Aquaculture Technical Series

United States
Department of Agriculture

Cooperative
State Research
Service

Extmsion Service
and Land-Grant University
Cooperating Extension
Services

Baitfish Production in the United States

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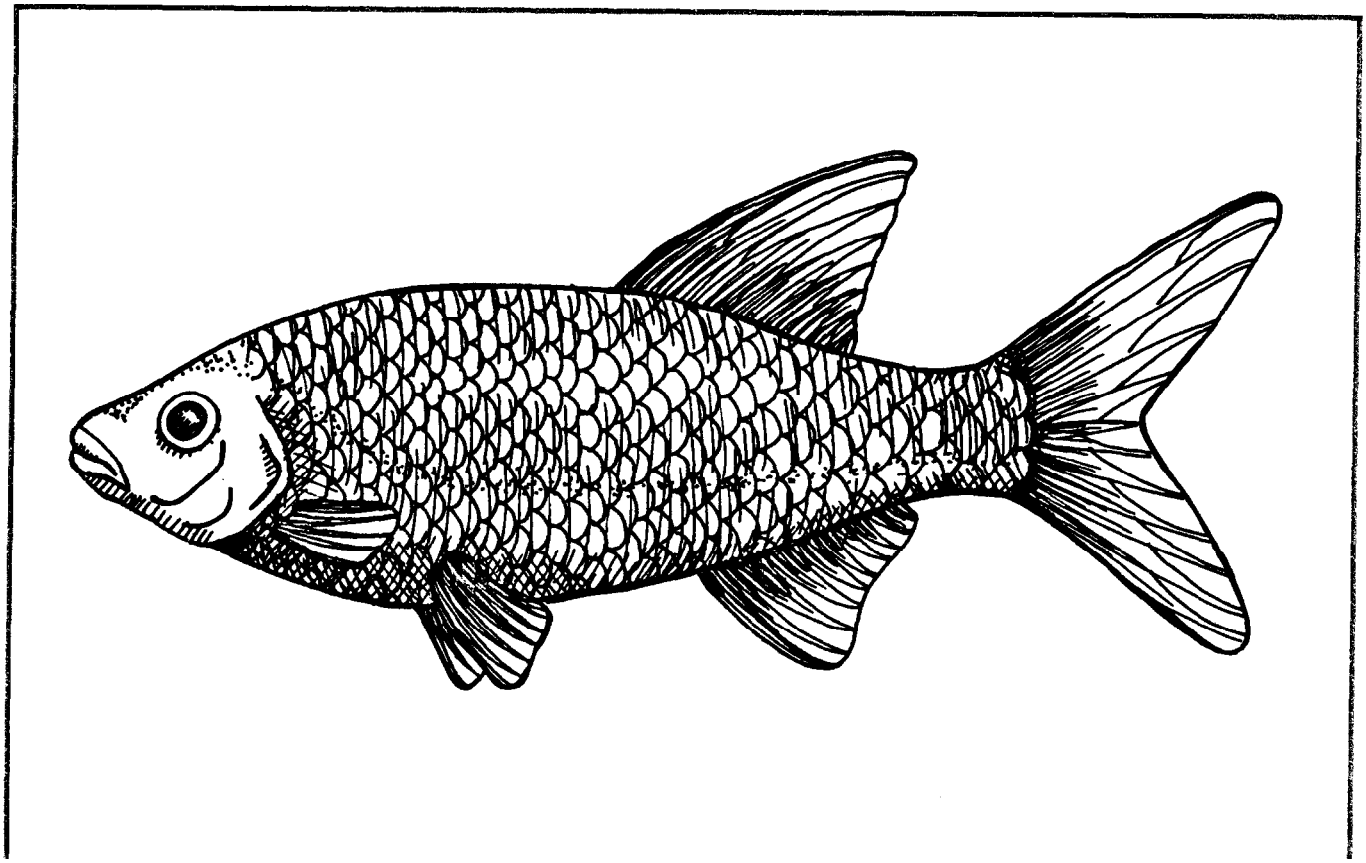

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This material is based upon work supported by the Cooperative State Research Service and Extension Service, U.S. Department of Agriculture, under Special Project No. 87-EXCA-3-0836.

Baitfish Production

Baitfish production provides an attractive alternative to traditional fish farming in many parts of the United States. Baitfish are used by sportfish enthusiasts who prefer live bait over artificial lures or attractants. Baitfish are also used as feeder fish. Although the baitfish industry has not always been profitable, previous successes and increasing demand for baitfishes present an optimistic future for new producers.

In 1950, I.F. Anderson began construction of ponds to raise baitfish in Lonoke County, Arkansas. He used local, wild golden shiners as broodstock. About one year later, two commercial fishermen, Harry Saul and Robert Treadway, quit trapping wild fish from the White River, constructed ponds in Prairie County, Arkansas and started baitfish farming. They purchased their original broodstock from a Missouri hatchery.

The baitfish produced by hatcheries were superior to those trapped from the river. They were hardy and could be graded to various sizes according to use. Commercial production also meant more reliable supplies of fishes.

Since 1950, the baitfish industry has expanded. In 1990, there were 27,800 acres in Arkansas. Species propagated included golden shiner, fathead minnow and goldfish. Nearly all baitfishes sold today are produced on commercial farms.

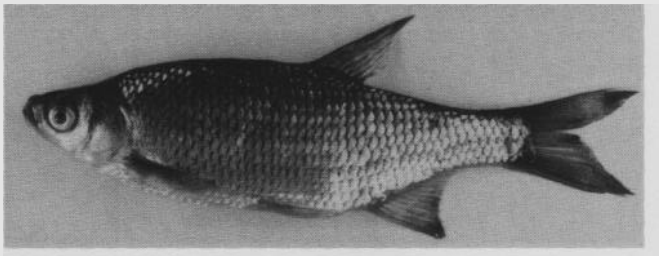
Arkansas produces over half the nation's baitfishes. Other major baitfish production areas are the Southeastern states, New England states, California, Upper Midwestern States, and Texas. The U.S. Fish and Wildlife Service estimated golden shiner production at 7,776 metric tons and other minnow production at 3,700 metric tons with a total value over $66.5 million in 1987.

Species preference in selected regions of the United States indicates golden shiners are most popular in the Southeast, Southwest and West. Fathead minnows are the dominant species in the Midwest and Northeast. White suckers and golden shiners are also important species. Feeder fish markets are developing in the mid-Atlantic and Southeastern states for use in striped bass and hybrid striped bass culture.

Although markets for baitfishes are increasing, there is a concern that supply may be increasing faster. Improved production techniques, such as feeding, allow more fish to be raised on less acreage. Golden shiner and fathead minnow production has doubled on many farms. Because of declining groundwater levels in some areas, more efficient production methods and water conservation practices must be used by baitfish producers.

The baitfish industry is expanding in production of larger fishes for trotline, sport fishing and aquaculture markets. Tilapia and rudd are new fish in the industry; however, both may be subject to state and federal exotic fish introduction regulations.

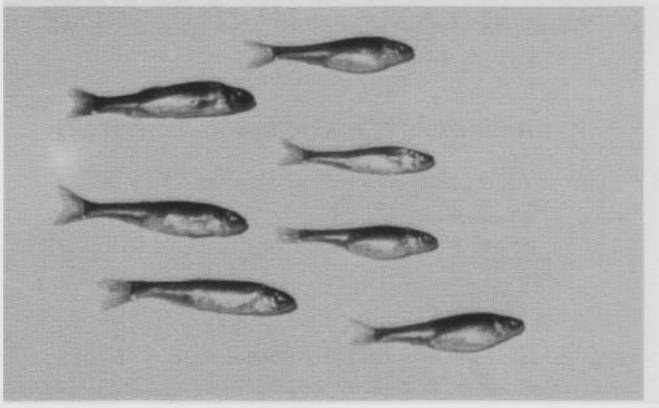
Golden shiner *(Notemigonus crysoleucas)*



IDENTIFICATION AND LIFE HISTORIES OF BAITFISHES

The bright, flashing appearance of the golden shiner has made it popular with fishermen. Its body is deep, compressed laterally and covered with large gold- or silver-colored scales that are rather loosely attached. The loosely attached scales can create a problem when fish are harvested, graded and loaded, because when scales are lost, fish marketability is drastically reduced. The lateral line is curved downward, and there is a fleshy, scaleless keel just anterior to the anal opening. Females grow faster and reach larger sizes than males. In the southern United States, fish become sexually mature at 1 year of age or

Fathead minnow *(Pimephales promelas)*

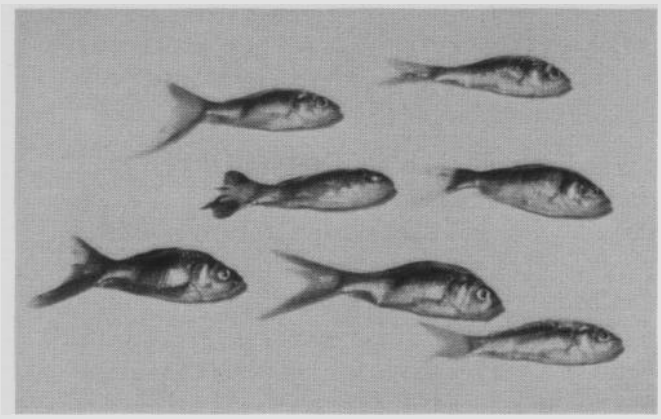


approximately 2 to 2 l/2 inches in length. Some have been known to live 8 years and attain a length of over 10 inches. Domesticated golden shiner broodstock is easier to handle than wild stocks which should be avoided.

The fathead minnow has a cylindrically-shaped body, small scales and dull color. It has a light, dusky stripe along the midside from the head to the base of the caudal fin. The lateral line is incomplete.

Adult males grow larger than females. This characteristic may create a problem if a mechanical grader is used to select broodstock. Grading for large fish may result in a greater population of males. Breeding males develop dark coloration about the head and may exhibit dark vertical bands on their body. Numerous horn-like projections, called breeding tubercles, develop on the head of adult males during the breeding season. A pad also forms on the back just behind the head. This pad is used to prepare the nest site and care for the eggs. Sexual maturity is reached at one year of age.

Goldfish *(Carassius aurutus)*



The goldfish is a heavy-bodied fish which resembles a carp. It has a stout, sawtoothed spine at the front of the dorsal and anal fins. The color of cultured goldfish varies from dark olive-brown, gold, white, red, black or some combination of these colors. Body shape and color may be improved by selecting broodstock with the desired characteristics. Goldfish are easy to seine, handle and transport.

White Sucker *(Catostomus commersoni)*

The white sucker has fine scales and a slender body. The scales are small near the head, becoming larger near the tail. The dorsal fin is short. Both the dorsal and caudal fins are dusky to clear, while the lower fins are white and often tinged with yellow or orange. The lips are covered with small, wart-like bumps. The back and sides are greenish with a brassy-silver luster shading to white on the belly. Breeding males are darker, nearly black above and white below with a pink band along the side. Small tubercles are present on the head and body but are best developed on the anal fin and lower lobe of the caudal fin. Dusky blotches are common on the sides of young white suckers.

PRODUCTION METHODS

Quality, disease-free fish from a cultured line are the best broodfish. These fish can be obtained from established, reputable farms.

Golden Shiner

Select ungraded yearling broodfish and have them evaluated by a diagnostician. Avoid fish with the ovarian parasite *(Pleistophara ovarie),* Asian tapeworm, *(Bothriocephalus opsarichthydis),* and anchor parasite, *(Lernaea cyprinacea).*

Extensive Culture

WILD SPAWN

Wild Spawn is an extensive method of production. Stock 20 to 40 pounds of broodfish per acre. Fish should weigh 3 to 12 pounds/1000 fish or be from 333 to 83 fish per pound. Golden shiners are vegetative spawners. Plant a band of rye grass around the pond to serve as spawning material. Fish start spawning when water temperatures reach 70°F and stop at water temperatures above 85°F. Eggs are deposited on the rye grass and hatch in 7 to 10 days. Fertilize pond within a week after hatching. Apply 100 pounds of fertilizer (o-46-0, 18-46-o or equivalents) per surface acre.

Start feeding minnow fry four days after hatching. Feed a high protein meal, 38 percent crude protein or higher. Overfeed initially to insure all fish have the opportunity to feed. When fish are one month old, change to a 32 percent crude protein meal or crumbled pellet. Begin feeding 2 pounds per acre and gradually increase to 10 to 20 pounds per acre.

Using the wild spawn method, egg laying, hatching, and grow-out occur in the same pond. Harvest the adults shortly after spawning stops. This prevents spread of disease from the adults to the young. Production using this method ranges from 200 to 350 pounds per acre.

Intensive Culture

Two methods are used: (1) egg transfer and (2) fry transfer. For either method, stock broodfish at 300 to 500 pounds per acre. Place spawning mats, 21 x 30 inches, made of Spawntex®l (material similar to heating and air conditioning filters) sandwiched between 6-x 6-inch concrete reinforcement wire in the pond. Keep the pond free of vegetation to prevent uncontrolled egg deposition.

EGG TRANSFER

Broodfish start "running" (swimming parallel) to the pond bank prior to spawning. Place spawning mats in shallow water about 1 inch below the surface when fish begin running. Stake the pond side of the mat to hold it parallel to the bank. Place mats in an end-to-end arrangement. There is no recommended number of mats for brood ponds, but it is not uncommon to use 500 or more in a lo-acre brood pond.

Mats are ready to transfer to fry rearing ponds when they are uniformly covered with eggs. Egg covered mats appear as if dusted by a fine powder or snow.

Mats are usually covered with eggs in 12 to 24 hours after placement. Never leave a mat in a brood pond more than 24 hours regardless of egg coverage. As spawning slows down, decrease the number of mats in the pond.

Mats are picked up, stacked on a trailer or pickup truck bed, and covered by a tarp or burlap-like material. Mats can stay out of water up to one hour if they are kept moist and out of direct sunlight.

For rearing ponds, stock 50 to 75 egg-covered mats per acre. Place the mats in shallow water 6 to 12 inches deep to allow eggs to hatch. Leave mats in the rearing pond for one week after hatching. This provides a protective area for fry. Use the same fertilization and feeding schedule as with the wild spawn method.

FRY TRANSFER

Place 100 to 200 egg-covered mats per acre in ponds. The objective is to produce as many fry as possible, grow them to about 3/4 inch, then transfer them to grow-out ponds. Fry are harvested using lift traps and fine mesh fry seines.

[1]Spawntex®. Blockson and Co., Michigan City, IN.

Stocking densities for golden shiners depend on when fish are to be sold, size of fish desired and length of growing season. Most ponds are stocked with 50,000 to 200,000 fry per acre.

Fry numbers may be determined by a volumetric displacement method. Count the number of fry in 1 ounce. Multiply that number by the number of ounces of fry transferred. For example, if there are 200 fry in 1 ounce, then 1000 ounces (3 1 1/4 quarts) are needed to stock an acre with 200,000 fry.

Fathead Minnows

Select broodfish at least 2 l/2 inches long. Males grow faster than females, so selection based on large size leads to mostly male populations. Fathead minnows have fewer parasite problems than other baitfishes. However, potential broodfish should be examined by a diagnostician.

Fathead minnows are fractional spawners, releasing only a few eggs at each spawn. Culture of fathead minnows is restricted to wild spawn and fry transfer methods.

WILD SPAWN

Stock broodfish at 500 to 2,000 (2 1/2 to 10 pounds) per acre. Fish should be 2 l/2 inches long and weigh 5 pounds per 1000 (200 fish per pound). Sex ratios should be five females per male. There is a size difference between adult male and female fathead minnows, and the sexes can be separated using a 15/64- or 16/64-inch bar grader. Most females swim through the grader while males are trapped. Take samples of each sex to estimate numbers.

Fathead minnows spawn on the underside of objects in the pond. Use spawning boards, 12 x 4 x 1 inches stapled to wire stretched parallel to the pond bank. Space boards about 1 foot apart. Some producers use oak pallets tied to posts driven into the ground. Use four to six pallets per acre.

The broodfish spawn over several months. Ponds are fertilized and fed at the same rate as with golden shiners.

FRY TRANSFER

Stock broodfish, five females per each male, at 20,000 to 25,000 fish per acre (100 to 125 pounds per acre). This method can produce up to three million fry per acre. Stock fry at 100,000 to 300,000 per acre. Estimate numbers using the same method as with golden shiners.

Goldfish

Broodstock selection depends on the market. Fish are produced for the aquarium, landscape pond, feeder or bait market. Pay attention to color and shape of the adult fish. Slim-bodied varieties are preferred for bait. Cull heavy, thick-bodied fish. Plumper fish, trilobed tail, and "bug-eyed" condition are desirable traits for the aquarium market. Feeder goldfish are smaller (3 to 5 pounds/1000 fish), so use the same criteria used for selecting broodfish for bait.

The same spawning methods are used in goldfish production as with golden shiners. For wild spawn, stock 10 to 20 pounds of broodfish per acre. Fish should weigh 17 to 50 per pound (3 to 5 inches in length). Avoid using broodfish over l/4 pound. These fish may have parasites such as: Trichodina, Gyrodactylus and Dactylogyrus. Avoid using broodfish infected with "ulcer disease." This disease can kill 100 percent of the broodfish.

For the egg and fry transfer methods, stock broodfish at 800 to 1000 pounds per acre. Rearing ponds are stocked at 50 to 150 mats per acre. Fry are stocked from 25,000 to 1 ,000,000 per acre. Rearing ponds are fertilized and fed at the same rates as golden shiners. Many producers fertilize ponds based on light penetration into the pond water. Ponds are fertilized when a shiny object is visible at water depths greater than 16 inches.

White Suckers

This species is more common in northern states. Broodfish are harvested from the wild. Broodfish collection may require special permits or be subject to regulation.

COLLECTION OF EGGS

Sucker spawning dates are regulated by water temperature and may range from mid-April to late May. Suckers "run" when water temperatures are between 45°F and 59°F.

Fish are trapped or seined below dams or waterfalls. Brooders are sorted by sex and put in tanks for transportation to the hatchery.

Suckers are stripped by moving the thumb and forefinger gently down the abdomen toward the vent until the eggs or sperm are released. Eggs from one or two females are first stripped into a damp pan, then milt (sperm) from one to three males is stripped into the same pan. Next, add a small amount of water. Gently stir the sperm and water. Wait a few minutes, then wash the eggs. Add a thick suspension of bentonite clay. This is called "mucking" the eggs. This prevents the eggs from sticking together during incubation and hatching.

After thoroughly mixing the eggs and clay, wash the eggs again. Place the eggs in a tub for water hardening. Once hardened, pour the eggs into hatching jars at 2 to 3 quarts of eggs per jar. Adjust water flow through the jars at one gallon per minute. This gently rolls the eggs.

Eggs hatch in four to six days at water temperatures of 65°F or warmer and in 10 to 15 days at 50°F to 60°F. Eggs won't hatch in water colder than 50°F. Eggs that hatch in 10 to 15 days produce healthier fry than those produced from shorter hatching periods.

Sucker fry settle to the bottom of the hatching jar when the water is shut off. Numbers of fry can be estimated at this time. Pour the fry into a graduated container and allow them to settle. Determine the volume of fry in ounces. There are about 2,720,5-day-old fry per ounce. A pond stocked at 40,000 fry would need 14.7 ounces of fry.

Fry are transported from the hatchery to rearing ponds in oxygenated plastic bags. Before releasing the fry, let the plastic bag float along the pond's edge. This lets the temperatures equalize and prevents temperature shock.

STOCKING REARING PONDS

Sucker ponds are stocked at 40,000 fry per acre. Some growers adjust stocking rates to influence fish size. Suckers require no special feed. They grow on plankton, insects and invertebrates in the pond.

OVERWINTERING SUCKERS

Suckers too small for sale the first year can be overwintered in ponds. It is essential to keep snow office-covered ponds. Snow cover prevents light penetration and limits oxygen production. Some producers use large aerators to prevent formation of ice cover.

FEEDING NUTRITION REQUIREMENTS

Most baitfish ponds need to be fertilized. Supplemental feeding increases production. Fry need a nutritionally complete diet high in protein. Starter feeds should be fine, ground flour. Fry feed should be made into a slurry and fed on all sides of the pond. This ensures all fish have the opportunity to feed.

Table 1. Fry Feed Formula Developed at the Fish Farm Experiment Station, Stuttgart, Arkansas.

Ingredient	Pounds	
Soybean Flour	600	
Fish Hour	375	
Dried Skim milk	375	
Rice Bran	400	Calculated
Distillers Solubles	200	Protein
Bone meal	25	38%
Mineralized Salts	20	
Vitamin Premix	5	
TOTAL	2,000	

Table 2. Ingredients Used by Industry and Research for Grow-out Feeds for Baitfishes.

Ingredients	Industry	Fish Farm Experiment Station
Meat Scraps	5-15%	15%
Fish meal	5-10%	10%
Feather Meal	5-10%	10%
Soybean Meal	5-15%	10%
Cottonseed Meal	5-15%	15%
Wheat Middlings	5-15%	13%
Alfalfa Meal	0- 5%	2%
Rice Bran	20-40%	22%
Vitamins and Minerals	0- 5%	3%

At three to four weeks, change the diet to a grower feed. The grower ration is a more coarsely ground meal, crumbled pellet or floating pellet. It is fed dry. Broadcast the feed along one side of the pond.

Feeding rates are determined by species and stocking rates. Golden shiners, goldfish and fathead minnows are fed 10 to 20 pounds per acre per day during the growing season.

HARVESTING, HANDLING, HOLDING AND TRANSPORTING

Many fish mortalities are caused by imporper harvesting, handling and transporting. Baitfish species may be harvested by baiting and seining a pond corner, seining a whole pond or draining the pond.

Seining

Seines and dip nets should be made from knotless, woven nylon. The most common mesh size is 3/16 inch. Smaller mesh seines collect debris and are more difficult to handle. Large mesh seines catch fish behind the gills (gilling). Seine length should be 50 percent longer than the width of the pond. Seine depth should be twice the average pond depth.

For ponds one to two acres in size, stretch the seine across the end of the pond. One or two people are needed on each end of the seine. Walk slowly when pulling the seine so the lead line drags across the pond bottom. Angle the brail at 45” to 60” to pull the lead line ahead of the float line. Beaching the seine is the most critical step in seining. The lead line must not be raised off of the bottom, but it should not dig into the mud. Pull the float line faster than the lead line. The float line “rolls over” to form a bag when the lead line is pulled into the shore forming a “box.” “Stake” the corners with concrete reinforcement bars or electric fence posts.

Fish are dipped out of the seine into buckets. A 5 gallon plastic bucket works well. A bucket holds 15 to 20 pounds of water and 25 pounds of fish. The buckets are carried to a transport truck and emptied into aerated tanks.

Lift Nets and Traps

Lift nets and traps can be used for harvesting fathead minnows and goldfish. To use a lift net, lower the net in a shallow area. Place a ball of moistened fish food in the center of the net. Wait 15 to 30 minutes, approach the net cautiously, and lift the net rapidly by means of a lever. Dip the fish out of the net and reset. Several traps can be used simultaneously.

Long Distance Hauling Trucks Have Liquid Oxygen tanks and Insulated Compartments

For traps, wrap the fish food in burlap or cheesecloth. Lower the trap to the pond bottom. Wait 15 to 30 minutes, grab the float line, lift the trap, empty the fish into a bucket, and reset the trap.

Holding

Holding vats are made from concrete blocks or poured cement. Sizes vary depending on the operation. Vats 5 feet x 30 feet x 18 inches deep are most common. Holding facilities need an adequate water supply. Aeration for vats is usually provided by electric agitators or blowers.

Transportation

Hauling tanks may be constructed from marine plywood, Styrofoam insulated sheet metal or insulated fiberglass. Tanks need a drain at least six inches in diameter.

Hauling tank aeration systems include 12 volt agitators, blowers and liquid oxygen systems. Two to four agitators are needed per compartment. One blower can serve four, 75-gallon compartments. Liquid oxygen systems require a liquid oxygen cylinder, regulator, one flow meter per compartment and an oxygen dispersion hose. The regulator is set at 20 pounds per square inch. Flow meters are set at three to five liters per minute. Both can be adjusted depending on the fish load and the number of compartments.

PROBLEMS OR CONSTRAINTS

Anticipation of problems and knowing how to solve them are essential to the successful operation of a fish farm. In the baitfish industry, some common problems include parasites, diseases, water quality deterioration, predators, weed infestation and legal or regulatory constraints.

Parasites and Disease

At some time an outbreak of some type of disease or parasite will likely occur. However, the severity, frequency and duration of these outbreaks can be reduced by controlling fish stress. Conditions favorable for disease outbreaks require a host, such as the fish, a disease organism such as a parasite and a stress such as low dissolved oxygen. Common stress factors are rough handling, water temperature changes, low oxygen, water quality changes, poor nutrition and fish crowding.

Diseases can be classified as infectious and noninfectious. Infectious diseases include those caused by parasitic bacterial and viral pathogens. In the baitfish industry, it is believed that parasites are the most devastating disease agents because of the variety and number of parasites. Yet treatment of parasite infestations if often simpler than treatment of bacterial or viral infections.

PROTOZOANS

Protozoans are small parasites and usually require microscopic examination for diagnosis. Infections of the gills and skin are most common. However, some protozoans can infect fish ovaries causing partial or complete sterility.

1. *Ich*

Ich is usually visible as white spots on the skin; however, it also infects the gills of fish. Occurring from fall to spring, Ich often appears after fish have been seined and moved from one pond to another.

2. *Trichodina*

Trichodina is a circular protozoan with many abrasive grooves on its surface. It irritates the skin and gills causing fish to die from impaired respiration problems, secondary infections or starvation. Outbreaks can occur from fall to spring.

3. Ictyoboda

Ictyoboda (Costia) is an extremely small parasite. Large numbers cause severe irritation to gills. On the skin, erosion of mucus and skin makes the fish susceptible to secondary bacterial infections. Early diagnosis and treatment are important in limiting mortality.

4. Chilodonella

Chilodonella is a parasite that usually attacks the gills but can be found on the skin. It causes red, puffy or frayed gills. Fish mortality is more rapid and extensive than with other external parasites. It occurs in cool weather from fall to spring.

5. Scyphidia and Epistylis

Scyphidia and Epistylis attach to the gill or skin surface. They usually occur in the spring and these parasites are characteristic of over fertile water.

6. Sporozoan Parasites

Sporozoan parasites are protozoans which produce a cyst in the fish that contains spores. Mitraspora cyprini infects goldfish and can be found in the kidney. The kidney enlarges and the fish appears bloated. Myxobolus notemigoni and M. aregenteus form cysts beneath the scales of golden

shiners, making the fish unsightly. Pleisto-phora ovarie infects golden shiner ovaries, reducing egg production. Egg masses appear discolored, opaque, yellow or brown instead of light green. Treatments for these diseases have not been developed and prevention requires culling of infected fish and disinfection of ponds. Pleisto-phora infections may be reduced by removing golden shiner females from brood fish ponds after two years of age.

TREMATODES (GRUBS)

Flukes or grubs infect gills, skin and internal organs of fish. These parasites weaken fish and make the fish more susceptible to bacterial or more lethal parasitic infections. The brain fluke of the fathead minnow, *(Ornithodiplostomum ptychocheilus)* can be controlled by killing its secondary host, the snail. Black grub and yellow grub can also be controlled by destroying snail populations.

CESTODES (TAPEWORMS)

The Asian tapeworm has become an important golden shiner parasite. Small fish less than 1 inch in length are susceptible, with up to 80 percent mortality. Copepods carry infected stages and the parasite can be transferred by wildlife and equipment. Good pond management, including pond disinfection, disposal of diseased stock and treatment to kill copepods can reduce the chances of infection.

In fathead minnows, *Ligula intestinalis,* a large visceral worm can cause mortalities of about three percent. No effective treatment has been developed, but prevention by disposal of diseased fish and pond disinfection can reduce losses.

NEMATODES (ROUNDWORMS)

Roundworms are infrequently found in several organs of baitfish. However, in golden shiners, *Capillaira catostomi,* causes significant mortality by infecting the gut and the fish starves.

CRUSTACEANS

Two crustaceans cause significant damage to baitfish. *Argulus* is an irritant to goldfish causing weight loss and mortality in extreme cases. The anchor worm, *Lernaea,* infects all fishes and may cause mortality in small fish. The protruding "worm" and red sores cause the fish to be unsalable. Control of copepod forms of these crustaceans is effective in controlling adult forms.

FUNGI

Fungi are often a secondary problem associated with another infection. They usually occur in the fall or winter, but fungus can grow on stressed fish even in the summer. *Suprolegnia* covers the body of fish with cotton-like growth and causes skin lesions and chronic but severe losses. *Branchiomyces* grows on the gills of golden shiners causing impaired respiration and mortalities. Good water quality and adequate fish nutrition help prevent fungus outbreaks.

BACTERIAL DISEASES

Bacterial infections of baitfishes are almost always related to environmental stress. The most important bacteria, *Flexibacter columnaris, Aeromonas hydrophilla* and *A. salmonicida* are found in most soil and water. Because these bacteria are almost always present, they become a problem when conditions favor their growth, especially when warm water becomes nutrient rich or fish are crowded or stressed.

Columnaris infections are often recognized by a pale saddle shaped patch on the back of fish. Other signs are eroded fins and gill filaments. Fish in warm or cold water are susceptible to columnaris when they are stressed. Recent studies indicate that the pH of water may be changed to control columnaris infections.

Goldfish ulcer disease, A. *salmonicidu,* attacks large goldfish. Mortalities of over 40 percent can result. Lesions on the fish start as small white spots but grow to 1 inch or more in size and are hemorrhagic. Changing water temperatures in the spring and fall encourages this disease.

Another bacterial disease, A. *hydrophilla,* is common to all species of baitfish. Erosion of skin resulting in open sores or shallow ulcers, bloating, popeye and hemorrhaging under the chin and around fins are all signs of this bacterial infection. Warm water, over 80°F, favors outbreaks..

VIRAL DISEASES

The only important viral disease of baitfish infects golden shiners. The golden shiner virus causes gradual mortalities over several months. A few dead or dying fish may appear each day. Hemorrhaging of the underside, back, eye, and head of the fish are signs of this disease. The virus usually occurs in the fall when fish reach 2 1/2 inches in length. Because of the low mortality associated with the disease and the lack of an effective control, the disease is usually allowed to

run its course. Pond management including the isolation of infected stock and pond disinfection may help control the spread of the virus.

Water Quality

Feeding and fertilizing enrich the water to produce more fish. At the same time, wasted feed and fish wastes encourage phytoplankton blooms. Phytoplankton and bacteria may use the oxygen that could be available to support fish. Ammonia, nitrite and carbon dioxide also may accumulate and at times cause stress or mortality in fish.

The use of oxygen meters and chemical test kits can remove a great deal of the risks associated with water quality deterioration. Careful and routine monitoring of water quality allows the producer to respond to a potential problem with prevention before losses occur. This often involves using aeration or flushing with fresh water.

Water quality is also important in the holding building. A common problem is iron. At 0.5 ppm, iron begins to coat the gills of fish causing impaired respiration. Sand filters may be used with aeration to remove iron from incoming well water. Less common problems are the presence of hydrogen sulfide or ammonia in well water. Hydrogen sulfide leaves the water as a gas after aeration.

Predator Control

Sharing the profits of baitfish production with fish predators is not the desire of any producer. A predator problem left unchecked can cause serious losses. Predators may include mammals, birds, reptiles, carnivorous fishes, insects and copepods.

Using filtered or well water is the first step in predator control. Filters reduce the introduction of predatory fishes. Mowing grass and weeds along the pond bank will discourage many shoreline predators. Well maintained levee slopes which fall quickly to water of two feet or more discourage wading birds.

Weed Control

Pond management for fish culture encourages the growth of weeds by increasing the fertility of pond water and soils. Construction of ponds with water levels greater than two feet deep makes control easier. However, some weeds inevitably start to grow. Seining baitfish is severely impaired by the presence of weeds. Rolling fragile minnows with weeds in a seine usually results in the loss of fish.

Weed control can be accomplished mechanically, chemically or biologically. The extent of weed infestation, a farmer's resources and legal regulations determine which method is used.

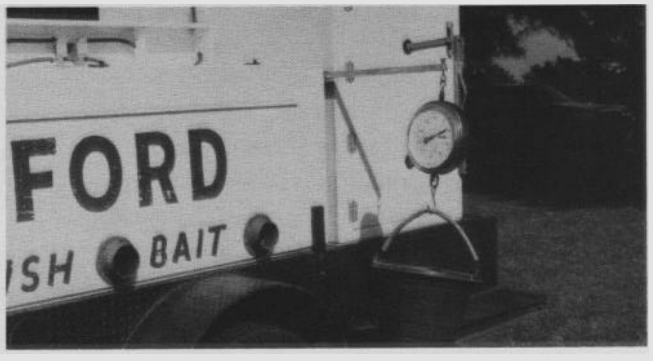
Mechanical control of weeds is limited to a few options. Periodic drying or pond drawdown can be effective on partial infestations of shallow water weeds. Pulling or raking weeds can help control shoreline weeds if started early enough.

The most widespread method of weed control is use of approved algicides and herbicides. Several broad spectrum chemicals are available for control of most water weeds. Before using any chemical, be sure the chemical is cleared for aquatic use, is effective against the weed species present, is not toxic to the fish present and is as economical as other available methods.

Biological control of weeds is usually accomplished by weed-eating fish. However, some insects have been used to control weeds such as water hyacinths and alligator weed. Excellent success with weed control has been achieved in the fish culture areas of Alabama, Arkansas and Mississippi by the use of the grass carp (white amur). Other states use sterile triploid grass carp. Regulations concerning the stocking of exotic fish govern the use of grass carp. The fish farmer must be familiar with those regulations in his state.

Legal Constraints

State and federal rules and regulations govern the baitfish industry. A legal constraint may be discouraging to one individual but not another who is familiar with the compliance procedures. Contact the county Extension agent or state fisheries officer for information about regulations and procedures for various types of fish farming businesses. Some states have more regulations than others. However, most regulations exist to protect critical natural resources of the state.



Live hauling truck for local delivery to retail outlets.

MARKETING

Selling baitfish to sportsfishermen can be as simple as setting up a roadside bait house or as complicated as a system of wholesale distributors, jobbers and dealers. It is important to determine a production level that is matched to the market demand whether retail or wholesale.

To determine the species to be marketed and number of fish that can be sold, invest time into researching available market options. Sufficient time spent on marketing before production begins increases the chance of financial success. Remember that organized marketing in the baitfish industry is designed to discourage the entry of new producers. A new producer must find his own niche in the market or face stiff competition from existing growers.

Options

LIVE-HAULERS

Live shipment of fish requires trucks equipped with water tanks and aeration or contracting with live-haulers who have this equipment. Live-haulers can be hired to deliver fish to buyers or they can be buyers themselves. In most cases, the live-hauler is also the distributor or jobber.

By contracting with several live-haulers, the producer can sell large quantities of fish. The live-hauling distributor sells to retail outlets and assumes risks associated with fish transportation and customer credit. Live-hauling trucks vary in design and holding capacities; however, most live-haulers transport between 3,000 and 6,000 pounds of live fish. Larger farm acreages are needed to supply live hauling distributors consistently. A farm size of about 100 water acres is considered large enough to supply regional or national distributors.

ON-FARM DIRECT SALES

Small farmers can sell baitfish directly to fishermen. The location of the farm in the proximity of a developed sport fishery is essential. A fish-holding facility is required to have fish readily available for customers.

Ponds of 1 acre or less are used for growing a single species like fathead minnows or golden shiners. Fathead minnows can be raised with catfish. Small farmers often receive retail prices for their fish and sell ungraded lots of fish. Ungraded fathead minnows are usually sold on the farm as crappie bait.

On-farm sales can also be combined with fee fishing operations. Sportfish ponds can provide an on-farm market for baitfish.

LOCAL RETAIL SALES

Establishing retail outlets or selling to other local retailers may allow the small farmer to increase sales volume. The species of fish produced should reflect demand for bait in the local area.

One problem faced by retailing baitfish is competition from larger distributors. If sales volume increases, competitors may take notice and competitively enter your newly developed market. Locations remote from metropolitan areas or those not already serviced by distributors may provide better markets for small producers. Good customer service and high quality fish help any small producer retain established sales.

The baitfish retailer may also want to provide customers with worms, crickets and other fishing supplies. Snacks, drinks and some grocery items may help attract customers to the bait outlet.

Marketing Strategies

Matching the harvest of baitfish from ponds with the market demand requires careful planning. Stocking rates, stocking times, and feeding schedules influence the size and number of fish available for sale. The producer must develop a strategy to deliver the desired sizes and species of baitfishes required by the market.

The heavier a pond is stocked, the slower fish will grow. Golden shiners stocked in excess of 200,000 fry per acre in June will not be large enough to sell as 3 1/2 -inch crappie bait in March of the following year. Whereas, stocking at lOO,OOO-150,000 per acre will produce fish exceeding 3 l/2 inches the following spring. To produce larger golden shiners, stock at 50,000 fish per acre.

Graded fish are separated at the farm prior to sale. Three grades of fathead minnows and four for golden shiners are commonly marketed (Table 3). Goldfish 1 l/2 to 2 inches long are usually sold in the feeder fish market.

Spring and summer are seasons of highest baitfish demand. Regional and seasonal differences can be overcome by marketing nationally. Weather conditions can cause sudden peaks and declines in demand.

Goldfish are sold to feeder fish markets throughout the year. However, this market is very restricted. Recent growth in the market has been the result of

Table 3. Grading of Salable Sizes of Fathead Minnow and Golden Shiner.*

Grader spacing (inches)	Size classification	Total length (inches)	Fish per pound
FATHEAD MINNOW			
< 13/64	Subsalable	_	_
>13/64 but <15/64	Small	1.75	350
> 15/64 but < 17/64	Medium	2.25	250
> 17/64	Large	>2.75	<175
GOLDEN SHINER			
< 12/64	Subsalable	_	_
> 12/64 but < 14/64	Small	1.75	325
> 14/64 but < 16/64	Medium	2.50	200
> 16/64 but < 18/64	Large	3.00	125
> 18/64	Jumbo	>3.00	<125

*Source: Flickinger, S.A. 197 1. Pond culture of baitfishes. Bulletin 478A. Cooperative Extension Service. Colorado State University, Ft. Collins. CO.

striped bass and hybrid bass production. Some baitfish have a very regional market. The white sucker is used by fishermen in the Midwest and New England states. Before marketing any fish, comply with local, state and federal fisheries regulations, including any state through which live fish are transported or marketed.

Marketing for Different Production Systems

Production systems for baitfish vary in size and intensity of management. Marketing is the most important factor in the success and growth of baitfish farming operations. Producers with small markets, limited time to develop new markets or part-time commitments should consider less intensive, smaller, production systems.

Large farms of hundreds or thousands of acres usually produce several species of baitfishes. Golden shiners, fathead minnows and goldfish are grown in ponds containing only one species of fish (monoculture). Broodfish are spawned, eggs are hatched, and young are grown to market size on the same farm. White sucker producers often collect small fish from the wild. Holding tanks equipped with aerators and graders are constructed in a building. Baitfish are sold to wholesalers from these tanks. Few of the larger farmers sell to retail customers. National markets are serviced by large farming operations.

Smaller farms serve smaller market areas. Wholesale and retail sales are mixed and fewer species are grown. Fish are usually grown in monoculture and the species is determined by local market demand.

One adaptation of the small farm system is the polyculture of fathead minnows and cattish. While using the minnows as forage for catfish, the producer sells some minnows as bait. Lift traps or comer seining can be used to harvest the bait fish . Polyculture operations usually sell only to retail customers; however, some have been able to raise enough extra minnows to service a wholesale route.

ECONOMICS

The cost of development depends on the size and type of production facility. Major investment items include the purchase price of land, pond construction, holding tanks and equipment. Other expenses are for brood fish, mats or boards for spawning, fish feed, fertilizer, utilities, seines, other harvesting items, etc. Pond construction cost varies greatly depending on location.

Since costs vary considerably by location and season, the illustrated cost items and their values should be used as a guide only (Tables 5, 6 and 7). The costs for farm set up and production are for a small golden shiner farm. Costs for farming other species would be similar. For proper planning and evaluation get current quotations from local suppliers and contractors for the items listed.

Table 5. Cost of Investment Items for a 25-acre Golden Shiner Baitfish Farm with 20 Surface Acres of Water.

Item	Units	cost	Your Cost
LAND	25 acres (4-5 ponds)	$20,000	----
POND CONSTRUCTION			
Earth Moving	26,000 cubic yards	$35,100	----
Drain Pipe (8”)	260 feet	1,430	----
Gravel	193 cubic yards	1,545	----
Grass Cover	4 acres	150	----
		$38,225	----
WATER SUPPLY			
Well and Pump	300-500 GPM	$15,000	
Supply Line (4”)	160 feet	520	----
		$15,520	
HOLDING BUILDING			
Tanks	4 (250 cubic feet)	$ 2,500	----
Water Supply Line	500 feet (2”)	1 ,500	----
Building	30’ x 40’	6,000	----
		$10,000	
TOTAL INVESTMENT ITEM COST		$83,745	

Water can be supplied from several sources and costs vary considerably. Most of the expense involves lifting water from a well and distributing it through supply pipes. Several ponds are often constructed near a well to reduce plumbing costs. Canals are often used as an alternative to pipes. Water can be aerated in canals to precipitate out iron. However, canals take

Table 6. Cost of Equipment Items for a 25-acre Golden Shiner Baitfish Farm.

Item	Units	Unit Cost	Your Cost
Boat, motor, trailer	1	**$ 3,500**	----
Seines and harvest items	1	**4,000**	----
Paddle wheel aerator	1	1,500	
Oxygen meter	1	800	----
Chemical kit	1	175	___
Hauling tank	1	1,500	----
Truck	1	$15,000	----
TOTAL EQUIPMENT ITEM COST		$26,475	----

Table 7. Cost Per Acre of Water for Operating a Golden Shiner Farm with 20 Acres of Water Surface.

Item	Quantity	Unit Cost	cost	Your Cost
Brood fish	25 lb	$2.50	$ 63	----
Fertilizer	120 lb	.20	24	___
Feed	2,500 lb	.14	350	----
Labor	12.5 hr	4.75	60	___
Tractor costs	3.4 hr	20.00	68	___
Well operation	5.5 acre ft	20.00	110	----
Truck cost	520 miles	.21	110	----
Chemicals	1 treatment	80.00	80	___
Spawning mats	50	2.00	100	----
Misc. supplies			25	
Telephone			25	___
Insurance			20	___
Tax and permits			20	____
Estimated interest (60% of land, construction, and equipment; 100% of operating)			193	----
Total Cost			$1,248	
Returns from sales of 800 pounds per acre			$2,000	
Net Returns Per Acre			$ 752	----

up acreage that could be used for fish culture. They are usually populated with undesirable wild fishes or predators.

Production Costs

Production costs vary by level of management. Table 7 summarizes estimated costs for culturing golden shiners in 20 acres of water. Two practices, spawning with mats and feeding, increase the cost of operation considerably. In contrast, wild spawning on grasses or fertilization alone costs less, but production would be 300 to 400 pounds per acre rather than 800 to 1,000 pounds per acre. As bait production intensifies, aeration is required to prevent oxygen depletion and fish kills. Aeration requires additional equipment and labor.

REFERENCES AND ADDITIONAL INFORMATION

If you are a new or prospective baitfish farmer, not only will you need information concerning production management techniques, you may also need information concerning processing, marketing, economics, financial assistance, disease diagnostic services, water quality analyses, aquatic weed control, local and state laws and regulations, site selection and development, etc. In some areas, locating this information can be difficult. The following are possible sources of information or assistance.

1. The county Cooperative Extension Service office, usually listed under "County Government" in the telephone directory, can provide assistance. County Extension agents are employees of land grant universities. The county agent may assist you directly or draw upon the experience and training of a university expert or refer you to some other state or federal agency who can provide you with the information or service you need.

2. In the coastal and Great Lake states, land grant universities also have Sea Grant programs. In many of these states, marine advisory service specialists can provide needed information.

3. State game and fish agencies may also be a source of information on laws and regulations, production technology and diseases.

4. The United States Department of Agriculture Soil Conservation Service can assist in site selection and facility development. This agency is usually listed in the telephone directory under "Federal or United States Government."

5. The United States Department of Agriculture's five regional aquaculture centers can refer you to state specialists and other resources specific to your needs. The Centers are:

Center for Tropical and Subtropical Aquaculture, The Oceanic Institute
Makapu'i Point
Waimanalo, HI 96795

North Central Regional Aquaculture Center, Room 13, Nat. Res. Bldg.
Michigan State University
East Lansing, MI 48824-1222

Northeast Regional Aquaculture Center
University of Massachusetts-Dartmouth
Research 201
North Dartmouth, MA 02747

Southern Regional Aquaculture Center
Delta Branch Experiment Station
P.O. Box 197
Stoneville, MS 38776

Western Regional Aquaculture Consortium
School of Fisheries WH10
University of Washington
Seattle. WA 98195

6. The United States Department of Agriculture National Agriculture Library is the national Aquaculture Information Center. It provides informational services on aquaculture. The address is:

U.S. Department of Agriculture
Aquaculture Information Center
Room 304, National Agricultural Library
10301 Baltimore Boulevard
Beltsville, MD 20705

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30-, 1914, The University of Georgia College of Agricultural and Environmental Sciences and the U. S. Department of Agriculture cooperating.

C. Wayne Jordan, Director

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