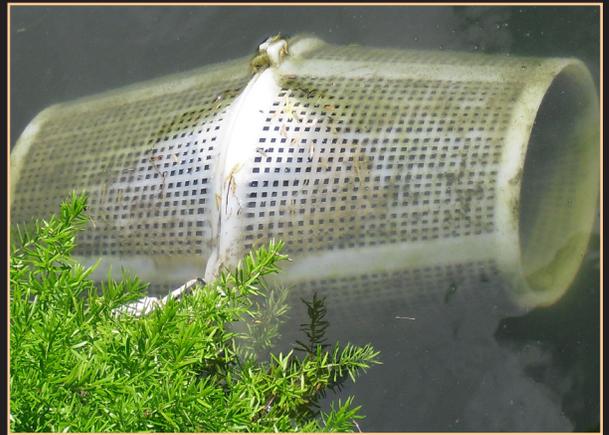


# Cocahoe Minnow

## Production Manual



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# Chapter 1. Introduction



Figure 1.1 A young angler fishes the Louisiana bayou. Photo: Louisiana Sea Grant.

Both marine and freshwater anglers have historically used wild stocks as a source of baitfish. The culture of freshwater baitfish began in the early 1950s in Mississippi, Arkansas, and Missouri as wild stocks became more difficult to harvest and interest in angling increased after World War II. Rapid expansion in the freshwater baitfish industry has resulted in well-established pond production techniques, which provide a consistent supply of fish for anglers. At present, marine baitfish culture is not well established, and a majority of marine baitfish is captured from wild stocks for sale to anglers.

from multiple wild-caught sources, the majority are not able to get enough to satisfy demand throughout the year. Thus, the supply of cultured cocahoe minnows could help to fulfill the demand that is currently unmet. Of those surveyed, most were interested in the various aspects of cocahoe minnow production (producing eggs, growing the fish, sales). Additionally the vast majority have unlimited access to saltwater for cocahoe culture and holding. The expected volume of cocahoe minnow sales is quite high, with the majority estimating weekly sales greater than 1,000 fish, and over 25 percent estimate weekly sales to be greater than 5,000 fish. Culture of marine baitfish could provide Louisiana anglers with a consistent supply of high-value live bait. Research was done at the LSU AgCenter’s Aquaculture Research Station in Baton Rouge, to identify best practices for culturing cocahoe minnows. In this production manual, we summarize the research findings and current best management practices for raising cocahoe minnows in Louisiana.

The development of an industry centered on the culture of marine baitfish represents a promising new opportunity within Louisiana and the surrounding coastal region. Of particular importance is the cocahoe minnow or Gulf killifish, *Fundulus grandis*, which is popular for redfish, speckled trout, flounder, and many other species. A survey about cocahoe minnow sales was sent to marina owners and bait shops, with a response rate over 50 percent from eight parishes (Figure 1.2). This survey indicated that more than 50 percent of bait sellers could not meet the demand for Gulf killifish, even with three or more suppliers (See Survey Report for additional information). The high level of responses to the survey indicated that there is interest in the “growing cocahoe minnows for bait” project. The majority of respondents were involved in sales of live bait to anglers; many of whom currently sell cocahoe minnows. While many respondents get their supply of cocahoe minnows

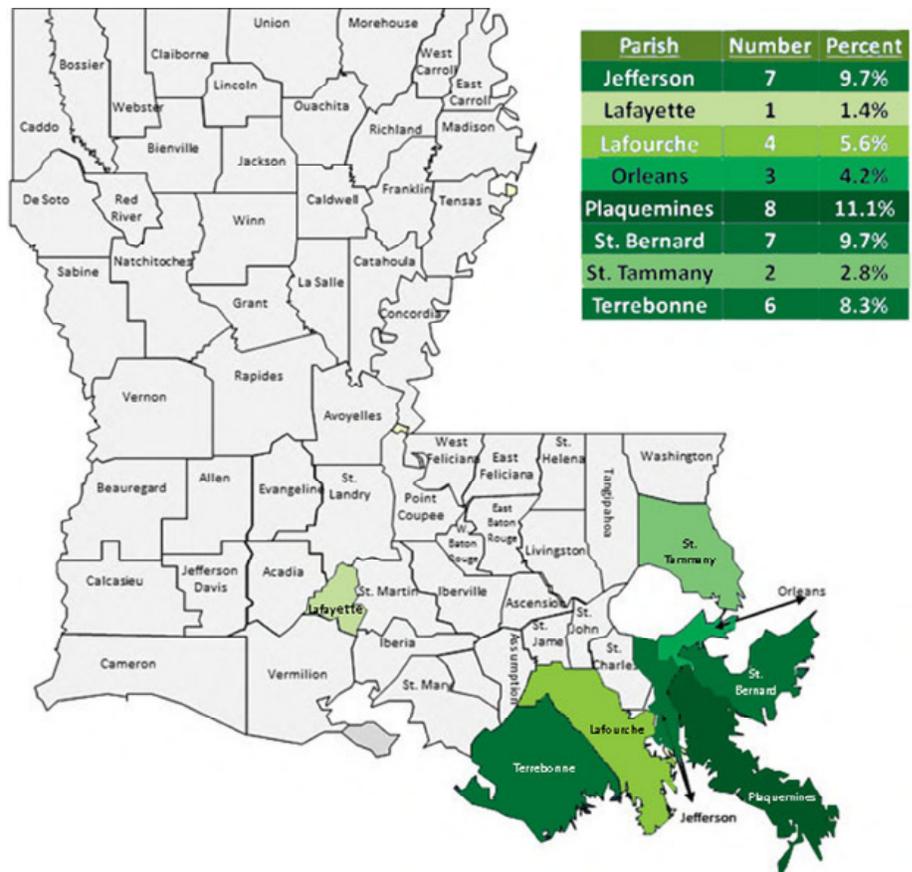


Figure 1.2 Percent by parish that were responded to the survey.

## Chapter 2. Killifish Biology



Figure 2.1 Typical Louisiana marsh, the cocahoe minnow's natural habitat. Photo: Paula Ouder

The Gulf killifish is commonly found in the estuaries along the Gulf of Mexico. The Gulf killifish, also known as the cocahoe minnow, mud minnow or bull minnow to many anglers, is a popular baitfish. In the wild, it can tolerate wide swings in salinity and oxygen as the marsh it inhabits is often a harsh environment. Specifically, these fish are able to tolerate many diseases, a wide range of salinities (from 0.5 parts per thousand (ppt) up to 76.1 ppt), and temporarily, low concentrations of dissolved oxygen.

Within their natural environment, cocahoe minnows are reported to spawn throughout the summer months, with peaks observed in early summer and late fall. Adult males and females are easily to distinguish



Figure 2.2 Cocahoe minnows; female (top) olive drab coloration and male (bottom) vibrant coloration, silver flecking and visible stripes. Photo: Craig Gothreaux

based on appearance, (Figure 2.2) making it easy to establish sex ratios when stocking. One of the issues aquaculturists of this species have encountered is the cocahoe's reproductive output, which is lower than other popular baitfish such as the golden shiner, *Notemigonus crysoleucas*, and goldfish, *Carassius auratus*. Spawning output for this fish varies with female size.



Figure 2.3 Freshly hatched cocahoe minnow larvae. Photo: Craig Gothreaux

However a typical individual can release between 100–250 eggs over a five-day period. While egg production is lower than some other species, an advantage is that the larvae are highly developed when the eggs hatch (Figure 2.3).

Cocahoe minnow eggs are partially resistant to drying when exposed to air. Spawning events are timed with semilunar tidal cycles when eggs are deposited at the high water mark of marsh grasses during spring tide and are exposed to air once the tide recedes. The eggs then hatch once the tide rises and the eggs are submerged again. Several killifish, such as the mummichog, cocahoe, and marsh killifish, can incubate their eggs out of water in humid environments. This technique called delayed hatching may be exploited to increase cohort size during aquaculture production.

Cocahoes are opportunistic omnivores, meaning they consume whatever plant or animal material is available. Their diets literally change with the tides. When the tide is low and fish are confined to the subtidal and low intertidal areas, they tend to feed on small crustaceans (amphipods) and plant material. Once the incoming tide floods the marsh surface, they actively forage on a wide range of food including grass shrimp, various small crabs and other small crustaceans, insects and larvae, worms, snails, fish, and detritus. Studies indicate that these fish typically enter the marsh hungry (low or empty gut content) and leave full (more diverse and greater amount gut content). This varied feeding behavior means they will actively forage on natural foods and are willing to accept prepared diets.

# Chapter 3. Water Quality

Water quality may be the most important factor in cocahoe minnow production. This section introduces parameters that must be taken into consideration when raising fish. A number of factors must be managed properly to ensure good survival and health of fish.

## Dissolved Oxygen (DO)

Dissolved oxygen is the most important factor to successfully maintain live bait. DO is often measured in parts per million (ppm) or milligrams per liter (mg/L), and the ideal range for live fish is 6 to 10 ppm of oxygen. At no time should oxygen be allowed to fall below 4 ppm.

DO problems may be chronic or acute. The most common chronic DO problems are caused by (1) overloading systems with too many fish and (2) warm, stagnant water. In addition, overfeeding, and uneaten feed can cause ongoing oxygen problems. The first sign of oxygen-related stress is usually an abrupt lack of activity, followed shortly by minnows crowding up at the surface and gulping for air or congregating near a water inlet or air stone.



Figure 3.1 Electric surface agitator used to increase oxygen and water flow. Photo: Greg Lutz

DO problems can usually be corrected by reducing the number of minnows per gallon of water (to about 1 pound of fish per 10 gallons of water). Other methods to improve oxygen levels include pumping tank water through spray nozzles, but avoid creating strong currents that can damage or exhaust fish. Some facilities use electric agitators to maintain sufficient levels of oxygen, but again care should be taken to avoid creating excessive currents



Figure 3.2 Air stones are an effective method to oxygenate water. Photo: Jill Christoferson

that can damage or exhaust live bait. Low-pressure air pumps and air stones can also be used to aerate tanks. An alternative in some situations is to use a low flow of compressed oxygen through an air stone; however, care should be taken not to super saturate DO from an oxygen bottle.

## Chlorine

Chlorine or chloramine is added by water companies to tap water to remove bacteria. Even very low concentrations of chlorine or chloramine can cause damage to the gills of minnows. Chlorine or chloramine in tap water can be removed by adding commercially available products such as sodium thiosulfate, or chlorine can be removed by aerating the water overnight.

### Note:

Chlorine will evaporate out of tap water over a few days, but chloramine will not and needs to be chemically removed.

## Temperature

Cocahoe minnows can tolerate a wide range of temperatures but cannot tolerate sudden temperature changes. The ideal temperature range for most bait holding systems is usually between 60 °F and 80 °F. Avoid direct sunlight on systems during most of the year to minimize unwanted heating (Figure 3.3). Under some limited circumstances, indoor fans can be directed across the surface of holding tanks to provide for evaporative cooling.



Figure 3.3 Use of shade cloth in outdoor pools can slightly reduce temperature over warmer months. Photo: Craig Gothreaux

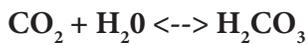
## Alkalinity

Ideally, baitfish systems that rely on biological filters should have water with alkalinity ranging from 100 to 250 ppm. In most instances, higher alkalinity will not cause problems, but lower levels may reduce the ability

of biofilters to break down ammonia into less toxic products. Alkalinity is a measure of carbonate and bicarbonate in water, and baking soda (sodium bicarbonate)

Water Parameter	Safe Range
DO	6-10 ppm
Chlorine	0
Alkalinity	≥ 100 ppm
pH	7.0-8.5
Salinity	5-15 ppt
Temperature	60 °F -80 °F
Total Ammonia Nitrogen	< 1mg/l

can be added to water as needed to maintain alkalinity levels at or above 100 ppm. Alkalinity also provides a buffer against acidification of water due to CO<sub>2</sub> buildup (really carbonic acid in equilibrium)



### pH

pH is a measure of the acidity of water. Normal levels are in the range of 7.5 to 9 pH units. pH can usually be maintained at acceptable levels as long as alkalinity is above 100 ppm. Moving live bait from a system where pH has already reached low levels into fresh water with a higher pH can cause stress and occasionally result in death.

### Ammonia

Total Ammonia Nitrogen (TAN) is given off as a waste product by the minnows, and therefore, can build up from overfeeding or overcrowding. As it builds up, it can become toxic to the fish. Bacteria break down ammonia to less toxic nitrite. Further breakdown results in the less toxic stable form of nitrate. Ammonia needs to be monitored to prevent mortality. The safe range of TAN decreases with higher pH and temperature, but generally should be less than 1.00 ppm.

### Nitrites

Nitrites are the less toxic product of broken down ammonia. While nitrites are considered relatively toxic in freshwater systems, they have a much less detrimental effect in saline water. As long as cocahoes are raised in their optimal salinity, between 5-15 ppt, nitrites should have a minimal effect on fish health unless the system

has a severe nitrite problem. For best results nitrite levels should try to be kept below 10 ppm.

### Toxic Substances

A number of commonly used household products can be toxic to live bait. These include insecticides, insect repellents, and common cleaning solutions used on windows, floors or other surfaces. Additionally, certain paints and metal fixtures used in holding systems can be toxic to live bait as well. Plumbing in fish holding systems should be done with PVC and not copper. Holding tanks made of concrete or block can release alkalis into the water for some time unless treated. The easiest approach is to fill a new concrete tank with water and add 1 pint of vinegar for every 50 gallons of water. Leave this solution in the tank for 4 or 5 days, drain, and repeat. Similarly, galvanized tanks can release zinc, which is toxic. Galvanized tanks should be coated with waterproof epoxy paint or other nontoxic coatings. Care should be taken whenever applying coatings to allow for sufficient curing time and flushing of any unwanted residues prior to putting holding tanks into use.

### Salinity

See Chapter 4.

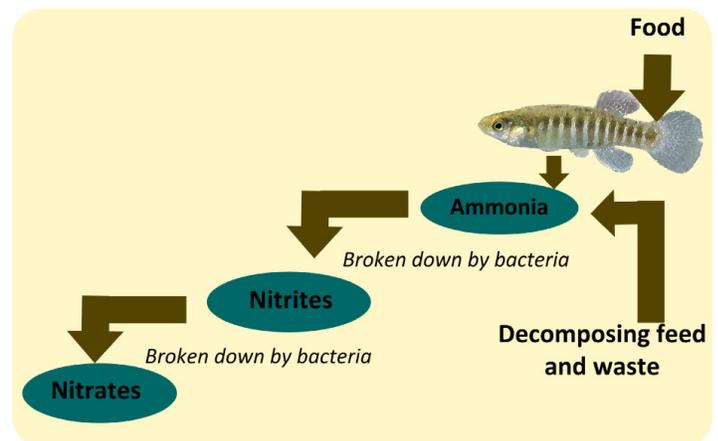


Figure 3.4 The ammonia cycle, begins with waste produced by fish in conjunction with decomposing elements such as uneaten feed produce ammonia, (NH<sub>3</sub>) which is toxic. This is broken down by bacteria to yield Nitrite, (NO<sub>2</sub>). Nitrite is then broken down further to Nitrate, (NO<sub>3</sub>).

# Chapter 4. Salt

Cocahoe minnows are an estuarine species. This means that they typically live in water that has varying amount of salt. How salty the water is, or the salinity, can be measured several different ways. The most common is parts per thousand (ppt or percent) or how many salt ions there are for every thousand water molecules. Salinity can also be measured in grams of salt per liter of solution (g/L). Cocahoe minnows can tolerate a wide range of salinities for at least short time periods. However, they do best in water between 5-15 ppt. When raising cocahoe minnows, or any other fish, it is important to take into consideration what kind of salt to use to maintain salinity. The most common forms of salt, such as road salt and rock salt contain only sodium chloride. Seawater, however, contains many other ions that are necessary for the survival of the fish. These ions include, but are not limited to, calcium, potassium, magnesium and sulfate in addition to sodium and chloride. All of these components play an important role in raising healthy fish.

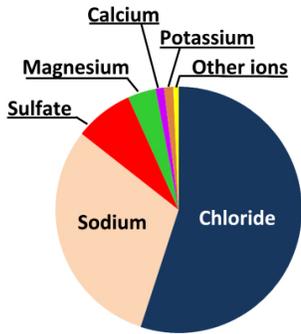


Figure 4.1 The elemental components of ocean salt.

When raising cocahoe minnows, or any other fish, it is important to take into consideration what kind of salt to use to maintain salinity. The most common forms of salt, such as road salt and rock salt contain only sodium chloride. Seawater, however, contains many other ions that are necessary for the survival of the fish. These ions include, but are not limited to, calcium, potassium, magnesium and sulfate in addition to sodium and chloride. All of these components play an important role in raising healthy fish.

## Kinds of Salts

Salt comes with many names and in many forms; however much of it means the same thing. The following table will help navigate the wide world of salt.

Name of Salt	Components
Table Salt	Sodium, Chloride and in most cases Iodine, Potassium and other additives (NOTE: Iodine is very harmful to fish and should therefor not be used)
Rock Salt, Halite, Solar Salt, Sea Salt	Sodium and Chloride only
Marine Salt	Chloride, Sodium, Sulfate, Magnesium, Calcium, Potassium, Bicarbonate, Bromide, Strontium, Fluoride

Salt compositions are basic overviews for each category and will vary by brand.

## What Kind of Salt to Use

The kind of salt to use depends on the source of the water. It is important to get the water tested for ionic content; Louisiana State University Department of Agricultural Chemistry charges about \$15 to test a water sample. There are also private companies that will test water samples usually for a fee. When using dechlorinated water from a tap or hose it will most likely require a marine salt. When using natural water from a bayou, estuary or pond, many of the additional ions may be present. If the water has most of the required ions, a cheaper salt, like rock salt, may be adequate or it may need to be supplemented with only a single missing ion like potassium. Rock salt is typically much less expensive than marine salt especially when using large quantities. For this reason it is best to use rock salt due to cost. However, it does not contain potassium, magnesium, and calcium, which are very important ions that cocahoes need to survive. Never use table salt. The iodine and additives it contains can be harmful to fish and invertebrates.

## How Much Salt to Use

The amount of salt needed depends on the salinity of the water source and the desired end salinity. Most marine salts will have directions to make full strength seawater, about 30 ppt. Cocahoe minnows can be raised at a lower salinity. As a rough guide, about 1 lb. of salt per 10 gallons of freshwater will yield about 12 ppt, an ideal salinity for raising cocahoes. However, this can vary depending on the water and type of salt used, and every culture situation should be assessed independently. A salinity-measuring instrument will be needed to check salinity not just while mixing the water but also periodically after the system has been established as evaporation will raise the salinity. There are several different types of instruments to measure salinity that range from the fairly inexpensive hydrometer, to a slightly more expensive refractometer, to the several thousand dollar electric water quality meters that can measure salinity, dissolved oxygen, pH, temperature, depth, etc. In most cases, a hydrometer or refractometer will be more than sufficient. Do not mix the startup water while the fish are in it as the rapid change in salinity can cause shock. Make sure salinity is at the right level before adding water to livestock.

# Chapter 5. Production Systems

There are two types of production scenarios regardless of the growing facility (whether ponds, pools or recirculating systems). These scenarios are the two-phase system, which uses two isolated units: one for broodstock to produce eggs and the other to hatch and grow the minnows to market size. The three-phase systems have separate units for broodstock, hatching eggs, and grow out (Figure 5.1). A dependable supply of salt or brackish water of good quality and quantity is very important to the successful culture of killifish in a

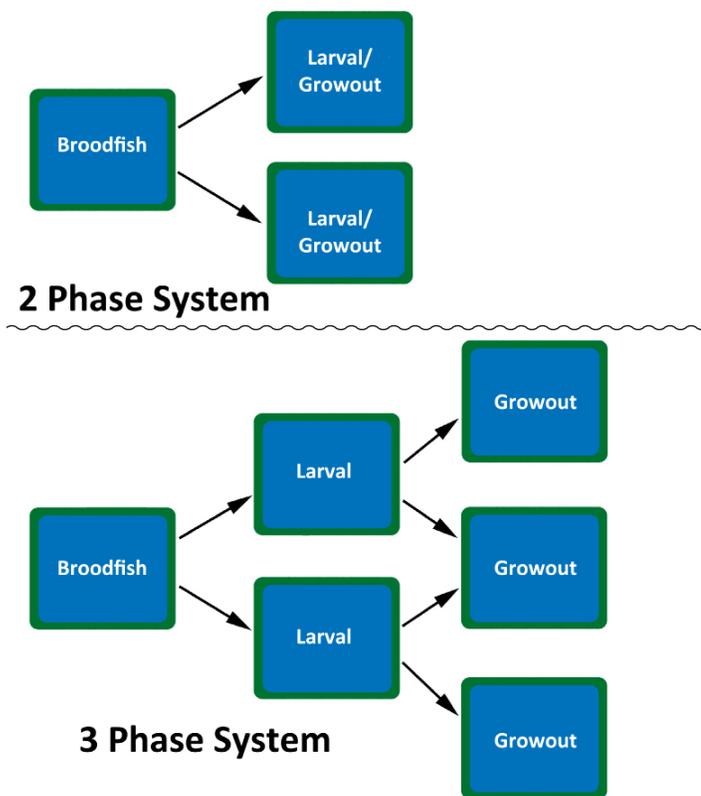


Figure 5.1 Two and three phase system.

production facility. Size of production system is usually dependent on the water to refill between crops and the quantity of fish that can be handled safely. The systems used in production are summarized below.

## Ponds

Pond aquaculture is one of the oldest methods of growing fishes. Pond culture has been used successfully in raising cocahoe minnow in several southern coastal states. Growth of cocahoes is inversely related to

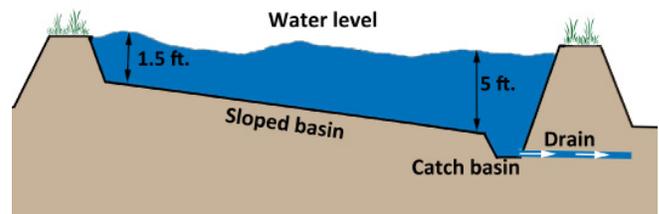


Figure 5.2 Lateral diagram of ideal pond form. stocking density; hence juvenile minnows (0.3 g to 0.5 g each) have been grown at 50,000 to 200,000 fish per acre in grow-out ponds depending on how soon they are needed on the market. Generally, the lower the stocking density, the faster the growth will be.

The optimum pond size has not been evaluated because most of the experimental studies have used smaller ponds (about 0.2 to 1 acre surface area). Natural productivity is critical to the successful culture of cocahoe minnows in ponds hence water should be fertilized to stimulate production of natural foods. Pond bottoms should be smooth and well graded to allow easy drainage. Culture ponds should have catch basins to assist in harvesting fish (Figure 5.2). Ponds of approximately 3-4 feet average depth having about 1.5 feet at the shallow and 5 feet at drainage end are good for minnow culture. All ponds should be filled with water that is passed through a fine cloth filter, about 800 microns or 0.03 inch is recommended, to eliminate wild fish that could compete for food or eat the cocahoes.

## Pools

Above ground tanks made of plastic or fiberglass have been used as pools for growing minnows. Research at the Aquaculture Research Station has utilized pools with bottoms filled



Figure 5.3 Fiberglass pools used for egg production. Photo: Craig Gothreaux with bottoms filled with dirt, which has proved to be valuable in regulating ammonia concentrations. As in ponds, natural productivity in pools is very important as it provides

supplemental nutrients, which may be absent or in insufficient amounts in the artificial diets given to the minnows.

Using pools instead of ponds has several advantages. Predation can be controlled from birds and other mammals as pools can be covered with nets. In addition, there are no problems with seepage from the surrounding area, which can contaminate pond water and even become toxic to fishes.

### Recirculating Aquaculture Systems (RAS)

Compared to ponds and pools, this is a rather recent technology for growing fish. Unlike the ponds and pools, this system enables the growing of fish at high densities in indoor tanks with a “controlled” environment for year-round production. In using RAS, farmers need very good biofilters to regulate nitrogenous wastes like ammonia. Many RAS units contain ultraviolet (UV) filters and other sterilization tools to keep algae and pathogens (associated with diseases) out of culture tanks. However, they are not required in all cases. Tanks need to be aerated continuously to supply DO to the minnows.

RAS offer fish producers a variety of advantages over pond culture. These include a method to maximize production on a limited supply of water and land, nearly complete control over the culture environment to maximize growth, the flexibility to locate production facilities near markets, complete and convenient harvesting, and quick and effective disease control.

Producers are able to manipulate production to meet demand throughout the year and to harvest at the most profitable times during the year.

In spite of these advantages, using RAS greatly increases initial cost of production, as it is highly mechanized (see Economics section). All the nutritional requirements of the minnow must be provided through feed. Research at the LSU AgCenter’s Aquaculture Research Station has shown that stocking density of two fish per liter and five fish per liter are the optimum densities for fry (0.05 g) and juvenile killifish (0.4 g) in RAS. In addition, initial research has demonstrated that recirculating technology does not result in the relatively faster growth as seen in ponds and pools.

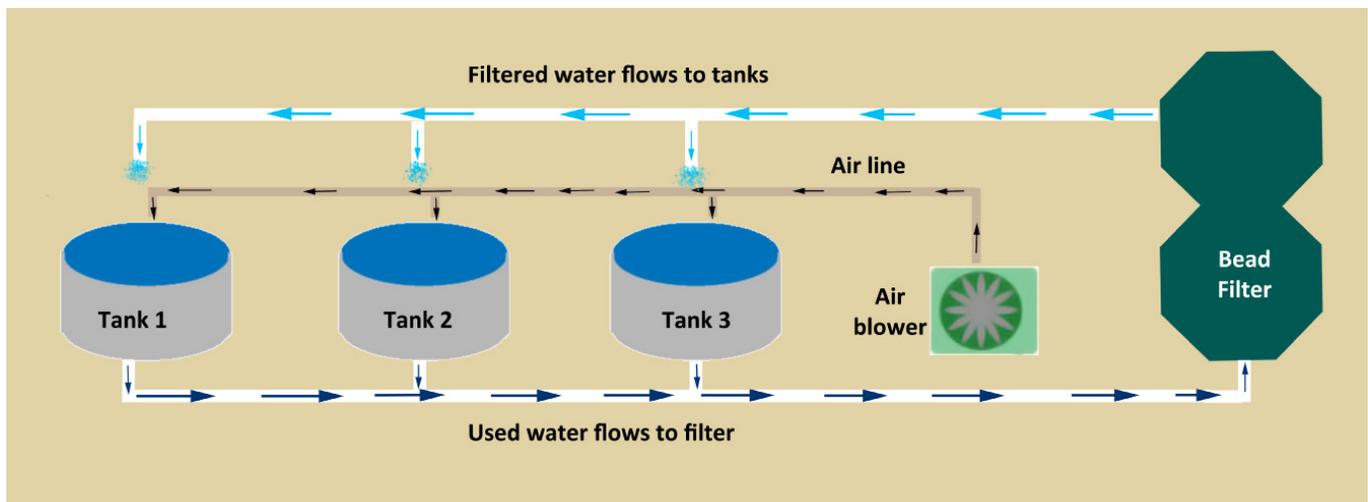


Figure 5.4 Diagram of a typical recirculating aquaculture system.

# Chapter 6. Spawning

## Pond Spawning

Production of cocahoe minnow eggs outdoors is achievable through the spring, summer, and fall months. Utilizing fertilized ponds has been successful in several southern coastal states. Pond spawning requires an ample supply of brackish water with a salinity between 5-15 parts per thousand (ppt) and a substantial amount of land. To prevent wild fish from entering the pond, the water source should be covered with a fine mesh as mentioned in the previous chapter. The three-phase system is the most popular system used for pond spawning and production and the one that will be explored in this chapter.

**Phase-1:** Phase-1 ponds are the spawning ponds strictly used for egg production and collection. Adult cocahoos that are 0.45 ounces or larger should be stocked at 10,000/acre with a 2:1 female to male ratio. Fish should be placed in ponds in mid-January to early February before water temperatures reach 59 °F. The fish should receive a feed with 28-40 percent protein at a ration of about 3 percent body weight twice a day.

As water temperatures reach 68 °F, place synthetic substrates or mats (Spawntex®) around the shallow edge of the pond for the females to lay their eggs on. Mats are about 2 inches thick and made of coconut fibers with a latex binder. This material is generally purchased by the roll and will need to be cut into smaller sections, about 3 feet by 2 feet is recommended. Attach the cut sections to a wire frame, and then suspend the sections below



Figure 6.1 Spawntex® mat with PVC floats. Photo: Craig Gothreaux

the water surface. This can be done using floats as in the picture shown but other methods will work as well (Figure 6.1). The mat material is too dense to allow fish to pass through, but each mat has sufficient void spaces to allow eggs to be trapped and retained.

The mats should be left in the pond 3-7 days depending on the rate of egg deposition and temperature. Mats should be checked

on a regular basis and transferred into the Phase-2 pond all at the same time. For more information on hatching different batches of eggs at the same time, see Chapter 7. This helps to prevent erratic hatching dates and variable sized fish that will lead to larger fish eating the smaller younger fish. When the mats are removed they should be replaced with new mats.

Peak egg production in the spring occurs between April and mid-May, and again in the fall in September and October, when weekly water temperatures range from 75 °F to 83 °F in the Baton Rouge, LA area. Your local temperatures may shift these peaks earlier or later.

**Phase-2:** Phase-2 ponds are hatching ponds used for eggs and growing fry. Hatching ponds are prepared in advance by filling to 1/3 capacity and fertilizing

with organic and inorganic fertilizers two weeks prior to stocking to promote plankton blooms. This will establish a first food for newly hatched fish. Treatments should be

administered to kill predaceous insects, and wild fish should be excluded. As the fry hatch in the pond, they are fed a finely ground minnow meal, 28-30 percent protein, at 5 pounds per acre a day. Fry and fingerlings are cultured in the Phase-2 ponds for 60-80 days.

**Phase-3:** The young fish are then transferred into a prepared Phase-3 pond for grow out to market-size minnows. Procedures and practices for grow out and ponds are available from previous extension and research documents (See Additional Resources section).

## Pool Spawning

Utilization of above ground pools at low salinities is practical for production of a large number of cocahoe minnow eggs. Production of eggs is achievable outdoors throughout the summer, with peaks in spring and

### Note:

The amount and type of fertilizer to use will depend on the size and condition of your pond. Please look into the Southern Region Aquaculture Center (SRAC) articles and other references listed below for more information about fertilizing ponds. You may also contact your local extension agent for this information.

fall (April or early May and September and October). Using pools to spawn coahoe minnows is practical for multiple reasons. Most predators, such as birds, can be excluded by using netting to cover the pool. Little water exchange is involved when using pools containing dirt, which helps to regulate nitrogenous waste. Pools typically contain lower numbers of broodfish, and river silt or other organic bottom cover can be used as both filter and waste trap. It is also easier to observe fish in small pools than fish in ponds.

**Research Study:** For the experiment at the AgCenter Aquaculture Research Station, 500-gallon pools were used. Two weeks prior to stocking, all pools were filled and fertilized daily with approximately 1.5 ounces of powdered feed (45 percent protein). Approximately 25 pounds of salt was added to each pool, which resulted in 5 ppt salinity. A regenerative blower supplied continuous aeration to all pools via air stones. The pools were stocked at a 2:1 female: male ratio. A synthetic spawning substrate or mat (Spawntex®) was used for the females to deposit eggs. Eggs were harvested from the mats every 3-4 days from April to October. Water was added as needed to maintain depth in the pools.

**Stocking and Feeding:** For experimental purposes, groups of pools were stocked with different numbers of females, but we found that a ratio of 60 females: 30 males resulted in the most eggs. Fish were fed a commercially available 45 percent protein, 12 percent fat, 2.4 mm diameter, extruded feed once daily at 3.5 percent of initial body weight per day. This percentage was constant throughout the study and adjusted for growth at two and three months after initial stocking. Currently studies indicate that a 40 percent protein, 9 percent fat ration could be cheaper and have similar results.

**Water Quality:** Prior to stocking and weekly thereafter, dissolved oxygen (DO), pH, salinity, total ammonia nitrogen (TAN), total alkalinity, and total hardness were recorded for each pool. Salinity was maintained at 5-6 ppt using rock salt. Temperature ranged from 67 °F to 88 °F. Water quality parameters were maintained within acceptable ranges: DO remained above 5.5 mg/L, pH ranged from 8.2 to 9.2, salinity ranged from 4.7 to 9.5 ppt, TAN ranged from 0 to 1.4 mg/L, alkalinity ranged from 310 to 900 mg/L, and hardness ranged from 200

to 420 mg/L. In June, temperature was reduced by placing Styrofoam panels over each pool for shade.

**Egg Collection:** A Spawntex® spawning mat was placed in each pool for spawning substrate. These mats are constructed of coconut fibers with a latex binder on a polyester net backing. Spawning mats were cut into 18 x 24 inch sections, placed on a wire frame, and then suspended 6 inches below the water surface from two floats made of sealed PVC tubing. Spawning began within 24 hours after mats were placed in pools. The mats were collected twice per week and replaced with clean mats. Depending on preference, egg-laden mats can be transferred into a hatching pool/pond for water incubation, or the eggs can be removed for air incubation.

For the purpose of the experiment, we needed to remove eggs from the spawning mats in order to quantify the



Figure 6.2 Live and dead eggs.  
Photo: Paula Ouder

numbers produced from each pool. Eggs were removed by manually tapping and shaking mats against a rigid screen positioned over a water-filled, plastic container.

Egg-laden water from the container was poured through nylon mesh (window screen) to collect the eggs. The eggs were separated from debris (algae, mat fibers, etc.) in order to quantify the numbers volumetrically. We found that 1 mL of eggs is roughly equal to about 100-120 eggs, as these eggs tended to decrease in size across the spawning season. Not all eggs produced are fertilized and/or viable, but the live eggs (brown pigment) can easily be distinguished from the dead eggs (white in color) as seen in Figure 6.2. After collection the eggs can be placed in hatching jars or be air incubated (see Air Incubation Section).

**Egg Production:** Throughout the study period, the 360 females stocked out produced more than 380,000 eggs. Egg production varied monthly due to natural semi lunar (tidal) cycles, with peaks occurring between full and new moon phases. The overall peak in egg production occurred between April and mid-May, when weekly water temperatures ranged from 75 °F to 83 °F (24 °C to 28 °C).

# Chapter 7. Air Incubation

## How To:

This type of homemade incubator will only be effective for outside temperatures warmer than the desired temperature. To make an incubator out of a working refrigerator acquire an external temperature controller, like the one pictured below. Connect the refrigerator to the female plug of the temperature controller. The male plug goes into an outlet. Place the display in an easy to see but out of the way area. Put the temperature sensor inside the refrigerator with the wire running out to the display. Make sure that the door will still close securely. Set the desired temperature on the dial or display, depending on the model you have. The temperature controller will turn the refrigerator on and off to achieve the desired temperature.

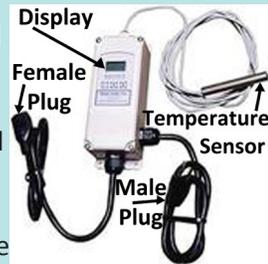


Photo courtesy of Aqua Logic Inc.

Air incubation appears to be a common occurrence in wild cocahoe minnows. Females are known to lay their eggs among the marsh grass during maximum high tides where they develop fully exposed to the humid air when the tide recedes. The eggs then hatch when they are flooded by the next maximum high tide, approximately 13-15 days later. This situation can be replicated in an aquaculture setting. Air incubation encourages all of the eggs to hatch at the same time yielding uniform sized larvae and subsequently uniform adult minnows. This reduces the likelihood of larger older minnows eating the newly hatched larvae. In addition, air incubation provides the opportunity for easy transport of eggs to grow out facilities or other locations.

## Recommended Procedure

Soak sheets of synthetic foam such as Expanded Polystyrene (EPS) or soft hobby foam in clean saline water approximately 5-15 parts per thousand (ppt), the same salinity used for hatching. Ensure that the foam sheets are wet but not soggy or over saturated. In lieu of foam sheets, eggs may be incubated directly on the spawning mats. Place one mat in a shallow container of the same size with a loose fitting lid (plastic is the most common). If using foam, place eggs on top of the foam sheets and gently cover with another moist foam sheet of the same

size. Place the lid on the container ensuring that it is loose enough to allow some airflow. The container(s) should then be placed in an area with a constant temperature between 68 °F and 74 °F. The temperature should be stable for the entire incubation period. A homemade incubator can help with this. An incubator can be made out of a working refrigerator by following the instructions in the “How To” box. The warmer the temperature, the more accelerated the development will be, shortening the incubation period. This allows for

Table 7.1 Minimum and maximum of days incubation for eggs hatched using air incubation. Data provided by Charles Brown.

Temperature	Minimum Number of Incubation Days	Maximum Number of Incubation Days
86 °F	5	11
79 °F	7	15
73 °F	9	19
68 °F	11	23

egg batches of different ages to be hatched at the same time by storing them at different temperatures. See Table 7.1 for a list of temperatures with approximate incubation periods. Moisten eggs every two days with salt water (5-15 ppt) in a spray bottle. Once the eggs are

## Helpful Tips:

- Use an incubator or modified refrigerator to maintain temperature (68-74°F) and keep egg-eating fruit fly larvae out
- Put eggs in containers at low densities to help control fungus
- Use saline water between 7-12 ppt to help fight against fungus
- Eggs must stay moist with salt water but not soaked to ensure true air incubation and help control fungus
- Make sure to clean and dry used incubation foam thoroughly after every use to prevent fly larvae infestations

ready to be hatched out, submerge eggs in water of the same salinity they have been stored. They should hatch in a few hours or minutes depending on their readiness to hatch.

Shortly after hatching, larvae will have the ability to feed. Feed options at this stage include live artemia nauplii (newly hatched brine shrimp), commercial larval diets (Otohime), or plankton collected from a natural water source or aquaculture pond.

# Chapter 8. Feeding and Nutrition

Modern fish feeds have evolved to be specific to the nutritional needs of a wide variety of species. The exact nutritional requirements for Gulf killifish are not known at this time; however, a few general assumptions can be made based on research completed to date. Additionally, information from nutritional studies of freshwater baitfish can help provide guideposts and general recommendations for Gulf killifish culture. The following is a summary of the issues related to Gulf killifish feeding and nutrition, with reference examples from published studies and personal observations, or from freshwater baitfish research when information specific to Gulf killifish is not available. This section serves as a basic summary of nutritional information for Gulf killifish culture. The type of culture system will influence whether diets are used as sources of supplemental nutrition, or to provide the complete nutritional needs of the fish.

## In Ponds or Outdoor Systems

The natural productivity of a fertilized pond or outdoor tank will provide at least some nutritional value to cultured fish. Natural foods are inexpensive sources of nutrients to fish, but the quantity and quality available will be determined by following appropriate fertilization and monitoring regimes. Rotifers and other plankton in a newly fertilized pond make easy prey for newly hatched fish that are ready for first feeding. As fish grow, so does the preference for larger zooplankton like copepods, insect larvae, worms, and snails. The role of prepared diets becomes more important as the amount of natural food decreases due to high fish density or low natural production. Previous studies on Gulf killifish reared at low densities in ponds found similar growth in fertilized ponds with or without supplemental feed. It is unclear whether supplemental feeding in Gulf killifish ponds results in direct consumption, or just serves as an additional source of fertilizing nutrients to support natural food. However, in the more thoroughly studied freshwater baitfish industry, the use of modern manufactured feeds greatly increased baitfish production even when natural foods were present.

The need for, and role of, supplemental feeding in Gulf killifish pond or outdoor tank production will be tied

directly to two factors: 1) density of fish stocked and 2) water temperature. When natural production is below the total nutritional demand of the biomass, then growth will be stunted if the system is not provided a supplemental diet. Seasonal variability also plays a role in outdoor production characteristics, as fish will eat more and grow faster when water temperature is warmer.

## In Tanks or Indoor Systems

When Gulf killifish are cultured in indoor closed systems, all of the nutritional requirements for survival and growth must be provided by the diet. Using a nutritionally complete, high quality diet increases the efficiency of these intensive fish culture systems. The benefit of this type of system is the complete control over variables influencing growth. Temperatures can be maintained at ideal levels, oxygen or aeration is typically constant, and fish can be fed multiple times per day with the use of automatic feeders. The caution is that closed recirculation systems are limited by the capacity of the filtration system to remove the nitrogenous waste byproducts (ammonia, nitrite). Care should be taken to only feed fish an amount that will be consumed in a short period of time (20-30 minutes), as excess feeding can reduce water quality and is an expensive waste of feed.

## Feeding Practices

The first nutrition derived by larval fish is provided by the yolk, which originates from the body, and thus diet, of female broodfish. Early hatching fish have large yolk volumes and will remain near the bottom of the tank. Once the yolk has been consumed, they begin exhibiting characteristics of swim-up fry, indicating readiness for first feeding. This can occur a few days after hatching, or shortly after hatching in the case of air-incubated embryos delayed past the normal hatch date. Brine shrimp are typically the first food offered, as they contain relatively high levels of nutrients and offer a moving live food that can benefit the predatory instincts of larval fish. After a few days of brine shrimp feeding, high quality powdered starter diets can be introduced, with a gradual total replacement. Recent studies have indicated some success in using commercially available

Feed type, composition, and size	Larvae (0.01 g)	Fry (0.05 – 0.5 g)	Juvenile (1 – 5 g)	Market size (5 – 7 g)	Brood fish (8 – 20 g)	Feeding rate
Breeder 45-12; 2.4mm						1 – 2 x/day
Maintenance 32-04; 3.6mm						1 x/day
Grower 40-09; 2.4mm						2 – 3x /day
Micro 50-14; 0.8mm						4 – 6x/day
Starter 50-10; powder						4 – 6x/day or constant
Artemia 56-17; live						1 – 3x/day
→ Hatch date	→ 2 weeks	→ 2 months	→ 4 – 6 months	→ 6 – 10 months	→ 8 – 12 months	

Figure 8.1 This chart provides examples of feed type, composition (% crude protein-% crude fat), size (mm), and rates of feeding for various sizes of cocahoe minnows. Additionally, the chart estimates the length of time it would take to grow cocahoe minnows to each size class, and what the approximate weight (g) of individual fish at each class.

starter diets to replace brine shrimp in the first stage of larval rearing.

As fish grow, diets can increase in size (proportionate to mouth gape) and decrease in nutrient levels and feeding rates. Feeding prepared diets that are appropriate in size helps to make feeding more efficient by maximizing the reward (nutritional intake) for the effort (energy spent feeding). Younger fish typically require higher nutrient levels that older fish. Nutrient levels can be reduced by feeding lower quality diets, or by simply feeding smaller amounts.

### Feed Components

Prepared diets can be broken down into three major component categories: macronutrients (energy and protein), micronutrients (vitamins and minerals), and non-nutritive elements.

#### Protein

Protein is the most expensive part of fish feed, so care should be taken to select feeds with appropriate levels of protein. The protein requirement can change with age of fish, as younger fish generally need to be fed a high protein diet at regular intervals to maximize growth. As fish age, the protein requirements are reduced.

It is important to note that not all proteins are the same. This is because proteins are made of individual amino

acids, which serve as the building blocks of a protein. Fish are unable to synthesize 10 of these amino acids, so they must be provided by the diet. Plant-based protein (soybean meal, cottonseed meal, etc.) are typically deficient in one or more of the essential amino acids. Animal-based protein (fishmeal, poultry meal, etc.) tend to have a better amino acid profile but are often more expensive than plant proteins. As a result, feeds are typically formulated on a least cost basis, which combines multiple sources of protein to achieve desired levels of specific amino acids.

#### Energy

Energy can be supplied by protein, fat, or carbohydrates. Fat is the preferred source of energy, because it is both cheap and energy-dense. Like protein, fats can come from plant or animal sources. Protein is a costly source of energy both financially and metabolically, so diets with sufficient energy should have the effect of sparing protein for growth. Carbohydrates are cheap sources of energy, but the digestive systems of most fish do not allow for complete breakdown and absorption of complex carbohydrates. Despite low digestibility, carbohydrates are useful as binders in commercially extruded, floating feeds.

While it is important for diets to provide enough energy to spare protein and maximize growth, there can be too much of a good thing. It is thought that fish eat to

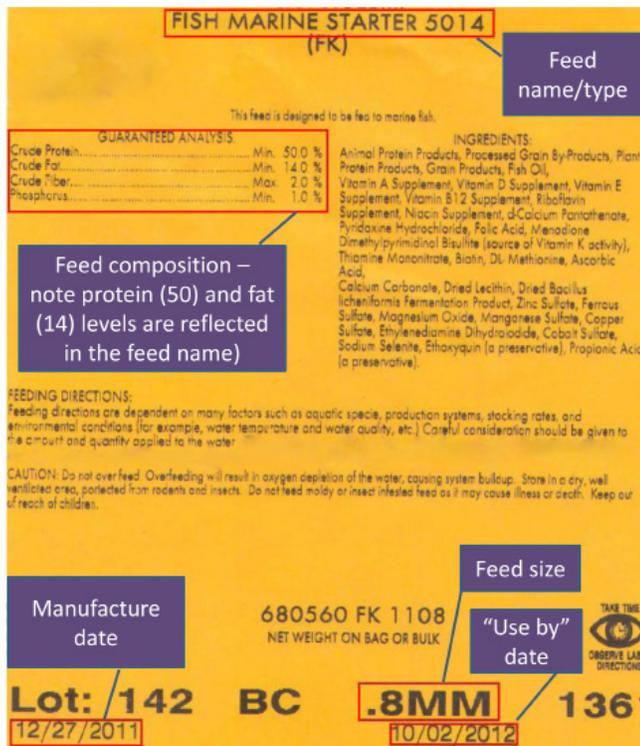


Figure 8.2 Atypical feed label for fish feeds has a number of important factors to identify when choosing a diet for your fish.

However, a small amount of fiber can actually promote digestion and absorption of other feed ingredients by helping to break apart feed materials in the digestive tract.

Water is another component in diets that provides no direct nutritional benefit. Its inclusion is usually the result of the feed manufacturing process (i.e. steam injection for extruded feeds). Most of the excess moisture is removed by drying feed, but some does remain. Moisture should be an important consideration for feed care and storage, because high moisture content promotes mold growth, which ruins feed. Care should be taken to store feed in a dry, cool location out of direct sunlight, as protein, fat, and vitamins are heat sensitive and can degrade at high temperatures. Only purchase as much feed as can be used before spoilage.

satisfy their energy needs. Energy is required primarily for basic metabolic demands, that is, to stay alive and function. After metabolic needs are met, then excess energy can be devoted to weight gain in the form of growth, protein accretion (building muscle), and fat deposition (stored energy). Diets with excessive energy can actually result in lowered feed intake and reduced weight gain. Diets high in fat are also at a higher risk of oxidative rancidity, which can ruin feed.

### Micronutrients

While needed at much lower levels, vitamins and minerals are essential for normal fish health and growth. Vitamins are either water-soluble (B and C) or fat-soluble (A, D, E, and K). The most important minerals are sodium, chloride, calcium, potassium, and phosphorus. It is also important to keep in mind that marine fish tend to have higher vitamin and mineral requirements than freshwater species.

### Non-nutritive

Fiber is a common component in feeds, especially in plant-based diets, but it is virtually indigestible to fish.

# Cocahoe Minnow Feeding and Growth:

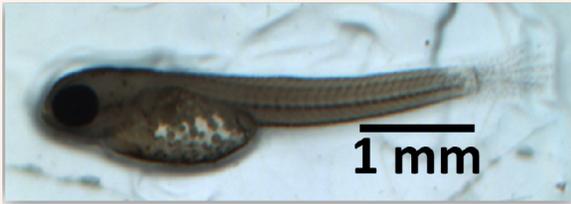


Figure 8.3 Newly hatched cocahoe larvae. Photo: Charles Brown

## Newly Hatched

- **Density** of newly hatched larvae is important for growth at this early stage
- Densities of more than **25 larvae per gallon** are not recommended
- Newly hatched Artemia should be fed **up to four or more** times per day
- While Artemia is best, **commercial larval diets** can be fed upon hatch
- In tanks larvae reach approximately 1 cm after **one and a half to two months**

## Fry (3/8 to 1<sup>1/2</sup> inch long)

- A density of **eight fish per gallon** has produced good survival
- Fish should be fed at least **three times per day** or more if possible
- Inadequate feeding or high density cause increased **cannibalism**
- **Dark colored** tanks appear to reduce cannibalism
- Feed should be **ground** or small diameter (<1mm)
- Feed should be **≥40 percent protein** and **≥9 percent fat**

## General Recommendations

- Salinity of 10-12 ppt
- 74-84 °F water temperature
- Market size fish are 3.5 inches or 5 to 7 grams

## Juveniles (1<sup>1/2</sup> inches long)

- With graded fish, density can be increased to **18 fish per gallon**
- Feed should be small diameter (<1mm.)



Figure 8.4 Juvenile cocahoe minnow. Photo: Josh Patterson

## Ponds or Pools

- Stock fish at **50,000-100,000** juveniles per acre
- Only **supplemental feeding** necessary
- Feed can be **<35 percent protein** and **<5 percent fat**



Figure 8.5 Example of a 0.10 acre pond. Photo: Chris Green

## Chapter 9. Hauling, Holding, and Handling

Water quality is the most important factor to manage while hauling minnows. Maintaining good water quality can make the difference between healthy, active bait or unhealthy bait and few return customers.

### Density

To keep minnows healthy during hauling, 1 pound of fish will require at least 1 gallon of water. When fish are crowded, stressed and excited, water quality will deteriorate rapidly. The major factors that limit loading density are adequate oxygen levels and the buildup of toxic waste products from the fish themselves.

### Temperature

Temperature influences other water quality variables, and it directly influences the metabolism of fish. While moving fish from one system to another, acclimate very slowly for temperature differences or else fish will become stressed and/or die. Slowly add the new temperature water into the old system to acclimate the fish until the water temperatures are less than five to seven degrees difference (F). In addition, going from cooler water to warmer water is more stressful than going from warmer to cooler. Adding about ½ pound of ice per gallon of water will generally lower the water temperature by about 10 °F. Ice made from chlorinated drinking water can cause problems as it dissolves; keep it sealed in plastic containers. Lowering the temperature during transport quiets fish, lowers their metabolism, and increases the oxygen level. For short trips (less than one hour), the hauling temperature should be similar to that of the water at the destination.

### Water Sources

A suitable water supply is needed for short-term holding and hauling. If well or tap water is used, salt must be added to match the salinity of the water from which the bait will be collected. Cool, uncontaminated well water is usually preferred for hauling fish, but water should not be more than five to ten degrees (F) cooler than the water from which the fish are collected. Ideally, hauling tanks should be insulated so cooler water will tend to remain cool for at least several hours. If water from a tap or hose comes from a chlorinated supply, the chlorine must be neutralized before adding fish. Many

commercial compounds are available for this use, and some neutralize ammonia. Make sure your chlorine remover will also neutralize chloramine, which is often used in rural water supplies since it breaks down much more slowly than chlorine.

Natural water from bayous or marshes where fish are collected will already have the correct salinity that the bait is accustomed to, but this water source often has dissolved organic material, a heavy algal bloom, or other organisms that can remove oxygen from the water and produce ammonia. Raw, untreated surface waters are also more likely to have harmful fish pathogens such as bacteria and parasites.

### Physical Condition

One critical factor to the successful handling and transport of fish is to make sure they are healthy and in good condition before they are hauled. If fish have already been crowded with low oxygen and high stress for some period, they will already be in poor condition and more susceptible to any disease organisms they contact.

### Aeration and Oxygen

Two common methods of aerating water during holding or hauling involve the use of mechanical agitators or compressed oxygen. Because fish are densely crowded and excited, it is essential to have an aeration system that can provide dissolved oxygen (DO) faster than it is consumed by the bait.



Figure 9.1 Oxygen meters are a critical part of many aquaculture operations. Photo: Greg Lutz

An oxygen meter or test kit is important for measuring oxygen concentrations in transport and receiving waters. Oxygen levels and water temperature can be monitored easily by using an oxygen meter; however most meters are relatively expensive. A low-cost alternative is to use test

kits based on glass ampules with contents that change color depending on the oxygen content of the water - for a cost of roughly \$1 per test.

Oxygen concentrations in tanks should be maintained above five parts per million (ppm) at all times. However, these levels may be difficult or impossible to attain when only using agitators – an oxygen cylinder with tubing and air stones is a more practical, efficient approach for maintaining adequate dissolved oxygen in tanks. Additionally, excessive agitation can be harmful to delicate scaled fish. For all of these reasons, diffused oxygen is the preferred aeration method for holding and hauling small fish.



Figure 9.2 Oxygen cylinders and hauling tank on trailer ready for transport. Photo: Greg Lutz

Oxygen cylinders are available from some industrial gas or welding suppliers. Pressure regulators are needed for each oxygen tank, and flow meters can be installed to adjust oxygen flow rates. Various diffusers such as air stones or porous tubing are available commercially for dispersing oxygen in the hauling tank.

Agitators can be used either alone or in combination with pure oxygen. Agitators also provide back-up aeration for emergencies when oxygen supplies run out. Cooling water with ice reduces metabolism rates of fish and increases the solubility of oxygen in the water. As fish breathe, over time carbon dioxide ( $\text{CO}_2$ ) will accumulate in the tank. High oxygen levels, air circulation and water agitation during hauling will all help to reduce any adverse effects from accumulated

$\text{CO}_2$ . Adding baking soda could also help to neutralize the carbonic acid that comes from  $\text{CO}_2$  in water.

### Other Water Quality Characteristics

Salinity, water hardness, alkalinity and pH test kits should be used to check transport and waters the fish will be held in. If you deliver fish to sites where chlorinated water is used, a chlorine test kit is also helpful to be



Figure 9.3 A refractometer is a relatively inexpensive instrument for checking salinity. Digital salinity meters are more costly but can be more precise. Different models can also measure other water quality characteristics. Photo: Jill Christoferson

sure chlorine in waters has been neutralized. If not, chlorine and chloramine neutralizers will be needed to dechlorinate water. Ammonia can also increase in hauling situations and is not removed by agitation. Fasting fish before transport, using clean water, and lowering the water temperature all help reduce ammonia. Ideally, the pH of hauling water should be 7 to 7.5; higher pH increases the toxicity of ammonia to aquatic animals.

Chronic fish losses or weak fish problems are often associated with handling and transporting fish in soft water or transferring fish from saltwater to freshwater. Hardness and alkalinity levels from 50 to 100 ppm are preferable. Sodium bicarbonate and calcium chloride will increase alkalinity and hardness and are safe to use. Add approximately 1 teaspoon of baking soda per 100 gallons of water to increase the alkalinity by 10 ppm. Add about 6 teaspoons full of calcium chloride per 100 gallons to increase the hardness by 50 ppm.

### Hauling Tank Design and Construction

Most commercially manufactured hauling tanks are insulated. Urethane foam, plastic foam and corkboard are common insulating materials, but they can also be used with homemade tanks, glued to the outer surface. Tanks should be equipped with an overflow drain to maintain water level and allow agitators to function at the proper operating depth. Another feature is an air vent or scoop to permit air circulation in the space between the water surface and top of the tank.

## **Disease Management**

Prophylactic treatment with approved chemicals can reduce pathogenic organisms that could cause problems during or after transport. Formalin may be used in holding vats for 15-minute to one-hour baths, but appropriate safety measures such as gloves, safety glasses, etc. should be taken when using this compound. Avoid over-treating with excessive doses or combinations of chemicals, and be prepared to flush any treatment with clean water (with the same salinity, hardness, alkalinity, etc.) if fish show any signs of stress.

Hauling tanks and equipment, such as dip nets, should be dried and/or disinfected between loads of fish. This practice reduces the possibility of spreading disease pathogens from one group of fish to another. Tanks and equipment can be thoroughly air-dried or treated with chlorine in approximately 1 teaspoon of bleach per 5 gallons of water solution for an hour. Flush tanks thoroughly after chlorine treatment. A 5 percent solution of formalin can also be used to disinfect and will not damage nets and seines as chlorine does over time.

## **Nets, Netting, and Handling**

Select the proper mesh size and net material for harvest seines and dip nets to avoid injuring fish. Use soft 3/16 inch knotless nylon mesh nets for delicate minnows, and do not overload dip nets or loading baskets since the fish at the bottom can suffer serious damage from the weight of the animals on top of them. Bait should be handled rapidly and delicate scaled species should be kept in water whenever possible. During netting and transferring of fish, avoid the warmest times of the day and direct sunlight.

Partial drying of the skin surface or gills can occur while moving small minnows. This in turn can allow bacterial and parasitic infections to occur, so minimize the time out of water on windy days when the drying effect is greatest. Cold winter air and wind chill factors can also cause temperature shock when fish are moved in nets.

# Chapter 10. Disease

Cocahoe minnows are hardy fish; however they can be susceptible to disease. This section is meant as a guide and only covers some of the more common health problems encountered when culturing these fish. The best treatment is prevention by maintaining good water quality. In the instance of an outbreak, a fish disease expert should be consulted before going forward with any treatment. Make sure the fish disease expert is knowledgeable about which chemicals are approved for use. Also note that some of these infections can be transferred to humans in rare cases so use caution when handling infected fish, especially if you have open wounds or sores on your hands.

## Common Symptoms

While these symptoms can be indications of disease, they can also be signs of poor water quality, or other stressors.

### Fin rot

Fin rot is generally an easily spotted condition where the fins and tail of a fish become noticeably degraded.



Figure 10.1 Cocahoe minnow exhibiting fin rot. Photo: Craig Gothreaux

They may change colors, appear inflamed at the base and be frayed or ragged. Fin degradation begins at the edges of the fin and works its way toward the base. Once the infection

reaches the base the fish will not be able to regenerate new fin tissue, and the infection may spread to the body.

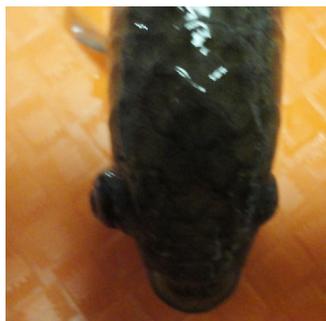


Figure 10.2 Cocahoe minnow exhibiting pop-eye. Photo: Paige O'Malley

Fin rot may be a symptom of disease, but this is not always the case.

### Pop-eye

Pop-eye is a common symptom that can result from a number of infections. This is another noticeable symptom. Pop-eye occurs when fluid builds up either behind the eye or in the eye. This causes bubbles in the

skin surrounding the eye eventually causing the eye to bulge out of its socket. If not treated in a timely manner the fish can lose sight in the affected eye.

### Scale loss and shedding

Small amounts of scale loss occur naturally. However, when large patches of scales are lost it can become a problem. This can be a sign of an existing infection



Figure 10.3 Fish with extensive scale loss on head. Picture: Paige O'Malley

where the tissue holding the scales has become degraded. It can also indicate an infection that causes the fish to rub against hard surfaces, causing patches of scale loss. Areas without scales can open the fish up for further infection. Also be aware of areas with raised scales as this is most likely an early phase of scale shedding and can be an indicator of disease.

### Backbone deformities

Backbone deformities are common in cultured fish. Typically the spine will bend abnormally, sometimes at an angle. Depending on the direction of the bend, this condition can be referred to as scoliosis, a horizontal bend, or lordosis a vertical bend. If developed during early life stages, the condition may be permanent. Backbone deformities have a number of causes; in cultured fish it is commonly associated with a Vitamin C deficiency. In other cases, it can also be a genetic defect, the result of an injury, or a symptom of a bacterial infection.



Figure 10.4 Fish exhibiting scoliosis. Picture: Paige O'Malley

## Diseases

### *Flexibacter columnaris*

This bacterial infection surfaces most commonly when cocahoe minnows are exposed to freshwater for prolonged periods of time. *Flexibacter columnaris*, commonly referred to simply as *columnaris*, is found

in freshwater. It is often a secondary infection preying on fish with weakened immune systems due to stress. This disease is highly contagious and can be transferred through contaminated nets, containers, and food.

Fin-rot is a common symptom of *columnaris* as well as white or light gray spots around the fins or gills and on the head. These spots can become yellowish or brownish in color as infection progresses, and the surrounding area may become tinged with red. Infection can also cause what is known as “saddle-back” where lesions on the back extend down the sides giving a saddle like appearance. Lesions on the mouth may look cottony or moldy and will eventually lead to the erosion of the mouth structure. Fish will start breathing rapidly or gasping when the bacteria invades the gills causing the gill filaments to disintegrate.

#### ***Aeromonas hydrophila***

This is another opportunistic bacterium that is associated with prolonged exposure to freshwater in coccinellid minnows. This bacteria is found in almost all freshwater and in the gut of many fish. It typically only becomes a problem when the fish are stressed for long periods.

Signs of infection can be highly variable. This makes it extremely difficult to diagnose based on symptoms, and an expert should be consulted before any drastic treatment is undertaken. Signs of infection can include ulcers often surrounded by a bright red ring, tail and fin rot, loss of appetite, pale gills, abnormal swimming and hemorrhagic septicemia. Hemorrhagic septicemia is a condition that can cause lesions leading to scale shedding, hemorrhages in the gills and anal area, ulcers, pop-eye, and abdominal swelling.

#### ***Vibrio sp.***

*Vibrio* is primarily a saltwater and estuarine disease. It is present in most saltwater systems and usually becomes a problem when fish have been stressed. Once a fish has been infected the amount of bacteria in the water significantly increases creating a higher likelihood of other fish becoming infected.

Infection usually begins with loss of appetite and fish acting lethargic. As the infection progresses fish can begin to show boil like sores on the body, bloody open

sores, discolored skin with areas of red dying tissue, and bloody blotches around the fins and mouth. If the infection becomes internal, fish can present with pop-eye, distended stomach and bloody anus. In some cases, even if infection is not fatal fish will eat very little and thus grow very slowly.

#### ***Streptococcus sp.***

*Streptococcus*, or Strep, is more aggressive than the previously mentioned diseases. While it is opportunistic, it can also be lethal under non-stressful conditions when it is found in high concentrations.

Affected fish typically display erratic swimming (commonly spinning or spiraling), bloody areas on the body such as at the base of fins, gill plates and anus or in the eyes and pop-eye. Death occurs rapidly with this disease. Other symptoms can include cloudy eyes, distended stomach, ulcers and loss of buoyancy control.

#### **Parasites**

There are wide varieties of parasites that can affect coccinellid minnows. While there are many different types, there are characteristics that many of these infestations share. If your fish begin exhibiting some of these symptoms, taking a sample to an expert will give you a better idea of what you are dealing with and how to treat it.

Common symptoms of external parasite infestations can include concave stomach, rapid breathing, and excess mucus produced from the gills. Fish may rub against substrate, rocks or sides and bottom of holding tanks, also known as “flashing.” They may exhibit scale loss or ooze a pinkish fluid. Fins and tail erosion may also be a sign of parasite infestation. In some cases parasites may be visible hanging from fish in their fins, flesh, mouth or anus.

# Chapter 11. Common Predators and Methods of Control

## Eggs, Larvae, and Juveniles

Predaceous aquatic insects such as diving beetles, water scorpions, and water boatmen are common predators to fish eggs and larvae. In addition, larger cocahoes and other fish will feed on smaller cocahoes so grading of different sized batches is critical.



Figure 11.1 Dragonfly Larvae  
Photo: Paula Ouder

### Ways to minimize threat:

- Ponds and Pools: Hatching ponds and pools should be treated to kill predaceous insects before stocking with eggs.
- Before filling and stocking, any wild fish should also be excluded from the ponds and pools by using a fine mesh material (800 micron or 0.03 inch) to cover the water supply pipe.



Figure 11.2 Barrier netting, featured in the pool above can be beneficial in excluding predatory birds. Photo: Jill Christoferson

## Market Size and Broodfish

In ponds, avian predators such as cormorants, pelicans, and egrets are huge predators of fish. Raccoons, snakes and turtles are also predators of larger fish and can easily access ponds. Raccoons can swipe at fish from the pond edge or wade into shallow areas; this makes small ponds more vulnerable.



Figure 11.3 Raccoons can become a problem in small or shallow ponds.  
Illustration: Louisiana Sea Grant

### Ways to minimize threat:

- Use predator barrier netting to exclude predatory birds from the ponds and pools.
- Relocate snakes and turtles from cocahoe ponds.
- Avoid ponds that are very shallow or use netting around the edge to discourage raccoons.



Figure 11.4 Egret stalking fish in marsh. Photo: Jill Christoferson

# Chapter 12. Legal Considerations

Please note: This portion examines some but not all of the legal requirements needed for engaging in the aquaculture of coahoe minnows. It does not address any legal requirements for selling the minnows.

## Permitting

The Louisiana Pollutant Discharge Elimination System (LPDES) and the Louisiana Water Discharge Permit System (LWDPS) require permits for the discharge of pollutants from any point source into the waters of the state. These permits can be obtained from the Louisiana Department of Environmental Quality. If a facility is an aquatic animal production facility or an aquaculture project then it may be necessary to obtain both permits. The first step in determining if you need a permit is to determine if the operation is a concentrated aquatic animal production facility or an aquaculture project. A concentrated aquatic animal production facility is a hatchery, fish farm, or other facility that contains, grows, or holds aquatic animals. An aquaculture project is a defined, managed water area where pollutants discharge for the maintenance or production of harvestable freshwater, estuarine, or marine plants or animals.<sup>1</sup>

If the facility is a concentrated aquatic animal production facility for a warm water fish species, such as a minnow, it will be necessary to obtain an LWDPS and LPDES permit only if the pond, raceway or other similar structure discharges at least 30 days per year.<sup>2</sup> Discharging means that the facility would place, release, spill, drain, pump, leak, seep, dispose, bypass or let pollutants escape into the waters or subsurface water or ground.<sup>3</sup> Formalin and/or chlorine in the water used to produce minnows are pollutants. If that water is to be released into surface water, a permit will be needed unless the exceptions are met.

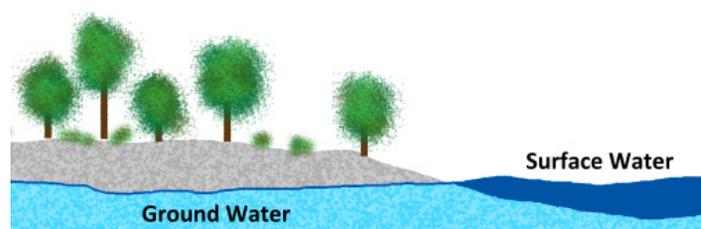


Figure 12.1 Diagram of typical water table.

There are three exceptions:

1. If the structure discharges less than 30 days per year, no permit is needed.
2. No LWDPS or LPDES is required if the structure is a closed pond which discharges only during periods of excess runoff.
3. No LWDPS is needed if the facility produces less than 45,454 harvest weight kilograms (approximately 100,000 pounds) of aquatic animals per year.<sup>4</sup>

If the facility is an aquaculture project, both LWDPS and LPDES permits are needed. An aquaculture project is different from a concentrated aquatic animal production facility because an aquaculture project occurs in the waters of the state in a designated project area in which the cultivated species is confined. Here, the pollutant (formalin, chlorine) can only be discharged into the water if it is expected to ensure that the aquaculture crop will enjoy increased growth attributable to the discharge of pollutants.<sup>5</sup> No LPDES permit will be issued unless the aquaculture project is intended to produce a crop which has significant direct or indirect commercial value or is intended to be operated for research into possible production of such a crop.<sup>6</sup> Moreover, no permit will be issued to the aquaculture project unless the designated project area does not occupy a space which is larger than can be economically operated for the crop under cultivation or for research purposes. Lastly, there must not be a migration of the pollutants from the designated project area to water outside the aquaculture project if this migration contributes to a violation of water quality standards.<sup>7</sup> There are no exceptions to the mandatory LWDPS/LPDES requirement for aquaculture projects.

Before the decision is made regarding whether or not a permit (LPDES and LWDPS) must be obtained, a permit application should be filed and the state administrative authority will conduct an on-site inspection of the facility and determine whether the facility should be regulated under the permit systems.<sup>8</sup>

## **Domesticated Aquatic Organism License**

Any person who wishes to engage in the production of fish in privately owned waters or ponds must apply to the Louisiana Department of Wildlife and Fisheries for a domesticated aquatic organism license.<sup>9</sup> This license is valid for one year at a cost of \$15 for residents. The license authorizes the bearer to transport domesticated aquatic organisms over the highways of the state. With this license, the holder is entitled to sell domesticated aquatic organisms in any size, quantity, or limit without restriction within the state or outside of the state.<sup>10</sup>

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<sup>1</sup> LAC 33: IX § 301(L)

<sup>2</sup> LAC 33: IX § 323(A) (2)

<sup>3</sup> LAC 33: IX § 107

<sup>4</sup> LAC 33: IX § 323(A) (2)

<sup>5</sup> LAC 33: IX § 301(L)

<sup>6</sup> LAC 33: IX § 3903(A)

<sup>7</sup> LAC 33: IX § 3903(A)

<sup>8</sup> LAC 33: IX § 2507(2)

<sup>9</sup> La. R.S. 56:411 (2011)

<sup>10</sup> La. R.S. 56:412 (2011)

## Chapter 13. Economic Analysis

Undertaking a large project such as baitfish farming requires a good deal of advanced planning to ensure that prudent decisions are made. The purpose of this section is to provide cost estimates for potential producers. These estimates may assist interested parties in deciding which type of production, if any, is right for their individual situation. However, projected costs and returns vary considerably based on available resources and scale. These cost projections are meant to act as a guideline only for interested parties and potential producers to make cost estimates appropriate to their unique situations. Every individual situation will be unique and cannot be duplicated here.

In order to gain an accurate economic portrayal, interviews were conducted at four Louisiana bait shops across three parishes. These interviews served to provide information on interactions between wholesalers and retailers. Shop owners and managers were asked questions regarding holding capacity, types of holding systems, sale price, and survivability of coahoe minnows. They also provided data on wholesale prices, reliability of wholesalers, and turnover on minnow batches. All of the shops interviewed sold coahoe minnows as live bait. Of the four shops interviewed, three received their minnows from external harvesters. One of the shops interviewed caught their own bait. This shop also provided valuable information on the costs associated with catching minnows. The information collected in these interviews was used to determine our estimated standard price per minnow as well as the volume of minnows that could be sold per average unit of time. For the purpose of our estimates, both the average wholesale price and the average weekly turnover were used.

Five owner-operator production examples were developed, and costs associated with each were identified and quantified. An economic model was developed to create the projected costs and returns for each example. Projected costs for production scenarios were the result of a combination of information obtained from past minnow production publications, research and operations taking place at the LSU AgCenter Aquaculture Research Station, and the bait

shop interviews. For these examples, it was assumed that the owner-operator was already in possession of the land needed with some type of existing structure for the production system. Prices of materials were based on average market value as of spring 2012. The costs and returns associated with these models are dependent on a number of factors. The type of production system employed and the size or scale of the operation have significant impacts on both the total investment needed and the estimated return as seen in our examples. The location of the operation may also influence costs. These numbers are based on hypothetical examples, and actual costs and returns will vary based on individual situations. All scenarios are assuming a price of \$0.15

### Owner-Operator Production Scenarios:

#### 1) Wild Harvest and Immediate Sale

*Minnows are trapped in the wild and sold immediately after harvest to bait shops or the public.*

#### 2) Wild Harvest and Long Term Holding

*Minnows are trapped in the wild with the majority of the catch sold immediately after harvest to bait shops or the public. In this scenario extra traps are fished and a portion of the catch is held over to be sold in the off season when fish are not as abundant.*

#### 3) Intensive Recirculated System

*Minnows are produced from eggs solely in tanks or pools in a closed recirculated system where all nutrition is provided via prepared feed.*

#### 4) Pond Only Production System

*Minnows are produced from eggs solely in ponds where nutrition comes primarily from natural productivity and supplemented with prepared feed.*

#### 5) Pool Spawning and Pond Growout Production System

*A hybrid system where minnows are produced from eggs. Broodfish are spawned intensively in pools. Larvae are hatched in outdoor ponds where nutrition comes primarily from natural productivity and supplemented with prepared feed.*

Table 1. Wild Harvest and Immediate Sale

<b><u>Start-Up Expenditures-Wild Harvest</u></b>	<b><u>Total</u></b>
<i>Harvesting Infrastructure</i>	
16' Boat, 25hp motor, trailer	\$9,267
Boat supplies and transport equipment	\$866
Traps	\$990
<i>Bait Holding</i>	
Submersible purging cages	\$579
Holding tank(s)	\$1,886
Pumps, plumbing, filters & other equip.	\$8,410
Contingency (10%)	<u>\$2,200</u>
<i>Total Start-up costs</i>	<b>\$24,197</b>
<b><u>Annual Operating Costs</u></b>	
Bait, fuel, fishing lease	\$8,664
Holding costs	\$382
Labor	\$3,600
Contingency (10%)	<u>\$905</u>
<i>Total Annual Operating Costs</i>	<b>\$12,646</b>
<b><u>Annual Fixed Costs</u></b>	
Principle and interest	\$2,308
Depreciation (10%)	<u>\$2,419</u>
<i>Total Annual Fixed Costs</i>	<b>\$4,728</b>
Total Annual Costs	<b>\$17,347</b>
Total Annual Revenue	<u>\$44,297</u>
Net Revenue to Owner	\$26,923
*This scenario will produce 295,313 fish per year	

Table 2. Wild Harvest and Long Term Holding

<b><u>Start-Up Expenditures-Harvest and Holding</u></b>	<b><u>Total</u></b>
<i>Harvesting Infrastructure</i>	
16' Boat, 25hp motor, trailer	\$9,267
Boat supplies and transport equipment	\$866
Traps	\$1,320
<i>Bait Holding</i>	
800 gallon poly holding tanks	\$1,886
Submersible purging cages	\$579
Holding tank(s)	\$1,886
Pumps, plumbing filters & other equip.	\$11,886
Contingency (10%)	<u>\$2,769</u>
<i>Total Start-up costs</i>	<b>\$30,458</b>
<b><u>Annual Operating Costs</u></b>	
Bait, fuel, fishing lease	\$11,379
Holding costs	\$435
Labor	\$3,600
Contingency (10%)	<u>\$1,181</u>
<i>Total Annual Operating Costs</i>	<b>\$15,413</b>
<b><u>Annual Fixed Costs</u></b>	
Principle and interest	\$2,906
Depreciation (10%)	<u>\$3,045</u>
<i>Total Annual Fixed Costs</i>	<b>\$5,951</b>
Total Annual Costs	<b>\$21,365</b>
Total Annual Revenue	<u>\$59,063</u>
Net Revenue to Owner	\$37,697
*This scenario will produce 393,750 fish per year	

per minnow and startup costs financed over five years.

### Wild Caught Harvest and Immediate Sale

The first example is for a wild caught harvester scenario with short-term holding (Table 1). This scenario is the current practice in the cocahoe minnow bait industry. In this scenario it is assumed that the owner-operator is fishing 30 traps on a 1000-acre lease for 150 days out of the year and catching an average of 75 minnows per trap. It is assumed there is some paid part-time help, and 100 percent of the surviving catch is sold. The projected number of minnows produced for sale per year in this scenario is 295,300 fish. This is enough cocahoes to support an estimated one or two shops if the supply is consistent year round. The number of minnows that would need to be sold to break even in this scenario is 115,827 fish per year (Table 1).

### Wild Caught Harvest and Long Term Holding

The next example expands on the first wild caught scenario with the addition of long-term holding (Table 2). This scenario is not as common but may be beneficial in supplying minnows when they are difficult to catch. In this scenario it is assumed that the owner-operator is fishing 40 traps on a 1000-acre lease for 150 days out of the year and catching an average of 75 minnows per trap. The number of traps fished in this scenario was increased to account for the additional minnows that would need to be held long-term to make this scenario feasible. This scenario also assumes there is some paid part-time help, and 100 percent of the surviving catch is sold. The projected number of minnows produced for sale per year in this scenario is 393,700 fish. This is enough to support an estimated one to three shops year round. The number of minnows that would need to be sold to break even in this scenario is 142,436 fish per year (Table 2).

Table 3. Intensive Recirculated System

<b>Start-Up Expenditures-Intensive Recirculated</b>	<b>Total</b>
<i>Holding Infrastructure</i>	
Fiberglass tanks	\$13,735
Growout tanks	\$90,437
Salinity and DO meter	\$1,270
Pumps, plumbing, filters & other equip.	\$28,654
Fish hauling tank	\$1,422
Holding tank(s)	\$1,886
Salt	\$4,919
Contingency (10%)	<u>\$15,683</u>
<b>Total Start-up costs</b>	<b>\$158,002</b>
<b>Annual Operating Costs</b>	
Spawning supplies	\$377
Feed	\$53,957
Electricity	\$7,561
Labor	\$36,000
Contingency (10%)	<u>\$6,189</u>
<b>Total Annual Operating Costs</b>	<b>\$97,895</b>
<b>Annual Fixed Costs</b>	
Principle and interest	\$15,075
Depreciation (10%)	<u>\$15,800</u>
<b>Total Annual Fixed Costs</b>	<b>\$30,875</b>
Total Annual Costs	<b>\$128,770</b>
Total Annual Revenue	<u>\$40,230</u>
<b>Net Revenue to Owner</b>	<b>-\$88,540</b>
*This scenario will produce 268,202 fish per year	

Table 4. Pond Only Production System

<b>Start-Up Expenditures-Ponds</b>	<b>Total: 10 Acre</b>	<b>Total: 2 Acre</b>
<i>Holding Infrastructure</i>		
Pond construction	\$46,159	\$9,656
Salinity and DO meter	\$1,270	\$1,270
Paddlewheel aerator	\$4,036	\$847
Aerator	\$3,683	\$1,841
Fish hauling tank	\$1,422	\$1,422
Holding tank(s)	\$1,886	\$1,886
Harvesting & testing supplies	\$1,767	\$1,546
Contingency (10%)	<u>\$6,022</u>	<u>\$1,847</u>
<b>Total Start-up costs</b>	<b>\$66,245</b>	<b>\$20,317</b>
<b>Annual Operating Costs</b>		
Spawning Supplies	\$987	\$67
Feed	\$50,175	\$10,035
Fertilizer	\$6,316	\$1,283
Electricity	\$2,274	\$764
Labor	\$27,000	\$18,000
Gas for distribution	\$1,284	\$1,284
Contingency (10%)	<u>\$8,675</u>	<u>\$3,015</u>
<b>Total Annual Operating Costs</b>	<b>\$96,712</b>	<b>\$34,450</b>
<b>Annual Fixed Costs</b>		
Principle and interest	\$6,321	\$1,938
Depreciation (10%)	<u>\$6,624</u>	<u>\$2,032</u>
<b>Total Annual Fixed Costs</b>	<b>\$12,945</b>	<b>\$3,970</b>
Total Annual Costs	<b>\$109,657</b>	<b>\$38,420</b>
Total Annual Revenue	<u>\$122,850</u>	<u>\$24,570</u>
<b>Net Revenue to Owner</b>	<b>\$13,193</b>	<b>-\$13,850</b>
*These scenarios will produce 819,000 and 163,800 fish per year respectively.		

### Closed Recirculated System

The costs and returns associated with minnow production in a closed recirculated system are outlined in Table 3. In this scenario the broodstock are spawned outdoors in six 2,641-gallon fiberglass pools in April and May and again in September through mid-October. They are stocked at a density of approximately 250 fish per tank with a 2:1 female to male ratio. Each female is assumed to produce approximately seven eggs per day. Of the total eggs produced, 75 percent are estimated to be viable. In this scenario the fish were air incubated and separated into two-week batches. They are then grown out in 500-gallon polyethylene tanks at a density of 19 fish per gallon at the fry and larvae stage and 11 fish per gallon at the juvenile stage. They will reach market size, approximately 0.18 oz. in eight months. Thus in the first year the returns will be lower as only one round of eggs will be ready for market that year. In this scenario, one full time employee will be required in addition to the owner operator due to the intensive nature of the system.

It is also assumed that 100 percent of the surviving fish will be sold. The projected number of fish produced the first startup year is 155,500 individuals. After the initial year the number of minnows produced is estimated to be 268,200 fish. This is enough to supply one to two bait shops year round; however, it would take about 858,467 fish per year sold at \$0.15 to break even in this system.

### Pond Only

The pond spawning and grow out scenario is outlined in Table 4. For this scenario, cost and yields were projected for the same operation at two different scales: 10-acre and 2-acre. In both cases the use of the three-phase pond system was assumed. Brood ponds were stocked at 10,000 fish per acre with a 2:1 female to male ratio. Eggs were separated into two-week batches with an assumed 65 percent viability. Fry ponds were stocked at a density of 1,000,000 per acre and grow out ponds were stocked

at a density of 100,000 fish per acre. It was assumed that the ponds were fertilized weekly and supplemented with feed. Of the viable eggs, it was assumed that only 60 percent would survive to market size, 39 percent survivability from the total eggs harvested. Market size would be attained in about six months, and 100 percent of fish reaching market size would be sold. For the 10-acre scenario, it was assumed that one full time employee and one part time employee would be required in addition to the owner-operator. For the 2-acre scenario, it was assumed that only one fulltime employee was needed in addition to the owner-operator. The 10-acre scenario accounts for three 0.25 acre brood ponds, four 0.2 acre larval ponds and fourteen 0.55 acre grow out ponds. At this scale approximately 475,000 fish would be produced the first year and 819,000 fish in subsequent years. This is enough to supply at least six to seven bait shops year round. To break even at this scale a minimum of 731,047 fish would need to be produced and sold, approximately 35 percent survivability of the total eggs produced.

The smaller scale 2-acre operation entails one 0.15 acre brood pond, four 0.04 acre larval ponds and seven 0.2 acre grow out ponds. At this scale approximately 95,000 fish will be produced the first year and 163,800 fish in the years after that. This is enough to supply one to two bait shops; however to breakeven at this scale, 256,134 fish would need to be produced and sold, 61 percent of the eggs produced.

### Pool Spawning and Pond Grow Out

The final scenario, in Table 5, is a hybrid system incorporating pool spawning with pond grow out. The costs and yields for this scenario were also projected on a larger 10-acre and smaller 2-acre scale. For both size operations, the fish were spawned in 2,641-gallon fiberglass pools at a density of 250 fish per pool at a 2:1 female to male ratio. Eggs were again separated into two-week batches. They would then be hatched in the larval ponds and transferred to grow out ponds after 3-4 weeks. They are stocked at the same densities by life stage as the ponds only scenario and fertilized and fed in the same manner. It is assumed that this scenario will yield a higher percentage of viable eggs (75 percent) because they are produced in a more controlled environment. However the pond survivability is assumed the same, yielding an overall survivability of 45 percent of the

Table 5. Pool Spawning and Pond Growout Production System

<b>Start-Up Expenditures-Pool &amp; Pond</b>	<b>Total 10 Acre</b>	<b>Total 2 Acre</b>
<b><i>Holding Infrastructure</i></b>		
Fiberglass tanks	\$68,673	\$13,735
Pond construction	\$47,752	\$9,550
Salinity and DO meter	\$1,270	\$1,270
Paddlewheel aerator	\$8,579	\$1,716
Aerator	\$3,683	\$3,683
Blower and air lines	\$2,289	\$458
Fish hauling tank	\$1,422	\$1,422
Holding tank(s)	\$1,886	\$1,886
Salt	\$4,707	\$941
Harvesting & testing supplies	\$2,083	\$1,583
Contingency (10%)	<u>\$14,234</u>	<u>\$3,624</u>
<b>Total Start-up costs</b>	<b>\$156,575</b>	<b>\$39,867</b>
<b><u>Annual Operating Costs</u></b>		
Spawning supplies	\$1,884	\$377
Fertilizer	\$6,079	\$1,283
Feed	\$50,612	\$10,122
Electricity	\$4,710	\$1,733
Labor	\$27,000	\$18,000
Supplemental salt	\$470	\$470
Gas for distribution	\$1,285	\$1,285
Contingency (10%)	<u>\$9,204</u>	<u>\$3,807</u>
<b>Total Annual Operating Costs</b>	<b>\$90,285</b>	<b>\$36,598</b>
<b><u>Annual Fixed Costs</u></b>		
Principle and Interest	\$14,939	\$3,804
Depreciation (10%)	<u>\$15,658</u>	<u>\$3,986</u>
<b>Total Annual Fixed Costs</b>	<b>\$30,597</b>	<b>\$7,790</b>
<b>Total Annual Costs</b>	<b>\$120,882</b>	<b>\$44,389</b>
<b>Total Annual Revenue</b>	<b>\$186,543</b>	<b>\$46,636</b>
<b>Net Revenue to Owner</b>	<b>\$65,661</b>	<b>\$2,247</b>
*These scenarios will produce 1,554,525 and 310,905 fish per year respectively.		

total eggs produced. Market size is reached in about six months. For the large-scale scenario it was assumed that one full time employee and one part-time employee would be needed in addition to the owner-operator. The large-scale scenario assumes 30 fiberglass pools for spawning, four 0.35 acre larval ponds and 14, 0.6 acre, grow out ponds. This would produce 901,600 fish the first year and 1,554,500 in subsequent years. At this level of production at least 12-15 bait shops would need to be supplied to sell 100 percent of the fish produced. As a more conservative estimate, the figures in Table 5 adopt an 80 percent sale of fish produced, which would still supply 8-12 bait shops. In order to break even at

this scale 805,880 fish would need to be sold.

In the smaller scale 2-acre operation it was assumed that one fulltime employee would be needed in addition to the owner operator (Table 5). This scenario at this scale utilizes six fiberglass pools, four 0.07 acre larval ponds, and eight 0.2 acre grow out ponds. At this scale, this scenario would produce 180,300 fish the first year and 310,900 in years after. At 100 percent sale of fish produced this would supply two to three bait shops year round. To break even at this scale 287,428 fish would need to be sold.

## **Conclusion**

When choosing the scenario that best suits your needs scale is a very important factor. The wild harvest scenario, while it turns a modest profit, requires the sale of the least minnows to break even. Conversely, the large scale 10 acre pool spawning and pond grow out scenario, which yielded the highest profit, requires an extremely high percentage of the minnows produced to be sold in order to break even. If this scenario were to be implemented it would be best to establish a guaranteed market with a set sale price prior to implementation. This would ensure enough of the product could be sold at a sustainable price for the owner operator to maintain a profit. The smaller scale 2 acre pool spawning and pond grow out may also be an avenue to be explored along with wild harvest and long

term holding as they both require relatively low volume of minnow sale to break even. Also in both cases, an adequate profit can be earned if the system is utilized to its maximum production potential. While the large-scale pond only scenario does produce a positive profit, the volume of minnows that would need to be sold to break even is high, and again, it would be wise to establish guaranteed buyers with a set sale price before this scenario was implemented. In addition scale is very important. While there was a small profit at the full 10 acre scale, 2-acre pond only scenario resulted in a loss. The recirculated system scenario produced the largest net loss to owner. In order to break even this system would require a threefold increase in market price as it is not able to produce the volume of minnows required to break even. This system is strongly inadvisable for anyone looking to enter cocahoe minnow production unless proper infrastructure is already in place.

All of the numbers and figures in this section were generated through generic conceptual economic models with no less than 39 specific assumptions that affect the costs and yields of these scenarios. Anyone seriously interested in investing in cocahoe minnow production is strongly encouraged to contact Dr. Julie Anderson at [JAnderson@Agcenter.lsu.edu](mailto:JAnderson@Agcenter.lsu.edu) or (225) 578-7718 or Dr. Christopher Green at [CGreen@Agcenter.lsu.edu](mailto:CGreen@Agcenter.lsu.edu) or (225) 765-2848 for a situational economic analysis.

# Chapter 14. Supplies

This section is meant as a guide and provides vending locations for some of the products commonly used in cocahoe production. **This section does not specifically endorse any of these products or vendors. Nor is it meant to exclude similar products or vendors. Many of the products may be available from other vendors not specifically mentioned in this section.**

**Salt:** Make sure to have your water checked to determine what type of salt is best for your system. Also make sure that you choose a salt measuring instrument that is best for your salinity range.

Product	Vendor
Crystal Salt	Aquaculture Systems Technology
Marine Mix	Aquaculture Sys. Tech. /Foster and Smith
Solar Salt	Hardware stores
Rock Salt	Hardware stores/Some general stores
Instant Ocean	Amazon/Foster and Smith/Pet Stores
Refractometer	Foster and Smith/ Aquatic Eco.
Hydrometer	Foster and Smith/Pet Stores

**Chlorine neutralizer:** If water comes from a municipal source, the chlorine must be neutralized before adding fish. Make sure your chlorine remover will also neutralize chloramine, which is often used in rural water supplies.

Product	Vendor
Proline Aqua-Coat	Aquatic Eco.
Dry AmQuel Plus	Aquatic Eco./Fish Farm Supply Co.
ChlorAm-X	Reed Mariculture/Aquatic Eco.
Sodium Thiosulfate	Aquatic Eco./Western Chemical Inc.

**Stress minimizers (during hauling):** All of these products are meant to improve water quality and/or fish condition. Make sure to read the labels carefully to choose the product that is right for your needs.

Product	Vendor
Kent Sure-Haul	Kentmarine.com
Stress Coat	Aquatic Eco./Pet Stores/Fosters & Smith
ChlorAm-X	Reed Mariculture/Aquatic Eco.
Ultimate Water Conditioner	Aquatic Eco./Amazon/Pond Supply Stores
General Baitfish Chemicals	Southern Aquaculture Supply

**Oxygen and water quality test kits:** Water testing is important to ensure the health of your fish. Knowing the levels of oxygen, ammonia, nitrites, and other water quality factors are essential. Make sure to select an instrument or test kit that tests for all of the important water quality factors.

**Oxygen Test Kits:**

*Advantages: inexpensive (usually less than \$50), sufficiently accurate for management decisions, chemicals have a long shelf life, does not require maintenance, maybe the best economical option on small farms.*

*Disadvantages: more time is required to take measurement, chemical reagents must be continually replaced (most kits provide chemicals for 30 to 100 measurements).*

**Oxygen Meters:**

*Advantages: accurate (when calibrated properly), ease of use, many measurements can be taken quickly, does not require continual purchase of replacement chemicals, maybe the best option on large farms where many measurements must be taken, will last many years if properly cared for and maintained.*

*Disadvantages: expense (\$600-\$1,000), requires calibration before use, and requires minor maintenance to keep it operating properly.*

Product	Vendor
LaMotte Saltwater Test Kits (Model AQ-4 or AQ-5)	Aquatic Eco./LaMotte Company
Water Quality Test Kits & Oxygen Meters	Global Water Instr. Inc./ Forestry Supp. Inc.
HACH Saltwater Master Test Kit	CHEMetrics Inc.
Water test strips	Aquarium/ Pet store
YSI/Oxygen Meter	Aquatic Eco./So. Aquaculture Supply

**Aeration:** Two common methods of aerating water during hauling involve the use of mechanical agitators, compressed oxygen, or both. Oxygen cylinders are available from some industrial gas or welding suppliers. Pressure regulators are needed for oxygen tanks, and flow meters can be installed to adjust oxygen flow rates.

Product	Vendor
Agitators and Aspirators	Aquatic Eco./Amazon/ Foster and Smith
Shearwater Bottom Draw Surface Aerator	Aquatic Eco.

**Dip nets:** Select the proper mesh size and net material for harvest seines and dip nets to avoid injuring fish. Use soft 3/16- inch knotless nylon mesh nets for delicate minnows.

Product	Vendor
Aquarium Mesh Nets	Pet Stores/Foster and Smith
Dip Nets	Memphis Net and Twine/Aquatic Eco.

**Netting for predaceous birds:** This is most effective over pools or small tanks and may be difficult to implement over large ponds. Make sure to choose the mesh size and tensile strength that will best suit your needs.

Product	Vendor
Predator Netting	Aquatic Eco.
Bird Barrier Netting	Aquaculture Sys. Tech. /Foster and Smith
Predator Netting	Memphis Net and Twine

**Hauling tanks:** Most commercially manufactured hauling tanks are insulated. Urethane foam, plastic foam and corkboard are common insulating materials, but they can also be used with homemade tanks, glued to the outer surface. Tanks should be equipped with an overflow drain to maintain water level and allow agitators to function at the proper operating depth. Another feature is an air vent or scoop to permit air circulation in the space between the water surface and tank top.

Product	Vendor
Hauling Tank	Aquatic Eco.
Hauling Tank	Aquaneering Inc./Reiff Manufacturing

**Tanks and Pools:** Make sure that when selecting tanks or pools, the material is appropriate for the conditions it will be housed. In general poly tanks are better for indoor use and fiberglass will fare better in outdoor conditions. It is important to check manufacturer specifications before purchasing to ensure that the materials will fit your individual needs.

Product	Vendor
Fiberglass Tanks/Pools	Aquatic Eco.
Tanks and Raceways	Red Ewald, Inc./AREA Inc.
Plastic Poly Tanks	Aquatic Eco./Polytank Inc.

**Larval feed:** Newly hatched larvae have shown the best growth on these two feeds. Brine shrimp nauplii are the most nutritious and are easily accessible, but require specific storing conditions and hatching apparatus. Otohime A is a successful alternative that does not have such stringent requirements.

Product	Vendor
Brine Shrimp Eggs	Brine Shrimp Direct/Pet Stores
Otohime A	Reed Mariculture

**Feed:** These are some of the vendors that offer varying types of aquaculture feed, make sure to select the feed that best suits the needs of your fish at their particular life stage(s).

Cargill  
[www.cargill.com](http://www.cargill.com)  
 (800) 928-2782  
 (985) 839-3400  
 1012 Pearl St.  
 Franklinton, LA 70438

Zeigler  
[www.zeiglerfeed.com](http://www.zeiglerfeed.com)  
 (717) 677-6181  
 (800) 841-6800  
 P.O. Box 95  
 Gardners, PA 17324

Rangen Inc.  
[www.rangen.com](http://www.rangen.com)  
 (800) 657-6446  
 115 13th Ave South  
 Buhl, ID 83316

Silver Cup Fish Feed  
[www.silvercup.com](http://www.silvercup.com)  
 (800) 521-9092  
 P.O. Box 57428  
 Murray, Utah 84157

**Spawning Mats:** Spawning mat material can either be sold by the roll or in individual sections depending on your operation and scale needs.

<b>Product</b>	<b>Vendor</b>
Spawntex® Mats	Blocksome& Co./Aquatic Eco.
PVC and Coated Wire	Local Hardware stores

**Pond fertilizer:** The fertilizer can be any organic or inorganic fertilizer. Rice bran can also be used.

<b>Product</b>	<b>Vendor</b>
12-12-12 Fertilizer	Local lawn and garden or hardware store
Rice Bran	Local feed or hardware stores.
Chicken Manure	Local lawn and garden or hardware store

## Vendor Contact Information

Aquaculture Systems Technology  
www.Beadfilters.com  
(504) 837-5575  
(800) 939-3659  
108 Industrial Ave.  
New Orleans, LA

Fish Farm Supply Co.  
www.fishfarmsupply.ca  
1-877-669-1096  
116 Bonnie Cres  
Elmira, ON N3B 3J8

Western Chemical Inc.  
www.wchemical.com  
800-283-5292  
360-384-5898  
1269 Lattimore Road  
Ferndale, WA 98248

Southern Aquaculture Supply  
www.southernaquaculturesupply.com  
870-265-3584  
800-850-7274  
931 Saint Mary's Street  
Lake Village, AR 71653

Global Water Inc.  
www.globalw.com  
1-800-876-1172  
PO Box 9010  
151 Graham Rd  
College Station, TX 77842

CHEMetrics  
www.chemetrics.com  
800.356.3072  
4295 Catlett Rd  
Midland, VA 22728

Aquaneering Inc.  
www.aquaneering.com  
858-578-2028  
7960 Stromesa Court  
San Diego, California 92126

Aquatic Eco-Systems  
www.aquaticesco.com  
(877) 347-4788  
2395 Apopka Blvd. Suite 100  
Apopka, FL 32703

Kent Marine  
www.kentmarine.com  
1-800-255-4527  
5401 West Oakwood Park Drive  
Franklin, WI 53132

Reed Mariculture Inc.  
www.reed-mariculture.com  
877-Seafarm (877-732-3276)  
408-377-1065  
871 East Hamilton Ave, Suite #D  
Campbell, CA 95008

LaMotte Company  
www.lamotte.com  
800-344-3100  
P.O. Box 329  
802 Washington Ave.  
Charlestown, MD 21620

Forestry Suppliers, Inc.  
www.forestry-suppliers.com  
800-752-8460  
205 West Rankin Street  
P.O. Box 8397  
Jackson, MS 39284-8397

Memphis Net and Twine Co. Inc.  
www.memphisnet.net  
888-674-7638  
P.O. Box 80331  
Memphis, TN 38108-0331

Reiff Manufacturing  
www.reiffman.com  
800-835-1081  
670 B Street  
Walla Walla, WA. 99362

Red Ewald, Inc.  
www.redewald.com  
800-242-3524  
P.O. Box 519  
Karnes City, TX 78118

AREA Inc.  
www.areainc.com  
305-248-4205  
P.O. Box 901303  
Homestead, FL 33090

PolyTank, Inc.  
www.polytankco.com  
800-328-7659  
62824 250th Street  
Litchfield, MN 55355

Brine Shrimp Direct  
www.brineshrimpdirect.com  
800-303-7914  
P.O. Box 3044  
Ogden, UT 84409

Drs. Foster and Smith  
www.drsfostersmith.com  
1-800-381-7179  
2253 Air Park Road,  
P.O. Box 100  
Rhineland, Wisconsin 54501

Amazon  
www.amazon.com  
1-866-216-1072

Blocksome & Co.  
www.blocksom.com  
219-874-3231  
P.O. Box 2007  
450 St. John Road Suite 710  
Michigan City, IN 46361

## Chapter 15. Additional Resources

Cocahoe Minnow Survey Report. (2010). Christopher Green, Julie Anderson, Craig Gothreaux, and Sunny Brogan. Louisiana State University Agricultural Center. ([http://www.lsuagcenter.com/en/crops\\_livestock/aquaculture/baitfish/minnows/Cocahoe-Minnow-Survey-Report.htm](http://www.lsuagcenter.com/en/crops_livestock/aquaculture/baitfish/minnows/Cocahoe-Minnow-Survey-Report.htm))

Management of Recreational and Farm Ponds in Louisiana. (2003). C. Greg Lutz, William E. Kelso, and Jeff Slade. Louisiana State University Agricultural Center. Pub. 2573. (<http://www.lsuagcenter.com/NR/rdonlyres/3928870C-592A-412B-8E9A-EC4B2C4EF3D5/2614/pub2573FarmPonds2.pdf>)

Growing Bull Minnows for Bait. (2004). Richard K. Wallace and Phillip L. Waters, Jr. Southern Regional Aquaculture Center. Publication No. 1200. (<https://srac.tamu.edu/>).

Southern Regional Aquaculture Center Fact Sheets (<https://srac.tamu.edu/>).

Fish Farming in Recirculating Aquaculture Systems (RAS). (2004). L. A. Helfrich and G. Libey. Department of Fisheries and Wildlife Sciences, Virginia Tech, USA. (<http://cnre.vt.edu/extension/fiw/fisheries/fishfarming/recirculating.pdf>)

Louisiana State University Agricultural Chemistry  
W.A. Callegari Environmental Center  
[www.lsuagcenter.com/Callegari](http://www.lsuagcenter.com/Callegari)  
Phone: (225) 578-6998  
Fax: (225) 578-7765  
1300 Dean Lee Drive  
Baton Rouge, LA 70820

St. Mary, Iberia, and Vermilion Parish Extension Office  
St. Mary Parish Court House  
Phone: (337) 828-4100  
Fax: (337) 828-0616  
500 Main Street Rm. 314  
Franklin, LA 70538-6199

St. Tammany and Tangipahoa Parish Extension Office  
Southeast Region  
Phone: (985) 543-4129  
21549 Old Covington Hwy.  
Hammond, LA 70403

Jefferson, Orleans, St. Charles and St. John Parish  
Extension Office  
LSU AgCenter  
Phone Number: (504) 736-6519  
Fax Number: (504) 736-6527  
1221 Elmwood Park Boulevard, Suite 300  
Jefferson, LA 70123

Plaquemines Parish Extension Office  
LSU AgCenter  
Phone: (504) 433-3664  
Fax: (504) 392-2448  
479 F. Edward Hebert Blvd., Suite 201  
Belle Chasse, LA 70037

Iberia, St. Martin, Lafayette, Vermilion, St. Landry, &  
Avoyelles Parish Extension Office  
LA Cooperative Extension Service  
Phone: (337) 276-5527  
Fax: (337) 276-9088  
P. O. Box 466  
Jeanerette, LA 70544-0466

Terrebonne and Lafourche Parish Extension Office  
LSU AgCenter  
Phone: (985) 873-6495  
511 Roussell Street  
Houma, LA 70360

Cameron and Calcasieu Parish Extension Office  
LSU AgCenter  
7101 Gulf Hwy.  
Lake Charles, LA 70607  
Phone: (337) 475-8812  
Fax: (337) 475-8815

Jefferson Davis, Vermilion, Acadia, St. Landry,  
Evangeline, Cameron, Calcasieu, Lafayette,  
Beauregard, & Allen Parish Extension Office  
LSU AgCenter  
Phone: (337) 898-4335  
Fax: (337) 893-7165  
1105 West Port St.  
Abbeville, LA 70510

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## Notes: