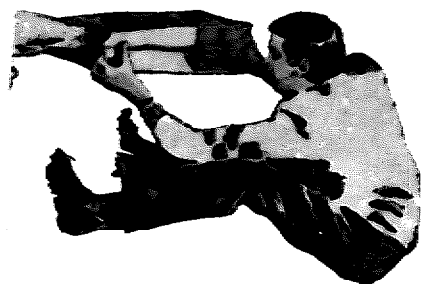
Man-made ponds are frequently very young ecosystems, with most of their life concentrated in just a few types of organisms. Furthermore inputs like large quantities of fish and feed have immediate effects on the natural food chain and on the demand for oxygen. Still, any healthy pond requires a balance. You might say that fostering and maintaining a man-made balance is the science of fish farming.

To practice this science successfully, you have to regulate all amounts of fish, feed, fertilizer, and oxygen. The idea is to keep them in right relation to each other and all else in the pond. Here are some tips gleaned from experience that might make your job a little easier.

Feeding and Fertilizing: Since some fish can thrive on fast-growing plankton and may need no extra feed, it might seem ideal to stock these species and encourage lush algae growth by adding fertilizer. Oxygen production would be high, and the fish would keep the algae from overgrowing. Realistically, though, most



FERTILIZER



LARGEMOUTH BASS



BLUEGILLS

PLANKTON



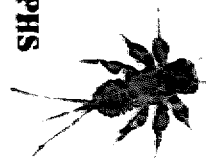
CADDIS FLY LARVAE



DRAGON FLY NYMPHS



MAY FLY NYMPHS



WORMS

FROGS



CRAYFISH





readily available species mostly eat organisms higher on the food chain and will quickly deplete your pond's natural foods. For all of these fish, you'll need commercial feed blends — readily available from livestock feed suppliers. Actually, to get bumper crops of *any* fish, supplementing natural foods is nearly always essential.

The next point to remember is that feeding at productive rates stimulates rapid growth and higher waste levels. Since more oxygen will be needed by the fast-growing fish and to ready the system to absorb their wastes, you might need to fertilize with manure. The life-giving nutrients thus provided will multiply algae, zooplankton, and bacteria. These will feed on the detritus and provide more oxygen and feed for the fish.

To determine if you do need to add fertilizer, there is a simple test you can make. If your algae are adequate, they should be so thick that you can't see any deeper than 15 to 18 inches into the water. To find out if this is so, mark the inches off on a yard-long stick and nail a tin can lid to the zero end. Then push the lid straight down into the water until it just vanishes from sight. Next pull the stick out and check the high water mark.

If the lid is visible past 18 inches you should fertilize with manure. For each acre of pond surface, use 500 pounds of fertilizer. (At that rate a 225-square-foot pond — that's 15 feet by 15 feet — would require 2½ pounds.) Put the weighed manure in burlap bags, and place them in the water anchored to poles. If the weather is warm and moderately sunny, a healthy bloom of algae should grow in 2 weeks.

Check with your dipstick regularly. Add more manure if needed, but be careful not to overdo it or you'll have to cope with dieback and stagnation.

Floating and sinking pellets sized for various fish are available from supply dealers.

Manuring will be most successful in ponds where warm water fish will grow. In large ponds with water temperatures between 50°F and 60°F, you may have trouble getting a thick bloom of algae even if you add much manure. But then the trout and other cold water species you would grow there prefer cooler water anyway.

Aerating: You can supplement oxygen contributed by air and algae by paying attention to the type of water enclosure you choose, to its design, and to mechanical devices that help oxygen exchange. For instance, by impounding a section of stream with a dam or netlike fence, you can make a fish farm that is always being supplied with freshly oxygenated water. (Tumbling, rolling fast-moving water breaks into waves and splashes that take more oxygen from the air.)

If you do farm a stream or brook, however, you won't easily reap the benefits of fertilization, for the manure will be washed far downstream. The same thing can happen to your fish food unless you devise a stationary feeder that can resist the current. Remember that your wasted feed or fertilizer is pollution for your neighbor downstream. And that adding these materials without being sure of their effects and destination is illegal as well as wasteful.

A better system would be to tap a portion of the stream water via a pipe or ditch. You might route it through a small pond built nearby, then back to the stream. Though the same potential problems exist, this kind of setup is more easily controlled. You can regulate the amount of water and rate of flow. And when storms swell the stream with water, mud, and debris, you can disconnect your enclosure.

Using the power of the stream you can increase oxygen by creating a small waterfall or spillway over rocks. This way you can charge a

small amount of incoming water as it enters a relatively large pool. This water also will bring in some oxygen-making algae and some fish foods. If the enclosure is much larger than the stream and much of the water remains within it for a week or so, you might encourage more algae with low level fertilization.

To take full advantage of aeration by wind, make the surface area larger rather than deepen the water when you want to increase your pond's volume. Also, avoid locations where trees or buildings will keep wind or sun from the surface. The water surface shouldn't lie too far below the banks either — especially in small ponds.

In some parts of the country mechanical aerators may be necessary if you're stocking and feeding a pond for higher production. The amount of supplementary aeration you need will depend upon your pond's natural oxygen levels — linked, of course, to wind and photosynthesis — and on the quantity of fish you've stocked per cubic foot of water.

Though mechanical aerating easily removes any doubts about adequate oxygen, you'd best start small, for the cost of the aerator and the power to run it easily can become one of your biggest expenses in fish culture. In very small ponds try bubbling aerators — the kind often used in aquarium tanks. They are cheap and use little power. In a 400-square-foot pond, try two with four aeration tubes on each. In a larger pond, you might have to use surface aerators, which churn or spray the water. Figure on 1 horsepower of aerator for every surface acre of water.

Even if your stocking rates are modest, you may find it necessary to

boost your pond's oxygen during "the dog days" of summer. The reason is that in sunny and very hot weather algae begin to grow much more vigorously than usual. Then when cloudy and perhaps slightly cooler weather sets in for a few days, oxygen production drops suddenly. Since the very high oxygen demand of the expanded population can't be met, some pond life will die.

This is the time when fish kills are most common, and in some places they occur regularly once or twice a season. The problem is worse at night and is heightened by decay of the dead algae. In a situation like this, a 1/20 h.p. aerator may supply enough oxygen to support several hundred pounds of fish, using just



A pond can be filled from a neighboring stream, as this one is. If extra oxygen is needed, use a lift pump.

four kilowatts of power a day. At 3 cents a kilowatt hour, 12 cents a day is a small price to pay for tiding your fish through. Another remedy if oxygen levels become perilously low is to harvest some fish. This will quickly reduce the demand on the oxygen source.

PUTTING IN A FISH POND

One of the missions of the Soil Conservation Service is to help people build ponds that will last. SCS staffers will gladly help you assess possible sites and soil and provide literature and advice on pond design. They should also know of experienced local builders if your project is too big for you to do yourself.

Many states have laws that regu-

late the use of water and the design and construction of ponds. Some require that plans for a dam be approved by a state agency before a construction permit is granted. So before you start building a pond, find out what laws apply locally.

Prior to talking with anyone at the Soil Conservation Service, you'll want to give your situation some thought. Here are some major aspects to consider and some techniques you might find useful.

Selecting a site: To fill your pond and replenish water lost by evaporation and seepage, locate it near a dependable source of good water. Possible sources are springs, wells, streams, and the runoff from rain. Runoff is the least dependable, and in



Through forceful mixing action a surface aerator speeds the migration of oxygen molecules from air to water.

areas of light rainfall a pond filled by runoff must be oversized to carry the fish through drought.

The soil at your site must be able to hold water, or you'll have to seal the pond artificially. Clay and silty clay are good for ponds, and sandy clay sometimes holds water adequately. But areas with rock outcroppings, limestone, shale ledges, or gravel require sealing.

For a good preliminary soil test, wet a handful with just enough water to dampen. Then squeeze. If the soil holds its shape after you open your hand, it's probably good for a pond.

There are two basic types of ponds. Impounding ponds are best suited to hilly areas. They use dams or banks of earth to block off the opening between two banks or slopes and are usually easier to build because less earth must be moved. Most of the reservoir created is above the natural ground level, though the size or depth can be increased by excavation.

Excavated ponds are pits dug below the pond surface, usually where land is fairly flat. There is no definite rule for choosing between the two types. But if the land surrounding your site slopes more than 4 percent, an impounding pond is likely to work.

To determine the slope, drive a stake into your site at the highest point you expect the water to reach. Then drive another stake in about 10 feet downhill. Using a carpenter's level, tie some string or rope level between the two stakes. Measure the height of the string from ground level on each stake. Subtracting the smaller height from the greater, divide by 10. Your answer is the percentage of slope. (See Figure 2.)

Designing the pond: Generally, build your pond as large as you can, for big ponds are easier to manage, though small ponds are cheaper to

build. Allow at least 10 cubic feet of space for every pound of fish you expect to harvest. To get 100 pounds, you'll need a pond with at least 35 feet of surface and a depth of 3 feet.

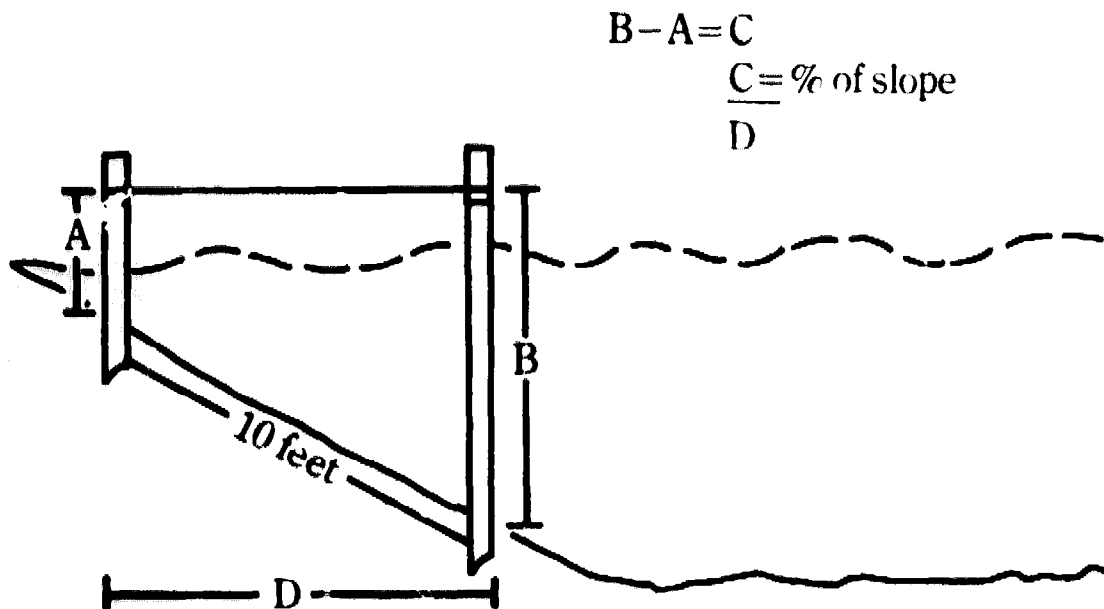
By the way, waters less than a yard deep do not make efficient use of surface area. Too, weeds grow best in shallow water. In addition to increasing oxygen demand, they provide young fish with protection from predators. This increases the chances for overpopulation and stunting. On the other hand, water at a depth of over 15 feet contains little oxygen since algae don't grow well over 10 feet down. The most productive depth is between 3 and 10 feet, and the most convenient shape for harvesting with nets is a rectangle.

Constructing the pond: After clearing the site, outline the perimeter with stakes and string. Excavate by hand, backhoe, or bulldozer, making the bottom slope from 2 to 5 percent to improve drainage. Install a series of pipes and trenches to carry off excess water from heavy rain safely and to drain the pond for harvest. (If your pond is small, you can use a pump or syphon.)

(To connect a stream to your pond for a ready supply of water, install a tube or dig a channel. Or use a sump pump. Filter the stream water before it enters the pond with a good material such as saran screen, style MS-904 (manufactured by National Filter Media Corporation, 1717 Dixwell Ave., New Haven, Conn. 06514).

If your water flow is light, make the screen into a "sock" and place it over the end of the inlet pipe. For a heavier flow, use a rigid filter or floating box. (Saran filters, which are fine enough to stop all but the smallest of wild fry, must be cleaned periodically.)

Your next step is to build the dikes and dams. Make them wide enough to withstand the pressure of the pond



water. A wall should be shaped so that the base is at least twice as wide as its total height. The top should be at least as wide as its total height and at least 20 inches higher than the water. And the walls should be tapered gradually from top to base. When you finish, plant grass on them.

Sealing the pond: Before sealing, thoroughly compact the sides and bottom with special equipment. For small ponds, you can make a tamping tool by attaching a square flat board to a pole.

For a simple, low cost sealant for a small pond, try gley, or biologic plastic. Developed for sealing ponds in the U.S.S.R., gley has been used successfully by the New Alchemy Institute in Costa Rica. Making it is a lot like composting. First, cover the bottom and sides of the pond thoroughly with pig manure. Then completely cover the manure with

freshly-cut grass, green leaves, and flattened cardboard cartons. Then add a layer of soil and firmly tamp down all three layers. Wait 3 weeks before filling the pond.

You can also seal small ponds with polyvinyl sheets, sold in many sizes by swimming pool dealers. To determine the length of sheeting you need, add twice the maximum depth of the pool to the length. For the width, add twice the maximum depth to the width. Then add 1½ feet all around to allow plenty of overlap.

Dig a shallow 10- to 12-inch-wide trench around the perimeter of the pond. Put the liner in the pond, pulling it moderately taut, and evenly cover it with 6 inches of soil. Place the edges in the trench and cover them with soil to hold them down and protect them from deteriorating in sunlight.



For large ponds, bentonite is the most commonly used sealant. It is available in 50-pound bags through some ceramic dealers. You'll need 8 pounds for each square foot if your soil is very sandy and 2 to 4 pounds for soil with more clay. If possible, consult your Extension Agent for an evaluation of your soil porosity and bentonite needs.

But if you have to establish application rates for yourself, a distributor of the clay suggests that you punch holes in the bottom of a container, put in a couple inches of your subsoil and compact it lightly. Then add a small, measured amount of bentonite and work it lightly into the surface. Add water to see if this amount seals. If it doesn't, continue adding measured amounts of clay until seepage stops. Then estimate your pond's requirements by using the same ratio of surface area to quantity of bentonite that worked in the small container. (To be on the safe side, add 15 percent more bentonite.)

STOCKING YOUR SYSTEM

The best times to stock fish are early spring and late fall. Then cooler temperatures reduce the rate of metabolism so the fish move more slowly and need less oxygen. They are easier to handle and there is less chance that any will die.

Consult your state's Fish Commission for lists of local commercial hatcheries. It's even possible that the Fish Commission or Soil Conservation Service in your state will provide fish free from state hatcheries.

If a species is readily available locally, it may be well adapted to your growing conditions. Certainly it will be the cheapest to buy. If by chance you can't find the fish you want nearby, you'll find many sources for all the species described here listed in the *Commercial Fish Farmers Buyers' Guide* (available for \$2.50 from Subscription Service, P.O. Box 4922, Manchester NH 03105). You may order fish from these dealers via air express. Be sure to learn the exact time the fish will leave the hatchery and make arrangements to meet them at the airport no matter what time they arrive.

Keep in mind that the fish you choose must be suited to your climate. In selecting from the catalog that follows, you should (1) estimate the highest water temperature in your pond in the summer, (2) identify the species that can tolerate that temperature, (3) estimate the average water temperature that will prevail over most of your growing season, (4) narrow your list to fish that do well at that temperature, and (5) determine the length of your growing seasons for the fish you've chosen so you can decide what size to stock.

Yearling fish, which are 3 to 8 inches long, have a better chance than smaller fingerlings to survive and reach edible size in one season. Though growing time and stocking rates vary with each species and the climate, a good rule of thumb is that at least 10 cubic feet of water is necessary to grow each pound of fish and that yearlings will take at least 6 months to mature. You can also assume that 40 percent of each pound you harvest will be lost when you clean the fish.

Bentonite makes a good sealer for large ponds.

A CATALOG OF FISH



THE CARP FAMILY

Common Carp (*Cyprinus carpio*). A special variety developed for hardiness and productivity is called Israeli (or Mirror) Carp.

Grass Carp or White Amur (*Ctenopharyngodon idella*)

Bighead Carp (*Aristichthys nobilis*)

Silver Carp (*Hypophthalmichthys molitrix*)

Oxygen: Can tolerate as few as 0.5 ppm. Grow best with 4 ppm and more.

Temperature: Can withstand great fluctuations. Best growth in water between 80°-85°F, but do well anywhere between 70°-90°F. Below 50°F they don't feed.

Ammonia: Can tolerate as much as 1.2 ppm.

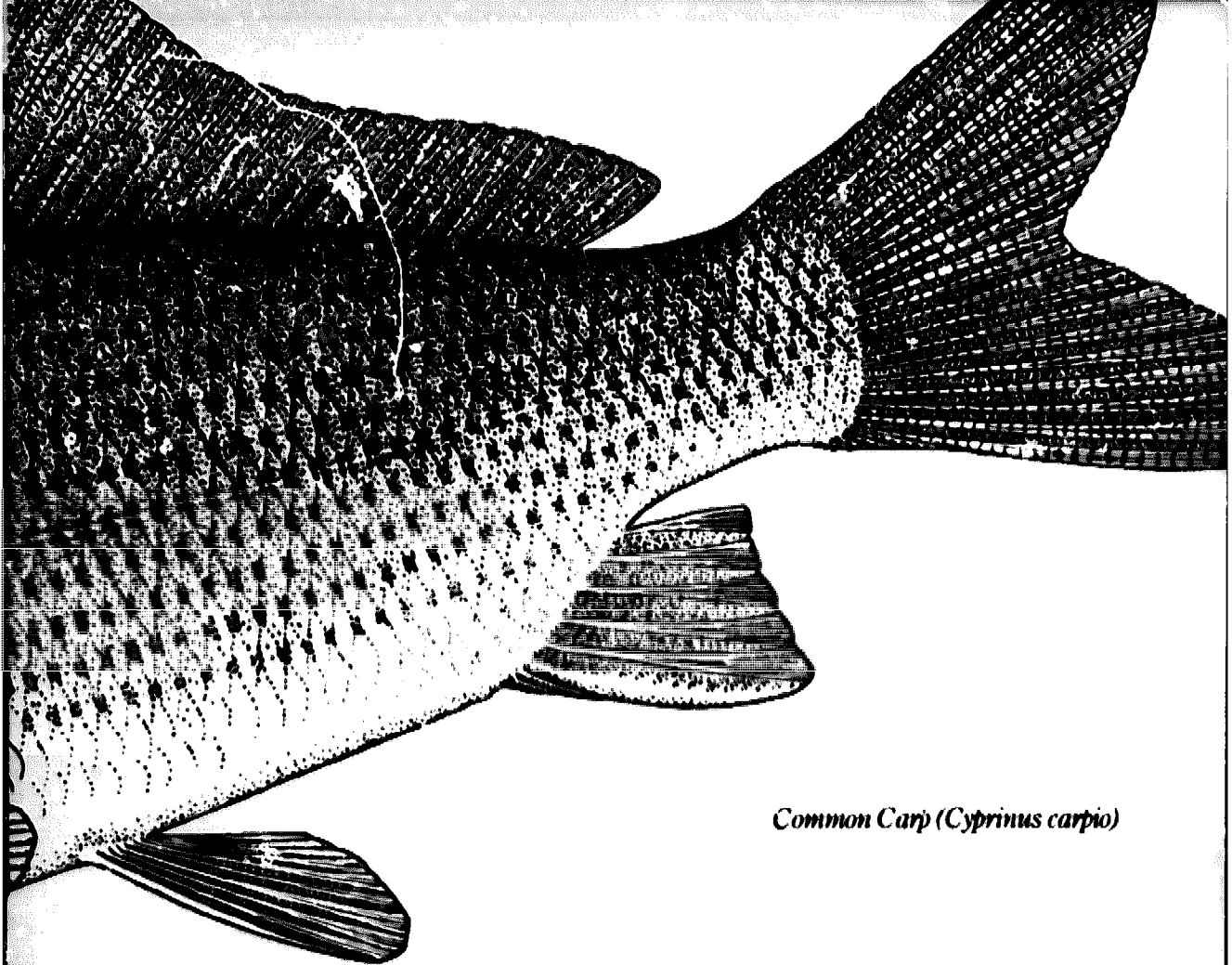
pH: Slightly alkaline (7.5) is best, but stand as much as 9.

Hardness: Usually takes care of itself. At least 50 ppm of calcium and magnesium ions is recommended.

Turbidity: Can tolerate high level of suspended solids.

Hardiness: All very hardy.

Strongest cultivated fish w/ resisting disease, adjusting to low oxygen levels.



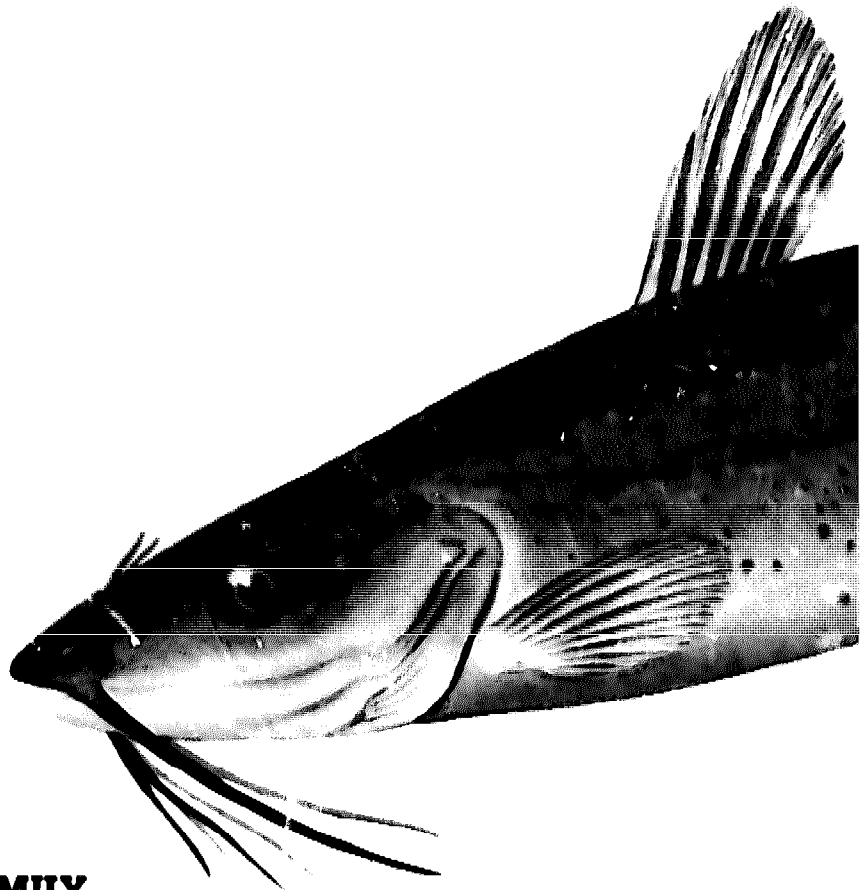
Common Carp (Cyprinus carpio)

Feeds: All eat low on food chain and forage well. Common carp eat pond bottom organisms and partially digested feed in detritus, including fecal matter of other fish. Grass carp feed on aquatic plants, including pond scum formed by filamentous algae. They will readily eat garden vegetable wastes, grass clippings, weeds, and fresh cut hay. Both common and grass carp also eat supplemental feeds like potatoes, soybeans, cottonseed meal, and oats. Bighead carp feed on zooplankton and silver carp eat phytoplankton. No information available on feed utilization.

Growth rate: Efficient growers. With adequate food, 1-inch fish reach edible size of 1-2 pounds in 7-9 months. 6-8 inch fish may mature in only 5 months.

Stocking: Can be combined with other fish to use more of pond's natural food supply and increase total harvest. Won't compete much with other species for food. Can help make pond more productive by controlling plankton growth. Combining four kinds of carp makes one of most productive low energy systems yet tested, yielding up to 3000 pounds per surface acre. Each specie also can be raised alone. For harvest in one season, stock 6-8 inch fish, no more than 500 per surface acre. With longer time to harvest, stock up to 4000 1-2 inch fish.

Availability: Easiest to obtain from hatcheries in South. Wild strains of common carp can be netted from lakes and rivers throughout country. Other species illegal in many states, but not in Arkansas and Mississippi.



THE CATFISH FAMILY

Channel Catfish (*Ictalurus punctatus*)

Brown Bullhead Catfish (*I. nebulosus*)

Black Bullhead Catfish (*I. melas*)

Yellow Bullhead Catfish (*I. natalis*)

Oxygen: Grow well at more than 4 ppm. At less than that, may not eat, thus weakening resistance to diseases and parasites.

Temperature: Grow most efficiently between 70°–90°F. Below 60°F growth stops.

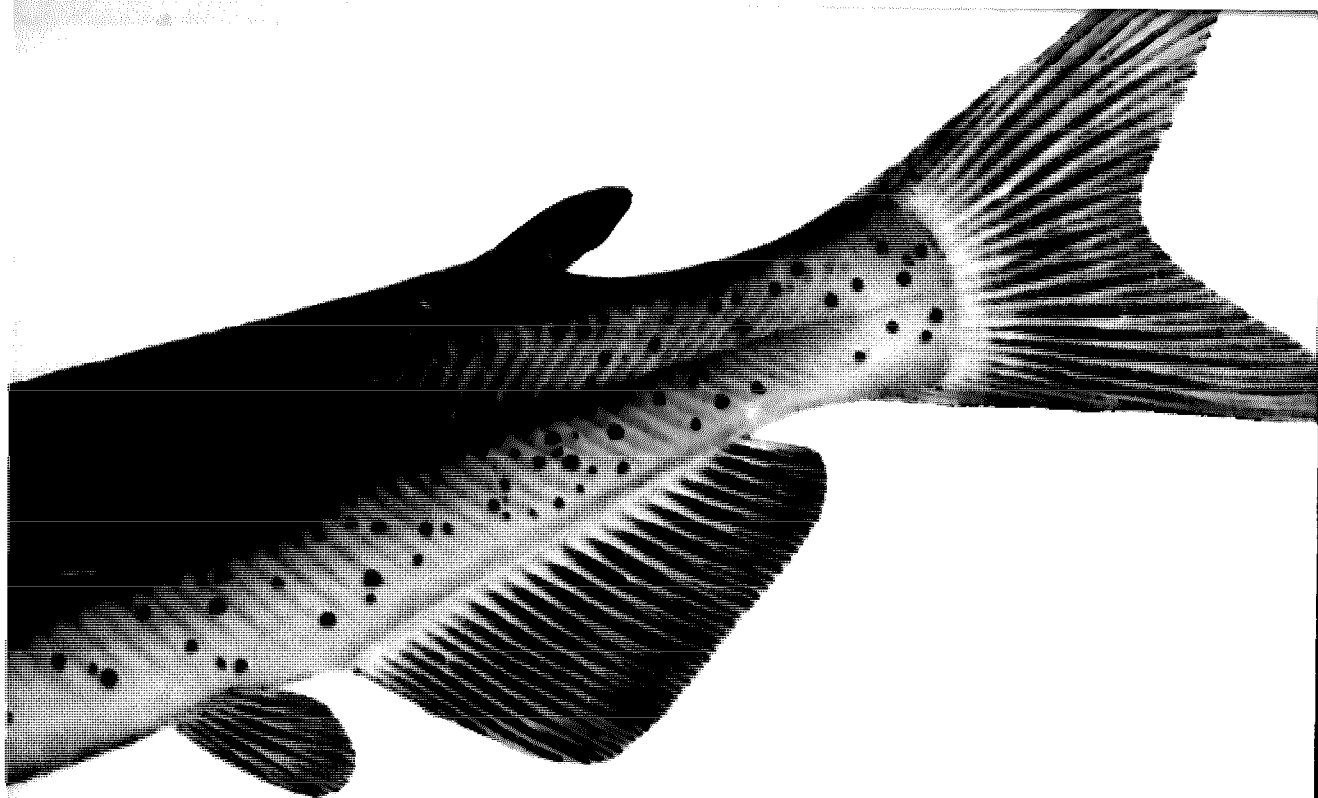
Ammonia: Keep below 1 ppm. 2 ppm can be lethal.

pH: Slightly alkaline (7.5) is best. Can stand up to 9.

Hardness: At least 50 ppm of calcium and magnesium ions recommended.

Turbidity: Tolerate high level of suspended solids from natural and artificial sources. Like common carp, spend much time in muddy water on pond bottom.

Hardiness: Can contract bacterial infections, viruses, or parasitic diseases if oxygen, ammonia, and temperature levels not maintained. Have normal mortality rate of 7–13 percent when conditions ideal.



Channel Catfish (Ictalurus punctatus)

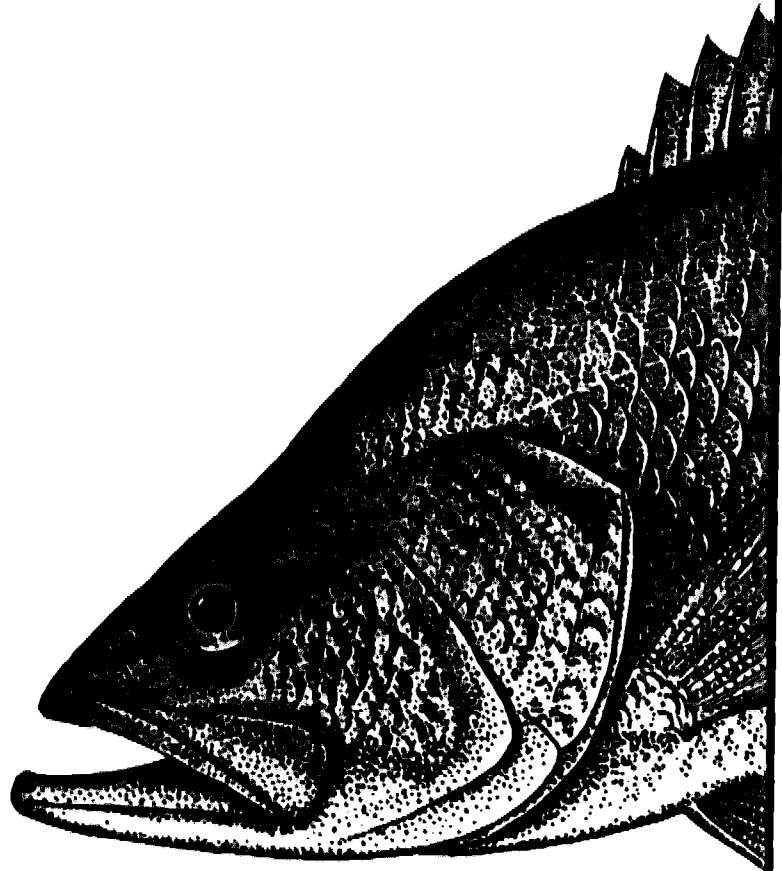
Feeds: Natural diet includes aquatic insects, crayfish, bluegills and other small fish, frogs, and some filamentous algae. For rapid growth, supplement with commercial pelleted catfish feeds. Will also grow on kitchen-waste blends if protein content is about 30 percent and fat levels kept low.

Feed utilization: May use 1–3 pounds of feed to produce 1 pound of meat. In intensive culture may convert feed as efficiently as 2 or 1½ pounds feed to 1 pound fish. Require more feed to gain weight when larger than 1½ pounds.

Growth rate: Can reach edible 1-pound size in 6 months if fed regularly.

Stocking: Will compete for limited food supply with other species that eat insects, amphibians, or small fish. Some catfish species tend to be bottom feeders so might compete little with species that feed nearer the surface. When prolific fish like bluegill are grown with catfish, young will provide extra food for catfish. For edible fish in one season, stock about 2000 6-inch fish per surface acre. For longer growing periods stock 1–2 inch fingerlings at 5,000 per surface acre. If stocking with bass and bluegills, use 100–200 catfish per surface acre. They must be the same size as the bass or the larger fish will eat smaller.

Availability: Can be purchased in most states in South and in a few in North.



THE SUNFISH FAMILY

Largemouth Bass (*Micropterus salmoides*)

Bluegill (*Lepomis macrochirus*)

Hybrid Sunfish (male *L. macrochirus* crossed with female green sunfish, *L. cyanellus*)

Oxygen: can tolerate no fewer than 2.5–3 ppm. Best growth at 5–8 ppm.

Temperature: Optimum is between 73°–77°F. Above 80°F and below 68°F growth declines significantly.

Ammonia: No more than 1 ppm.

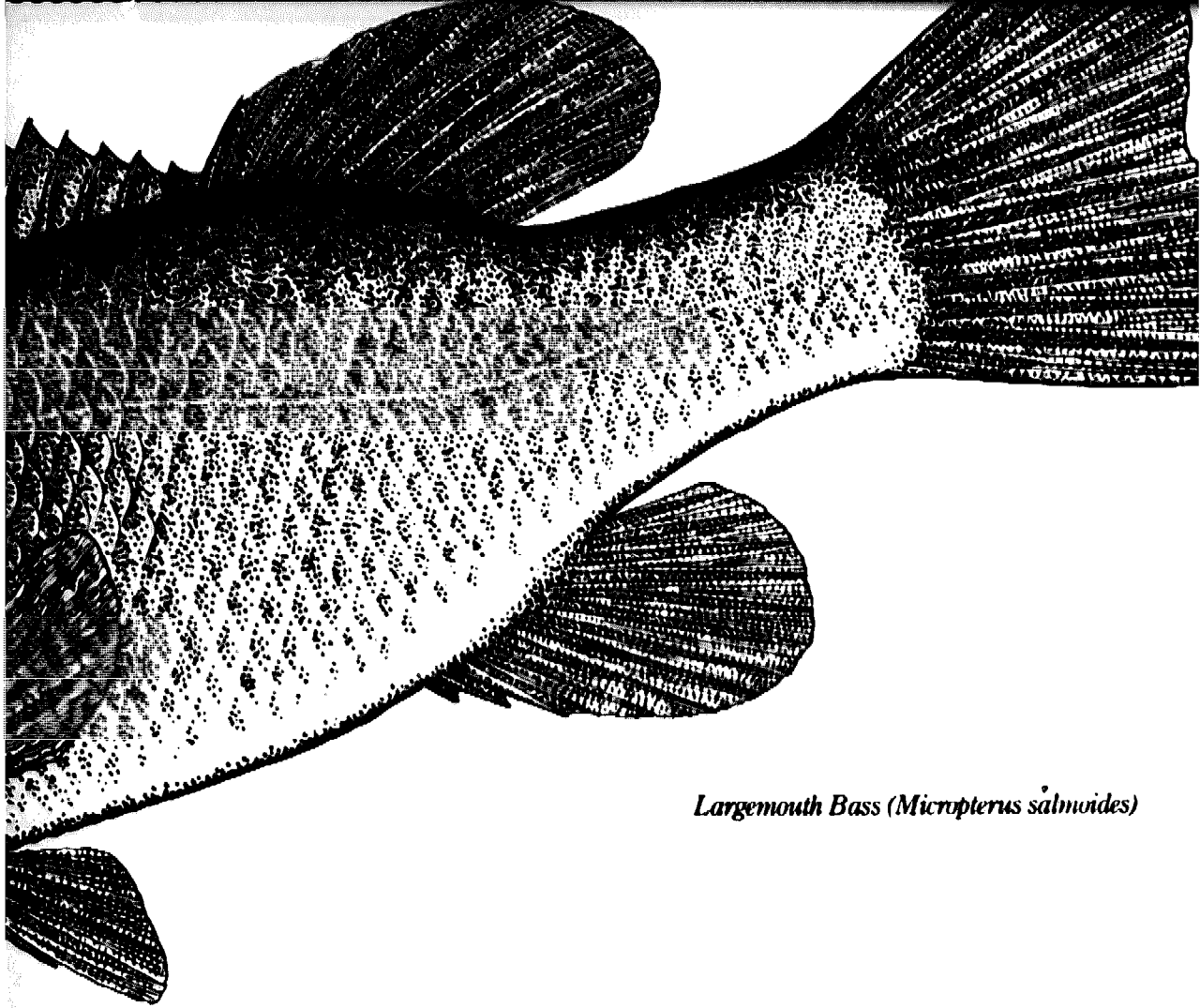
pH: Slightly alkaline (7.5) is best. Can take up to 9.

Hardness: At least 50 ppm of calcium and magnesium ions recommended.

Turbidity: Should have clear water. Especially important because they eat live food and must be able to see it. They also reproduce only when water is relatively clear.

Hardiness: Fairly hardy within limits of good water quality. But require relatively high levels of oxygen for active feeding and prefer narrow temperature range.

Feeds: Chiefly feed on invertebrates like insect larvae, water fleas, adult insects, algae, freshwater shrimp, small crayfish, and snails. Also eat young amphibians and small fish. In summer may turn to plants because of lack of animal foods. Bluegills also eat pelleted chows and food scraps. Bass must be trained to eat pelleted feeds. No information available on feed utilization.



Largemouth Bass (Micropterus salmoides)

Growth rate: May reach eating size of 1 pound in 6–9 months if supplemental feed given. Otherwise can take up to 6 years.

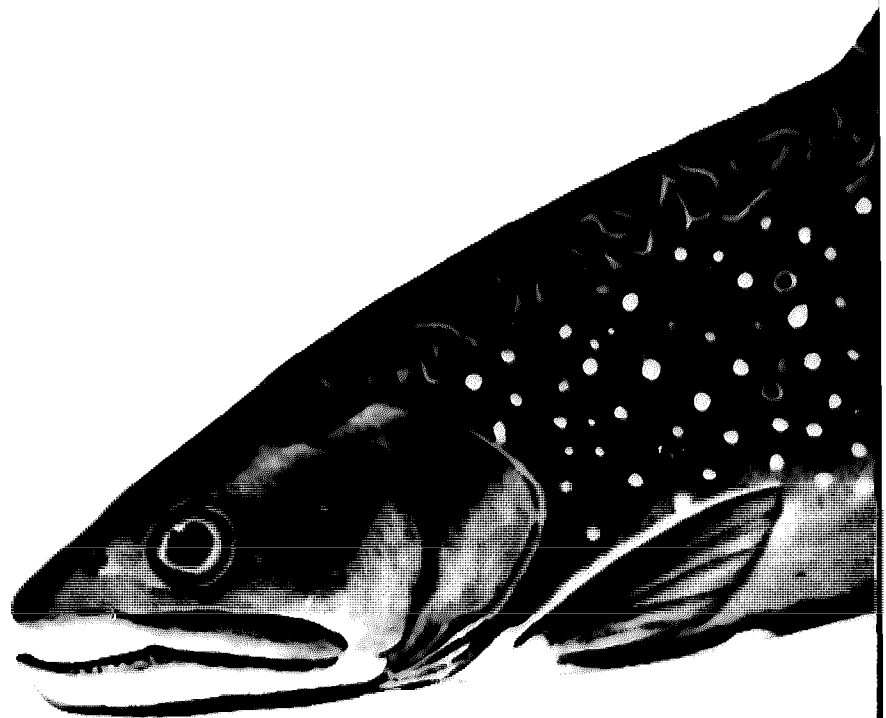
Stocking: Bluegills reproduce so rapidly that often growers get weight of fish planned for, but all the fish are too tiny to clean and cook. One solution: stock hybrid sunfish, which do not reproduce well. Or stock bluegills with larger fish that will feed on extra fry.

The bass-with-bluegill combination is popular. But be sure the pond will maintain temperatures at which the bass feed, or the bluegills will over-

populate and the bass will be too sluggish to chase down the fry. Also, don't harvest too many bass, lest you interrupt reproduction and reduce the number of predators needed to keep bluegills in check. Do harvest the bluegills fairly heavily.

Recommended stocking rates are 100 bass to 800–1000 bluegills per surface acre. (These rates may be low since they are based on untended pond culture.) As you harvest both species by fishing, maintain this 8 or 10 to 1 weight ratio. If stocking only hybrid sunfish, put in 1000–2000 5-inch fish per surface acre when feeding to harvest in one season. For longer time to harvest, stock same number of 1-inch fish.

Availability: Hatcheries in almost all states raise some kind of sunfish.



THE TROUT FAMILY

Brook Trout (*Salvelinus fontinalis*)

Brown Trout (*Salmo trutta*)

Rainbow Trout (*Salmo gairdneri*)

Oxygen: At least 5 ppm for good growth. Growth declines greatly if level below 5 ppm.

Temperature: 50°–60°F is OK, but 58°–60°F is best. Severely stressed above 70°F.

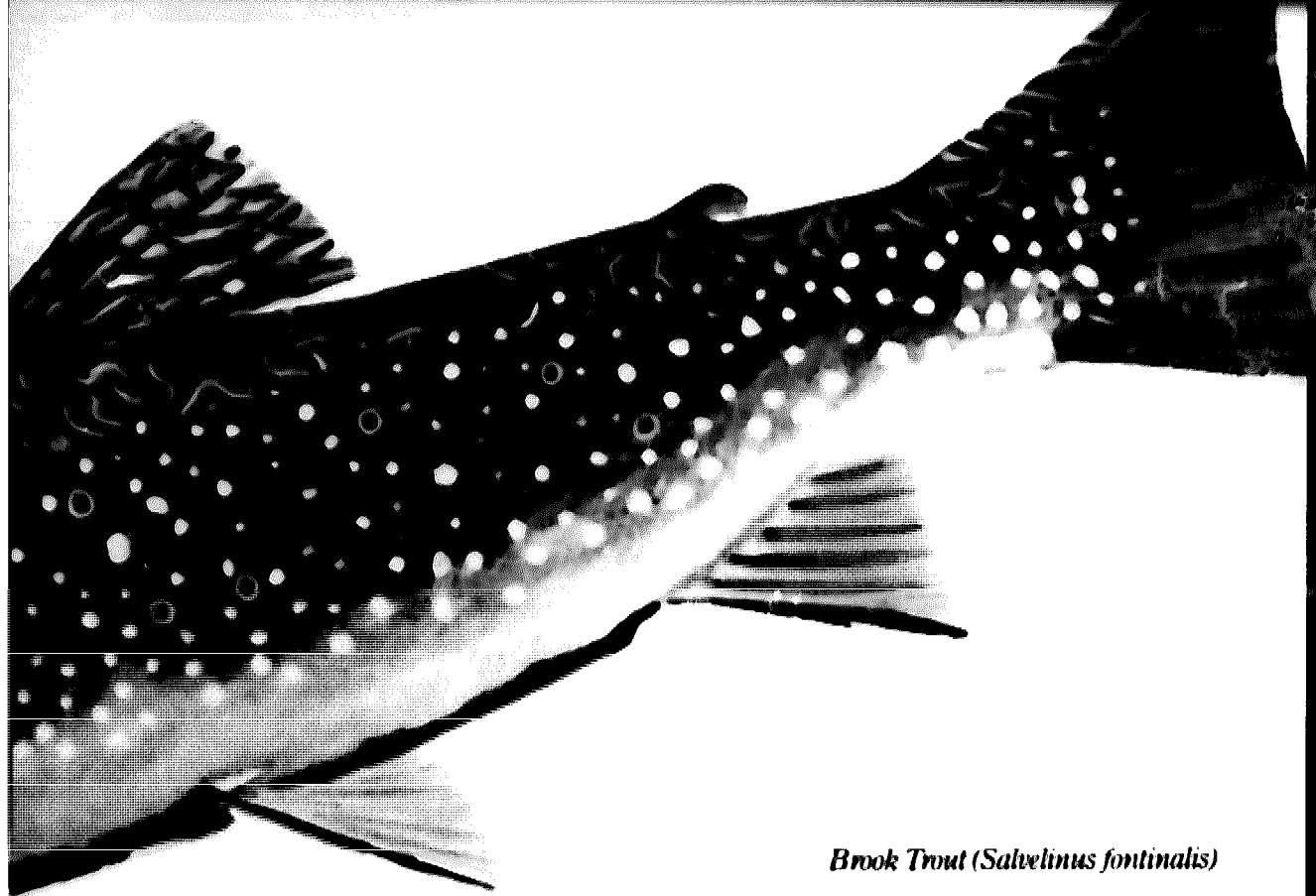
Ammonia: Over .7ppm is harmful.

pH: Can live in water from 6 to 8.

Hardness: Hard water (50–250 ppm calcium and magnesium ions) produces trout more economically than soft water.

Turbidity: Must have clear water to feed and breathe easily.

Hardiness: More susceptible to diseases and gill and liver tissue damage than most warm water species. If ideal conditions provided, death rate still from 2–13 percent.



Brook Trout (Salvelinus fontinalis)

Feeds: Eat high on the chain. Mostly live foods. Natural feeds include insects, larger crustaceans, snails and leeches, and some plankton. For fast growth when stocked densely, need high protein pelleted trout chow supplement (35 percent protein for fish over 3 inches, up to 45 percent for smaller fish). Will eat 1–12 percent of body weight depending on their size and water temperature.

Will overfeed, which makes for fatty livers and less hardy fish. In general, lower the feeding rate as they get larger and/or as the water temperature goes down.

Feed utilization: Need about 2 pounds of feed to produce 1 pound of meat. About 1/3 of total feed must be protein.

Growth rate: Yearlings given extra food may reach 1-pound eating size in 6 months. Without supplemental feed, will take 3–4 years.

Stocking: Usually not compatible with other species because of extremely high demand for oxygen and feed. Usually raised in flowing water. Stocked lightest of all species listed here. A surface acre will grow only a few hundred pounds of mature trout. To harvest in one season, stock no more than 2000 yearlings per acre. **Availability:** Grown by most hatcheries in northern half of U.S.

THE TILAPIA FAMILY

Java Tilapia (*Tilapia mossambica*)

Blue Tilapia (*T. aurea*)

Nile Tilapia (*T. nilotica*)

Tilapia are one of the most important food fishes throughout the world. At least 14 different species have been raised in both small and large ponds. Their popularity stems from the fact that they are hardy, easy to breed, rapid growers, and good tasting.

Since they are tropical fish, in all but the warmest regions of the U.S., tilapia have to be brought in for the winter and perhaps kept in a heated pond. Because they reproduce prolifically, it is quite possible to stock a few and end up with a pondful of tiny fish. If they survive the winter and reproduce, their rapid spreading can threaten other fish populations. Many states have outlawed them because of this.

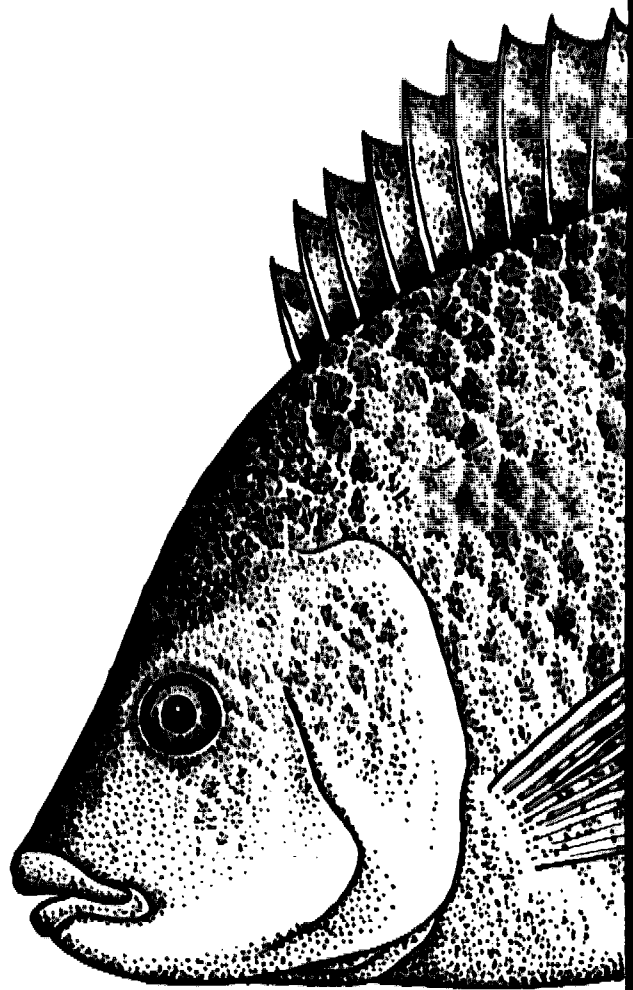
Oxygen: Can survive as few as 2ppm, partly because of unique ability to breathe oxygen from the air.

Temperature: Thrive in water from 64°-90°F. From 61°-50°F can survive but are lethargic. Below 50° most die.

Ammonia: Will tolerate a very high level, surviving in ponds with large amounts of organic matter.

Hardiness: Highly resistant to both diseases and parasites, and thrive within a fairly wide range of water quality factors.

Feeds: Some prefer large plants (garden wastes or grass clippings) while others like blue tilapia are adapted to feed on plankton. To make an artificial blend for blue tilapia, try mill flour sweepings and finely ground grain. A good homemade mixture is



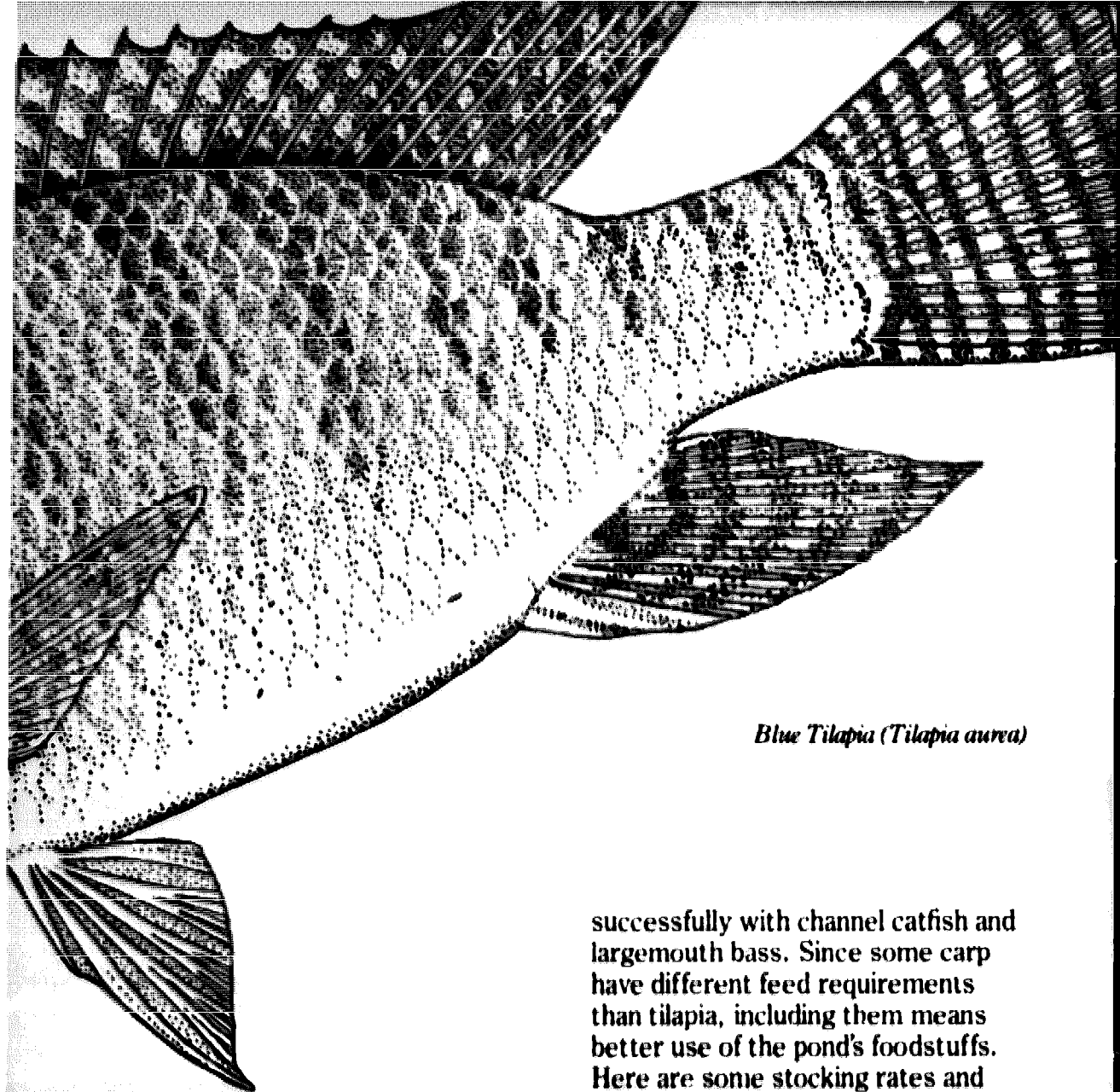
35 percent coffee pulp, 24 percent corn, 20 percent molasses, 10 percent bran, 10 percent cottonseed meal, and 1 percent urea. They also take pelleted feeds.

Java tilapia feed mainly on plankton but do eat all kinds of plants and vegetable feeds such as soybean or grain meal. If there is no plant food, they will accept animal food.

Nile tilapia reportedly feed on plankton, higher plants, and animal food.

Feed utilization: Blue tilapia consume less than their weight in pelleted feeds in growing to eating size. The rest of that weight comes from natural feeds. No information is available on other two species.

Growth rate: Varies greatly with stocking densities, frequency of reproduction, and available food. Fingerlings should reach eating size of at least 1/3 pound in 1 year of growing time if sexes raised together, but can grow to this size in as little as 4



Blue Tilapia (Tilapia aurea)

months. Under ideal conditions java tilapia may reach nearly 1 pound in one year. In salt water, may grow to 1 pound in 8 months. Try to obtain all males: they grow two to three times faster than females.

Stocking: Easiest to manage when grown with larger predators which will feed actively on tilapia young. Since tilapia tolerate such a wide range of water quality, be sure the predator chosen will be vigorous over most of the tilapia's growing season. If you overstock, all fish in pond will be crowded and stunted. For monoculture it's possible to get sterile hybrids or stock of all one sex so that reproduction is impossible.

Java and Nile tilapia can be raised

successfully with channel catfish and largemouth bass. Since some carp have different feed requirements than tilapia, including them means better use of the pond's foodstuffs. Here are some stocking rates and combinations of fingerlings per surface acre for polycultures yielding edible fish in one season: 1000 tilapia, 500 channel catfish, and 100 largemouth bass OR 1000 Java tilapia, 1000 Nile tilapia, and 200 largemouth bass OR 600 tilapia, 1200 common carp, 506 silver carp, 150 grass carp, and 60 largemouth bass.

For monoculture, stock from 2000-8000 fingerlings per surface acre, depending on intensity of supplemental feeding, aeration, and periodic harvesting. Fish will be edible in one season.

Availability: Most commonly raised by commercial dealers in Alabama, Arkansas, California, Idaho, and Oklahoma.

CARING FOR YOUR FISH

Before they come you'll want to make some preparations. For instance, when you order your fish, you should also order your fish chow at a farm supply store. A variety of chows are available for all kinds of fish, and there are floating or sinking pellets sized for fish of different lengths. But don't buy too much feed at one time since the nutritive value starts to decline after 3 months.

While you wait for your fish, you

might want to build a feeder. This device will let you monitor food intake. It also allows you to observe your fish and perhaps net them for an occasional check or harvest.

Here are instructions for a feeder that holds both floating and sinking feeds. Using 4 1x3x12" pieces of wood, put together a square inner frame. Then use 2 1x3x26" pieces of wood and 2 1x3x36" pieces to build a rectangular outer frame.



You can attach the inner frame of a homemade feeder to the end of the outer frame with good-sized loops of nylon string.

After painting both frames for durability, staple a 34x44" piece of screening onto the outer frame so it forms a concave catch basin. Next, hinge the inner frame to the inside of a narrow end of the outer frame.

Tying a 5-foot length of heavy nylon string to the opposite end of the inside frame, attach a small float to the other end of the string so you can remove the feeder from the pond easily.

Finally, place a stone in the end of the catch basin which has the float. The rock should be just heavy enough to sink the catch basin so it's at a 45° angle to the surface. Sinking feeds placed in the floating inner frame will drop onto the catch basin. Floating feeds will stay in the upper frame.

Since fish are sold by numbers of sized individuals and not by weight, you will also need some sort of bathroom scale or heavy-duty hanging meat scale to figure out feeding rates and monitor growth. A dip net and

large buckets also would be useful. You might also want to make provisions for a supplementary aeration system. To locate suppliers for such fish care musts, check with the Fish Commission. Or consult the very complete *Commercial Fish Farmers Buyers' Guide*.

About 6 weeks or so before you get your fish, you also will want to order some simple water testing materials. Use them and an outdoor thermometer to start checking water quality at least 2 weeks before you stock the pond.

To take temperature readings, tie the thermometer to a wooden float so it hangs about a foot below the float in 3 feet of water. For a good reading, keep it in the water for several minutes, then retrieve and read it rapidly. Record all readings regularly in a notebook along with other observations on the health of the pond.

If your pond has supported fish successfully before, the pH is proba-



To lessen stress during stocking add pond water to the holding tank gradually before you move the fish.

bly all right, for 50 percent of the bodies of water in the U.S. have a pH of under 7.6 and 95 percent are under 8.3. Hardness also usually takes care of itself. In fact, moderately high hardness levels are desirable, increasing fishes' resistance to several toxins. If you're unsure about pH or hardness, though, arrange for tests through the Agricultural Extension people.

The tests for oxygen and ammonia you'll need to do yourself, both before and after stocking. Complete kits cost under \$25 and are easy to use, but you can put together your own and save some money. In addition to a thermometer, to do oxygen tests you'll need O₂ #1 powder pillows, O₂ #2 powder pillows, O₂ #3 powder pillows, an O₂ collection bottle, a plastic measure, a mixing bottle, clippers (optional), and PAO titrant. For ammonia testing, buy the colored disc for ammonia, a disc holder, two test tubes, and Nessler reagent. All these materials can be ordered from Hach Chemical Company, P.O. Box 907, Ames, Iowa 50010.

If your initial oxygen level readings are too low for the fish you'll be stocking, fertilize the pond at the rate suggested earlier. And keep testing.

Ammonia is most likely to be a problem after fertilizing and stocking. A reading of over 3 ppm is approaching toxicity. But as the algae multiply, they should adjust to ammonia levels and absorb steadily what the fish produce.

In case your water quality doesn't reach acceptable levels as stocking time nears, remember to inform the hatchery to delay shipping.

When your fish come there's a sequence you should follow to help them adjust smoothly to a new aquatic environment. First, transport them from the hatchery or airport in a tank or plastic bag containing cool

water. If the trip is more than an hour, aerate the water by forcing air through it or splashing it. Disturb the fish as little as possible, for the entire stocking period is stressful for them and they will be somewhat weakened.

A rapid temperature change will stress them even more, so when you get home, measure the water temperatures in the container with the fish and in the pond. Then add pond water to the container slowly so its temperature is brought up to pond temperature gradually. Or you may be able to put the container into the pond and let it reach pond temperature without exchanging water. The entire process should take no more than an hour.

Your next move should be to fill a 5-gallon bucket partly with pond water and weigh it. Then add fish and take another reading. The difference is the weight of your fish. You'll need to know the total weight of the fish you're stocking to calculate how much to feed them initially and how much they've grown at harvest time.

You'll also want to disinfect your fish to remove any external parasites they might carry from the hatchery. Fill a container with pond water and mix in 2½ pounds of salt for each 10 gallons of water. Transfer the fish to this solution and leave them in it for two or three minutes—less if they're stressed. This treatment removes the mucous coating and with it the parasites. (The fish will quickly secrete a new coating.)

While the fish are still in the salt solution, drain off some of it and dilute what remains with more pond water. Do this a few times so salt won't be entering the pond with the fish. Then slowly ease the fish into the pond.

Feeding: Try feeding just a little after stocking, and when the fish start eating actively, begin your regu-

lar feeding rate, putting in food at the same time every day.

As a general rule, fish should have 3 percent of their total weight in feed every day. Weighing the fish on arrival will tell you only the initial feeding rate. From then on you must estimate how much they have grown and how much more you need to feed them. Do this and change the ration accordingly once a week.

As a rule of thumb, assume that fish grow a pound of flesh for each 2 pounds of feed. So to get the ration for each second-week feeding, take half the weight of the first week's total feed (half because 2 pounds feed becomes 1 pound of fish), and calculate 3 percent of that. Adding that number to the first week's daily ration will give the new daily ration. For the third week, begin with the total for the second week.

For example, if you stock 10 pounds of fingerlings, they should get .3 pounds of pellets each day for the first week, or a total of 2.1 pounds. So at the beginning of the second week, you can assume the fish have gained 1.05 pounds. Round that down to 1 pound for convenience. Since 3 percent of 1 is .03, add that to the .3 pound daily ration for the first week, and you'll see that the fish get .33 pound of feed daily for the second week. For the third week, begin with 2.3 pounds (the previous weekly total), assume the fish gained 1.1 pounds, and so on.

Always remember it's better to underfeed slightly than overfeed, since uneaten food is consumed by other organisms, especially bacteria, and will raise the oxygen demand of the pond. Besides, you want the fish to forage. So when you see unconsumed feed, cut back on the feeding rate. And clean excess out of the feeder regularly.

It's possible, by the way, to raise common carp and catfish on a feed

formulated from a careful blend of tablescraps. In Rodale trials, the growth rates of fish fed this way were about the same as those of same-species fish given commercial feeds. The homemade blend was made by putting high-protein food scraps (50 percent of total scraps), high-carbohydrate food scraps (25 percent of total scraps), and vegetable trimmings and wastes high in moisture, vitamins, and fiber (25 percent of total) through a food grinder. Fatty foods were carefully avoided.

Restaurants are a likely source for ample amounts of such kitchen scraps, which can be gathered, ground, and refrigerated one-week's-worth at a time. If you do blend your own feeds, try to use fresh material so the vitamins are adequate. It would also be good to add a balanced vitamin feed supplement, available at farm supply stores.

Feed your fish daily until a day or so before harvest. Then withhold food to let their digestive tracts empty. Fish can go without supplemental feeding for a week or more with no ill effects if you should need to be away. The only problem is that they won't grow without feeding and may lose some weight.

Making observations and changing the routine: Regular water quality checks are the only way to prevent problems for your fish and to learn about pond dynamics. For the first 2 weeks after stocking, you should record temperature and oxygen levels in the water and air temperature and amount of sunlight once each day. You'll find oxygen and temperature readings at the end of the day to be higher than those taken soon after dawn.

Ammonia also should be checked daily after stocking or fertilization until levels drop to the tolerable range. After that, a weekly check will do.



After the critical first weeks, you should monitor temperature and oxygen at least every other day. As you learn the workings of the pond, patterns will begin to emerge, and in several months you will come to recognize and anticipate the interactions of sunlight, temperature, algae, and fish. When you are able to tell the early signs of trouble, you will be able to get by with less testing.

According to the test results you get, you'll be changing your pond management somewhat. For example, you may learn that in your pond it is best to feed in the afternoon when oxygen levels are higher. If morning feedings are your practice, you may come to omit feedings on days that promise to be cloudy (in anticipation of low oxygen levels).

Here are some general principles you can use in adjusting management to water quality:

1. Fish feed more heavily as the water temperature moves toward the higher end of their optimum range.
2. Greater activity and heavy feeding consume oxygen faster.
3. Water holds less oxygen at higher temperature.
4. Withholding feed when oxygen approaches the lower limit decreases activity and reduces the need for oxygen.
5. Feeding must stop when fish don't eat because the water is too warm; otherwise, feed will raise the oxygen demand at a time when the fish need more oxygen than usual.
6. Additional fertilizer can be helpful when the oxygen levels and algal population are low.

Daily checks on water quality are essential during the first weeks of aquaculture.

Harvesting: It is simplest and most efficient to stock fish of the same size and harvest them all at once. Of course, this requires that you have the means to clean and freeze them all promptly since fish spoils fast. Ideally, you should take fish when they reach the minimum size for harvesting. As they get larger, their rate of growth slows and they require more food just to be kept alive. Harvesting a few at a time is more like fishing—it's fun, but time consuming, too.

If it suits your needs best, you can maintain fish in a deep pond over the winter quite safely. They won't need any feed after water temperature drops below their ideal range, and they won't grow. The only danger is that the water may become depleted of oxygen if the surface freezes over for very long. And of course very small ponds can freeze solid, which is lethal.

You can harvest most easily with large nets. There are two types. Gill nets allow you to take only fish of edible size. The mesh size should be large enough to allow undersized fish to swim through and to catch the others by the gills. Seines, on the other hand, take out all the fish. They are made of stronger fibers and have smaller mesh sizes.

Most ponds can be harvested with nets no longer than twice the width of the pond. The width of the net should be 33 to 50 percent larger than the depth of the water. A net dealer will be able to tell you the right size for your pond.

When you're ready to harvest, it's most convenient to let most of the water out of the pond. But remember to leave enough so that the fish can breathe. They will be concentrated in a small area and will become very active.

Begin netting when the water is about waist high. The trick is to posi-

tion the netting when you start so that it covers the pond from bank to bank and crosses the very bottom so no fish can get around it. When it's in position, begin to draw the ends along the perimeter of the pond so that they will meet opposite the starting point.

At the same time, people standing at the meeting point should begin drawing in the bottom ropes. Slowly the net will become a large bag holding all the fish. They can then be scooped up with large buckets and transferred to holding containers to await cleansing and freezing.

For high quality meat, keep your catch in the holding tank for about a day after harvest. The fresh clean water will cleanse the fish of mud and algae, which can give them a "pond water" taste. Put the tank in a cool or shady place, then flush it with spring or well water until it's filled with new water. You should also aerate the water enough to maintain the fish in good condition.

Treating troubles that may arise despite your best efforts is part of the challenge of aquaculture. Here are a few common problems and some solutions.

Muddy water can be caused by run-off or by wave action against the bank. Erosion can be stopped only by good soil conservation practices on the watershed, and you may have no control over such matters. However, if waves are eroding your banks in windy weather, protect them with a layer of gravel or rock (riprapping). If clay particles are suspended in the water, you may be able to get them to settle by adding gypsum at the rate of 12 pounds to every 1000 cubic feet of water.

Disease or parasites may be the culprit if a fish dies or the fish stop eating even though water quality (temperature, oxygen, ammonia

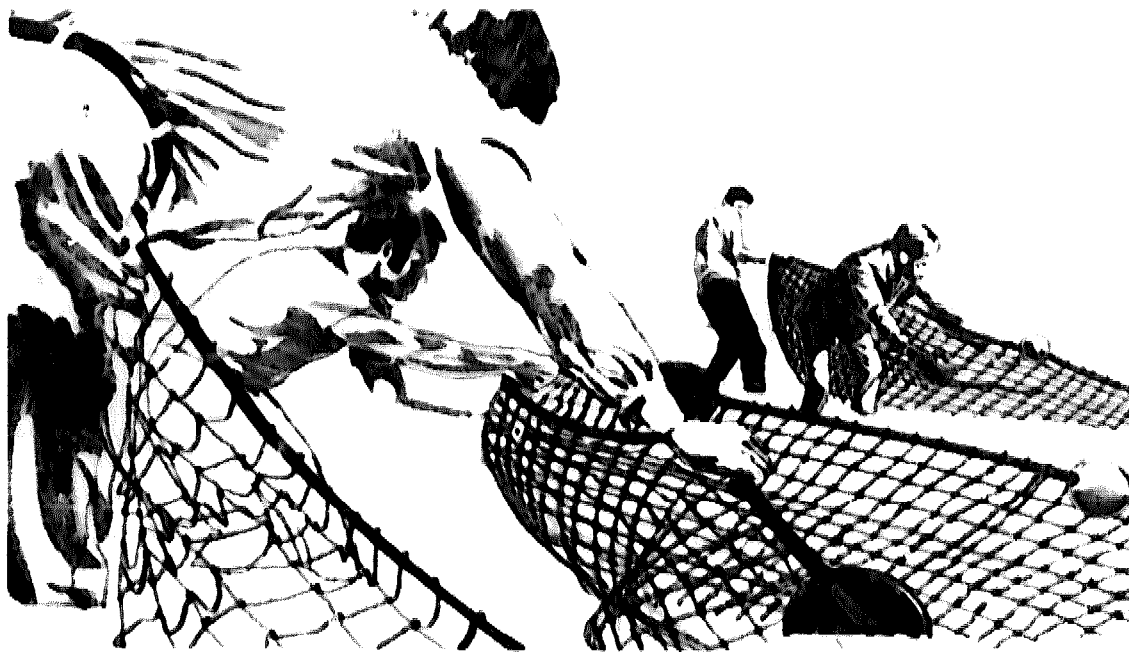
levels) has been fine. If this is the case and you have a dead fish that appears un mutilated by an animal, wrap it in plastic, refrigerate it, and notify the Fish Commission people. They will determine the cause of death and recommend treatment if any is possible.

Leaks can grow into a very serious problem. You should determine the cause immediately, calling on the Soil Conservation Service for help if necessary. Some small leaks can be stopped with extra sealing in the form of plastic sheets or bentonite clay granules. Severe leakage may require partial draining of the pond for repairs.

Muskrats can cause leaks if they begin to burrow into the dam sides. Burrows usually begin 6 to 18 inches below the water line. When you see them in the area, protect the banks by laying wire mesh several feet above and below the water line. Or you can do riprapping with very large stones. Also remove cattails and other aquatic plants that muskrats feed on.

Wild fish will compete with your fish for food and oxygen and may carry disease. If they are in a stocked pond, harvest all the fish, discard the undesirables, then drain the pond dry to make sure that all the wild fry are destroyed. Another method is to kill all fish with rotenone, then wait 6 weeks before restocking to make sure the rotenone has biodegraded completely. To protect your pond from wild fish, be sure to use very fine mesh screens or netting (as described earlier) to filter any water entering from a stream.

Raccoons and mink may prey on your fish. The only solution is to shoot or trap them.



Position the net so that it covers the pond from bank to bank and crosses the very bottom.

FIGURING OUT COSTS

Fish you grow yourself can cost as little as \$.25 a pound or as much as \$3 a pound. Obviously, knowing the economics before you get under way is a good idea. It will help you to keep your input and outcome in balance and prevent you from underestimating expenses and later finding it impossible or very costly to continue what you've started.

Calculating what your fish will cost in advance is easy. First, estimate the length of the active growing season, the volume of productive water you have, and how much fish will grow there. When you have projected the total weight of the fish you expect to harvest, reduce it by 40 percent to allow for losses in cleaning. Next, figure how much you will spend to produce that quantity of dressed fish.

Some things you will pay for only once. These initial costs include the pond, water testing supplies, nets, boots, aerator(s), holding tanks, pumps and such. Though these items will add up to a lot of money, only a portion of what you pay for each one

can be figured fairly into the cost of your first crop of fish. That amount is based on how long the item will be used. So estimate the life of each item and divide its total cost by the number of harvests you will make in that time.

Other inputs like feed, fingerlings, and power and transportation costs are purchased every time you begin a new season. So you must charge the entire expense of such items against the one crop they produce.

Once you have an annual charge for each long-life item, add them and add that total to the total for your seasonal inputs. Next divide the planned-for weight of dressed fish into that total. The result is the approximate price you'll be paying per pound of ready-to-eat fish.

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The Commercial Fish Farmer and Aquaculture News. Subscription Section, P.O. Box 4922, Manchester, NH 03105. The yearly buyers guide issue which lists suppliers of equipment and fish is also available separately for \$2.50.

FAO Aquaculture Bulletin. Fishery Resources and Environment Division of the Food and Agriculture organization of the United Nations, Rome, Italy.

Farm Pond Harvest. Professional Sportsman's Publishing Company, RR 2, Mokence, IL 60954.

Fisheries. American Fisheries Society, 5410 Grosvenor Lane, Bethesda, MD 20014.

The Progressive Fish-Culturist. United States Government Printing Office, Washington, DC 20402.

Government Booklets:

The following are available from the United States Government Printing Office, Washington, DC 20402.

Catfish Farming. Farmers' Bulletin No. 2260. \$.40.

Trout Ponds for Recreation. Farmers' Bulletin No. 2249. No charge.

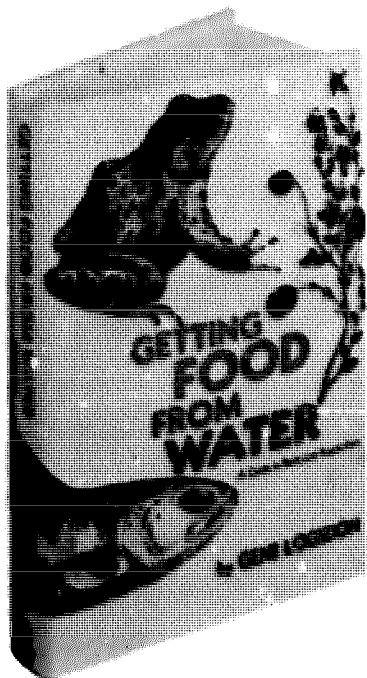
Warm Water Fish Ponds. Farmers' Bulletin No. 2250. No charge.

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Trout Ponds and Farm Ponds, a List of References. Write to Royal Ontario Museum, Department of Ichthyology and Herpetology, 100 Queen's Park, Toronto, Ontario, Canada M5S 2C6. Published 1974.



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YES! Please send me a copy of **GETTING FOOD FROM WATER** For my 15-day FREE home trial. If I decide to keep it, I'll pay \$8.95 (plus postage and handling). If not, I'll return it within 15 days and owe nothing.

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I enclose \$_____ for _____ copy(ies) of **GETTING FOOD FROM WATER**. 11515

Name _____

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(NOTE: PA residents add 6% sales tax.)

TO: RODALE BOOKS
Emmaus, PA 18049

Grow more fish and grow more self-suff

If rising food prices have you searching high and low for a new food source to help your family grow more self-sufficient, then cast your eye to backyard fish farming the Rodale way.

Raise fish as easily as you raise tomatoes

Like many good gardeners, you're probably fighting inflation by growing as much of your own food as your garden space will allow.

But you still may be *buying* your protein. And "meat," no matter how you slice it, still takes the biggest bite out of the average food budget.

Now you may grow that protein — delicious, high-quality, organically-grown protein — in a backyard "fish farm."

Fish—the near-perfect food source

Yes, fish — fresh fish. Come and get it! Low in fat, highly digestible, rich in protein — the almost "perfect" food. Not from the mercury-tainted oceans or marked-up markets, but from your own backyard. And for just pennies — as little as 25 cents per pound in direct costs for fingerlings and feed.

Whether you live in the city, suburbs, or out in the country, now you can grow enough fish to supply your family for a full year in a backyard tank or pond the size of a small swimming pool.

How?

The "secret" is *aeration*.

Fish do not live by feed alone

Fish need oxygen to live and grow. But water is limited in the amount of oxygen it can hold. So you would be limited in the number of fish you could

normally raise by the size of your pond or pool.

But no more.

Because we at Rodale Resources have developed oxygen-generating machine that now makes it possible for you to raise a bigger crop of fish in a small space.

Introducing the Rodale LSS-100C Aerator

Our new LSS-100C Aerator turns your pool or pond into a growing medium that is loaded with life-giving oxygen. The energy efficient 1/20 horsepower motor pumps over 60 gallons per minute — transferring enough atmospheric oxygen to help satisfy the requirements of over one hundred pounds of active growing fish.



With aerator.



Without aerator.

The LSS-100C helps your fish grow faster. And larger.

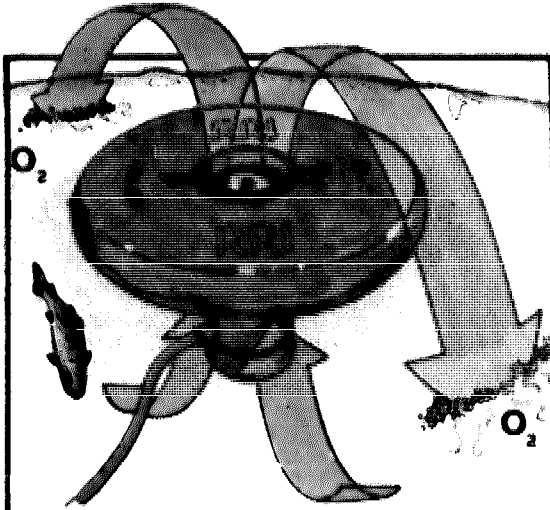
Tests show that fish production may be increased up to nine-fold with the addition of aeration — and with much better food conversion percentages — when raised in aerated waters as opposed to no aeration at all.

An investment that pays for itself

So a Rodale LSS-100C Aerator is a dollar-wise investment that can quickly pay for itself by increasing production. And by making it possible to grow more fish in an area which might normally be too small.



Efficient with a Rodale LSS-100C Aerator!



- Heavy-duty, long-lasting, construction covered by our one-year limited warranty**
- Pumps over 60 gallons of water per minute
- Shock-resistant, completely submersible waterproof motor
- Allows greater populations in smaller areas
- Helps fish grow larger and faster *naturally!*
- Rust-proof stainless steel parts

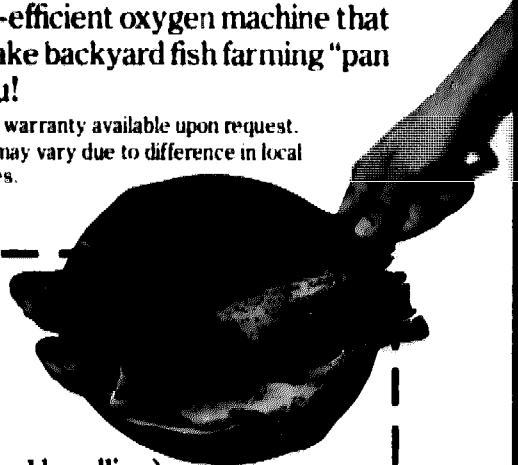
But don't think your profits will go bubbling away in big energy bills. Because the LSS-100C has been designed with energy-saving in mind. Our new capacitor-type motor is energy-efficient. We've found that it costs roughly one-half cent per hour to operate.* And round the clock operation is necessary only in special cases.

And Rodale Aerators are lightweight, heavy-duty, and reliable. Each is built with the same fine quality as our large five-horsepower Commercial Fish Farmer unit. And backed by our one-year, limited warranty.**

So if self-sufficiency is an idea that appeals to you, help turn that idea into a reality with a Rodale LSS-100C Aerator — the energy-efficient oxygen machine that can help make backyard fish farming "pan out" for you!

**Details of our warranty available upon request.

*Actual costs may vary due to difference in local electrical rates.



RODALE RESOURCES LSS-100C AERATOR ORDER FORM

Yes, please send me _____ (quantity) LSS-100C floating aerators at \$89.95 (add \$4.95 for insurance and handling).

SAVE: Order two or more LSS-100C aerators and receive a discount of \$5.00 on each unit..

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

My check is enclosed. Please charge my credit card account:

Master Charge □□□□□□-□□□-□□□□□□ _____
Expiration date

Visa □□□□-□□□□-□□□□-□□□□ _____
Expiration date

RODALE RESOURCES, INC. 576 North Street, Emmaus, PA 18049

MONEY-BACK GUARANTEE:

We guarantee satisfaction or your money back. If our LSS-100 does not perform to your expectations, return the unit for a full refund.

**Rodale Resources Inc.
Emmaus, PA 18049**

**Here's the information you
requested from Rodale Resources.**

**Bulk Rate
U.S. Postage
PAID
Rodale Resources.**

**Printed in U.S.A. / 12/77
Designed by Bill Bosler**