

# Baitfish

## AQUACULTURE CURRICULUM GUIDE

### YEAR TWO SPECIES MODULE

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**Description:** The module consists of the following three problem areas:

**Module:** Baitfish

**Problem Areas:** Expanding understanding of the species of baitfish commonly produced in the United States  
Understanding techniques involved in developing a baitfish operation and managing it properly  
Expanding understanding of techniques involved in the harvest, transport, and sale of baitfish

**Objectives:** The objectives for each problem area are given below.

- A. Expanding understanding of species of baitfish commonly produced in the United States
  - Identify the major species of baitfish
  - Describe the life history and characteristics of the Fathead Minnow and Golden Shiner
  - Identify the general requirements of the Fathead Minnow
  
- B. Understanding techniques involved in developing a baitfish operation and managing it properly
  - Identify the necessary facilities for producing baitfish
  - Identify the costs involved in producing baitfish
  - Identify the routine management techniques involved in baitfish culture
  - Identify aspects of the baitfish industry that may pose problems to the producer
  
- C. Expanding understanding of techniques involved in the harvest, transport, and sale of baitfish
  - Identify the equipment necessary for baitfish harvest
  - Describe the most common harvest techniques
  - Identify the hauling requirements of baitfish
  - Describe the major markets of baitfish

**Reference Materials:**

**Third Report to the Fish Farmers** (1984) by Dupree, H.K. & J.V. Hune , USFWS, Washington, DC.

**Baitfish Production: Enterprise Budget** (1988) by Engle, C.R., L.W. Dorman & D.L. Gray, SRAC Pub. No. 122.

**Baitfish** (1988) by Gray, D.L. , SRAC Pub. No. 120.

**Baitfish: Feeding Practices** (1988) by Gray, D.L., SRAC Pub. No. 121.

**Manual for Baitfish Culture in the South** by Guidice, J.J., D.L. Gray & J.M.. Martin , Pub. No. EC550. University of Arkansas Cooperative Extension and USFWS.

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**Forage Species: Range, Description, and Life History** (1988) by Higginbotham, B., SRAC Pub. No. 140.

**Forage Species: Production Techniques** (1988) by Higginbotham, B. SRAC Pub. No. 141.

**Forage Species: Production Techniques** (1988) by Higginbotham, B. ,SRAC Pub. No. 141

**Introduction to Aquaculture** (1992) by Landau, M., John Wiley & Sons, New York.

**The Fathead Minnow: An Overview on Propagation, Culturing, and Uses** (1986) by Martin, M. Aquaculture Magazine 12 (4): 48-50.

## **Presentation:**

### **A. What are the major species of baitfish produced in the United States?**

**Lead a discussion about baitfish. Ask the students how many of them have purchased Minnows for fishing. Ask them where they think those fish came from.**

Over 20 species of baitfish have been cultured in the United States. Of these, the most important are the

Fathead Minnow, Golden Shiner, and Goldfish.

**Use live examples, slides, photos, and/or TM 1 while you give a general description of each. The SRAC publications have some black and white drawings of these fish if no other visuals are available.**

#### 1. Fathead Minnow (*Pimephales promelas*):

- a. Cylindrical body.
- b. Small scales.
- c. Color is generally dull, although a strain of red Fathead Minnows has been developed.

These fish are referred to as "rosy reds."

- d. Males grow larger than females and develop horny projections on their head, called breeding tubercles, during the spawning season.
- e. Total length usually less than three inches.

#### 2. Golden Shiner (*Notemigonus crysoleucas*):

- a. Deep laterally compressed body.
- b. Shiny gold or silver color.
- c. Large scales.
- d. Lateral line curves down toward the pelvic fin then back up to the tail.
- e. Can grow to over 10 inches.
- f. Females often grow larger than males.

### **B. What life history strategies do the two most common species use?**

**Ask the class what they think Minnows and Shiners eat. Have the students suggest ways that Minnows could be fed. TM 2.**

1. Fathead Minnow
  - a. The diet of the Fathead Minnow consists mostly of algae and other plants, but aquatic insects are occasionally consumed.
  - b. Spawning begins when water temperatures warm to 65°F and continues throughout the summer whenever water temperatures are below 85°F.
  - c. Between 200 and 500 adhesive eggs are deposited onto the underside of a submerged object.
  - d. Males guard the eggs until they hatch.
  - e. Females may spawn over 15 times in one summer.
  - f. Fatheads hatched in May can mature during their first summer, but generally do not spawn until their second summer.

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### 2. Golden Shiner

- a. The Golden Shiner is omnivorous, feeding on a combination of algae, higher plants, crustaceans, snails, and insects.
- b. Spawning begins when water temperature reaches 70°F and ceases at 80°F.
- c. Up to 10,000 adhesive eggs are usually scattered over submerged filamentous algae or vascular plants. Nests are not constructed and the eggs are not guarded by either parent.
- d. Artificial spawning materials are used in commercial hatching situations.
- e. Eggs hatch in about four days.
- f. Larvae have a diet similar to the adult.

### C. What are the requirements of the Fathead Minnow and Golden Shiners?

Traditionally, water quality in baitfish production has not been a large problem, because the poundage of fish produced seldom exceeds the carrying capacity of the pond. Water quality is becoming more important today, however, because productivity/acre has to be increased due to increase in fixed costs. Ideal conditions for the culture of Fathead Minnows include:

1. Water temperature 70° to 80°F.
2. Phytoplankton densities such that the secci disk depth is less than 12 inches.
3. Fatheads prefer plastic over any other material.
4. DO above 3 mg/L at all times.
5. Ammonia concentrations less than 0.5 ppm and an un-ionized concentration of less than 0.04 ppm.

**Use TM 2.**

### D. What do Fathead Minnows and Golden Shiners eat?

The feeding of baitfish is becoming the most important feature of improved baitfish production.

**Use TM 3 to discuss the diet of baitfish. Consider both natural and formulated feeds. Contact feed mills or distributors and ask for samples and formulation data.**

1. Fathead Minnow
  - a. The diet of the Fathead Minnow consists mostly of algae and other plants, but aquatic insects are occasionally consumed.
  - b. Fatheads will readily consume artificial feeds.
2. Golden Shiner
  - a. The Golden Shiner is omnivorous feeding on a combination of algae, higher plants, crustaceans, snails and insects.
  - b. The Golden Shiner will also eat formulated feed.

### E. What techniques are used to feed baitfish?

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Use TM 4 as you discuss proper baitfish feeds. Discuss proper fertilizer application techniques. Visit a local chemical company and discuss various fertilizer types and formulas. Review manual and mechanical feeding techniques.

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## 1. Enhancing Natural Feeds

- a. Fertilization - Organic fertilizers stimulate the growth of both phytoplankton and zooplankton, while inorganic fertilizers promote the phytoplankton bloom. Both fertilizers enhance the natural prey of baitfish.
- b. Organic fertilizers include soybean meal, cottonseed meal, rice bran, livestock manures, and hay. However, overuse of manure can cause ammonia to reach stressful levels and lead to fish health problems.
- c. Inorganic fertilizers should be high in phosphorus. If high nitrogen organics are used then nitrogen need not be included. Potassium is never required. Common formulas used are 11-37-0, 10-20-0, and 0-46-0. Granulated formulas should either be dissolved in water before application, or placed in a mesh bag in the inflowing water stream.
- d. A combination of between 300 and 800 lb/ac organic fertilizer and 100 to 200 lb/ac inorganic should be applied to the pond prior to stocking.

## 2. Formulated Feeds

- a. Artificial feeding can double production.
- b. Both starter and grower feeds are available for baitfish. Starter feeds should be fed for the first few weeks of fry culture and then the fish can be switched to a grower diet.
- c. Baitfish starter feeds should be high in protein and complete in nutrients and vitamins. These feeds should be ground nearly as fine as flour.
- d. Starter diets should be fed 3 to 5 times per day on all sides of the pond for the first three weeks of culture.
- e. A grower diet can be either coarsely ground or pelleted and generally contains 30-35% protein.
- f. Grower diets can be either broadcast on the downwind side of the pond or placed in piles in the corners.
- g. Feeding should be done 1 to 3 times per day, but care should be taken to insure that all feed is being eaten since wasted feed can lead to water quality problems.
- h. Feeds are manufactured by two processes: (i) Extruded feeds are cooked hotter and longer, breaking down the basic ingredients to a more digestible form. (ii) Steam pellets are not cooked at high temperatures, but are manufactured cheaper.
- i. The different structures of feeds are used for a variety of reasons but consist of: (i) Sinking pellets - steam. (ii) Floating pellets - extruded. (iii) Meal - both. (iv) Crumble - extruded.
- as j. The various structures are used for different size of fish during different seasons and management tools.

**Discuss requirements of any plant community. Relate this to the algal community in a pond. Mention that phosphorus is generally the limiting nutrient in aquatic plant communities and relate this to formulation of the fertilizers used. Mention that fertilization can be reduced when feeding rates are high because the feed and fish waste supply many of the plant's required nutrients.**

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- k. Although bait fish will consume up to 10% of their body weight per day in peak feeding months, 3% of body weight is a high feed rate for a well-bloomed pond and more efficient.

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### F. How can fertilization increase minnow production?

Fertilization increases phyto and zooplankton populations, the primary food source of baitfish. More feed means more fish.

### G. In what type of facility are most baitfish cultured?

**If possible visit a baitfish farm or have a baitfish farmer visit the classroom to discuss production techniques. If this is not possible then have the class discuss ways that they think baitfish could be cultured.**

Virtually all baitfish are cultured in earthen ponds.

**While describing the ideal baitfish pond, draw an example for the class. Ask for student input and try to develop a design for a baitfish farm. Keep in mind that many successful baitfish farms operate under other than ideal conditions.**

The ideal baitfish pond should have the following characteristics:

1. Adequate supply of good water; 20 to 50 gallons per minute per acre is ideal.
2. Access to drainage area or canal such that all ponds can be completely drained during all seasons.
3. Completely surrounded by levees.
4. Accessible in all weather.
5. Poorly draining soil to prevent seepage and water loss.
6. Ten acres is considered the ideal size for the Fathead Minnow and Golden Shiner.
7. Flat bottom that slopes gradually toward the drain.
8. A harvest basin near the drain, which will facilitate the capture of remaining fish when the pond is drained.
9. Levee slope should be roughly 2.5 to 1, and at least 12' wide.
10. Levee should be designed to hold 12" of extra water in wet season, so pumping for replacement water in dry period will be kept to a minimum.

**Using an overhead or chalkboard, develop a setup and operating budgets of a hypothetical baitfish farm. Discuss potential net profits and how these could be altered to small management improvements or oversights.**

11. Crossover pipes between ponds for gravity flow from one pond to another; good way to seed blooms and move water.
12. Design to use a minimum amount of ground water for conservation purposes.

### H. How much capital is required to begin baitfish production?

1. Fixed Costs - The total initial investment for fixed cost items on a 100-acre farm including land @\$700/ac, pond construction, water supply, feed storage, and misc. equip. would be nearly \$200,000. When these items are depreciated over their normal expected life span the annual fixed cost, excluding items such as land, would be

roughly \$7,000 per annum, or \$700 per acre. NOTE: This budget does not include holding and grading costs.

2. Variable Costs - The average variable cost for a typical baitfish production farm including feed, labor, brood fish and spawning habitat, chemicals, and equipment operating is roughly \$400 per acre.

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## 3. Returns on Investment

- a. Production of properly managed baitfish ponds averages 500 lbs per acre.
- b. Baitfish generally sell for between \$2.50 and \$3.00 per pound.
- c. With average production and selling price a baitfish farmer can expect to gross about \$1,250 per acre. Adjusting for costs, the expected net is \$150 per acre.

## I. What are the management techniques involved in baitfish culture?

### 1. Pond Preparation

- a. Ponds should either be drained or killed every few years to eliminate competing wild fish.
- b. Puddles remaining following draining should be sterilized with chlorine or hydrated lime.
- c. Ponds should be filled and fertilized at least two weeks prior to stocking to allow a good phytoplankton bloom to develop.

### 2. Stocking

- a. There are two methods for establishing baitfish in culture ponds, natural reproduction and egg or fry stocking.
- b. Natural reproduction methods require that the producer stock an adequate number of brooders in each pond and supply spawning structure to them.
- c. Fathead Minnows will spawn on the underside of boards placed on the pond surface. They prefer 6' x 3' plastic sheets suspended 6" - 8" above water. Another common practice is to attach several 1 x 6 planks together with wire and anchor them a few feet a way from the pond bank.
- d. While Golden Shiners will spawn on mats of moss, grass, or other vegetation, most mats now are made of coated natural fibers, e.g., air conditioning filter material, sold in 50' rolls. Some producers still make mats with fire frames; others use loose sections of mat material.
- e. Golden Shiners can be stocked by removing spawning mats from a brood pond and placing them into the culture ponds; 100 mats per acre is a commonly used density.
- f. Fry stocking is more difficult than natural reproduction, but it is also less variable.
- g. Three- to four-week-old fry can be seined out of the brood ponds and transferred into culture ponds.
- h. Care should be taken not to stress the fragile fry; transferring should be done early in the day on cloudy days.
- i. The number of fry transferred should be carefully calculated.
- j. Stocking densities of 50,000 to 200,000 fry per acre are common.

### 3. Spreading Fish Around

- a. A major management technique deals with moving fish to get the "right" number of the sizes that one thinks the market will demand.
- b. Producers also practice spreading out fish seine from "overstocked" ponds (when around 2 lbs/1000) and stock in "understocked" ponds, to get sizes needed.

4. Fertilizing and Feeding - Review the baitfish feeding section of this module.
5. Water Quality Monitoring - Review the water quality module from previous semester.

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## 6. Population Sampling

**For a more complete guide to diseases and treatment see Guidice, Gray, and Martin (Baitfish Culture in the South).**

- a. Sample seining should be done every three or four weeks to monitor the population for growth and disease.
- b. A short 1/8-inch seine is ideal for this type of sampling.

## 7. Harvest - Review the baitfish harvest section of this module.

### J. What obstacles lie in the way of the beginning baitfish producer?

An understanding of the production economics and marketing is considered by many to be the primary difficulty for people entering the business.

**Use TM 5.**

### K. What are the major considerations in dealing with the health management of baitfish?

1. Stress is the key factor and good managers look to reduce stress at all times.
2. Crowded fish, particularly feeder goldfish, are more susceptible to parasites and diseases. Careful management can reduce the need for treatment.

#### 3. Bacterial Diseases - *Flexibacter columnaris*

- a. Columnaris can occur as an internal infection, an external infection, or both simultaneously. Internal infections may cause the fish to stop eating and swim listlessly in shallow water.
- b. External infections generally will appear as gray or dark yellow lesions or ulcerations on the skin. Infections often occur on the gills and in the mouth. These are usually dark yellow to brown.
- c. Diagnosis of the disease is made by identifying the bacteria either microscopically or through isolation and biochemical testing.
- d. An external infection of columnaris can be treated with potassium permanganate, although the process is very expensive.
- e. The most common method of treatment is to add 2 ppm to the water every hour until the red color persists for several hours.
- f. An internal infection should be treated with Terramycin medicated feed.

#### 4. Bacterial Diseases - *Aeromonas* and *pseudomonas*

- a. These are common bacteria of fresh water that may cause subacute or chronic infections following a period of stress.
- b. Behavioral changes caused by an infection may include reduced feeding activity, lethargy, and swimming listlessly in shallow water.
- c. Clinical signs of these infections are highly variable but may include small hemorrhages that look like pin pricks on the body and fins, irregular red or gray lesions on the

skin, eroded fins, raised scales, protruding eyes (exophthalmia), swollen abdomen, and a discharge of fluid from the anus.

d. Internal signs may include pale liver and kidney, hemorrhaging of the internal organs and body cavity, and fluid in the stomach and intestine.

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### 5. Protozoan Parasites - *Ichthyophthirius multifiliis* (Ich)

Ich can decimate a producer's stock once they become infected. Ich is the only protozoan parasite of fish that can be seen with the naked eye. The disease signs include small white spots on the skin, fins, and gills that when examined under a microscope are shown to be large ciliated protozoans with a crescent-shaped nucleus.

The complex life cycle of ich makes it difficult to treat. The mature parasite is found just under the skin of the fish and can't be treated when encysted because the skin protects the parasite from any chemical treatment. After spending one to three weeks (varies with temperature) in the fish, the adult leaves the fish and attaches to the bottom or side of the tank or pond. There it will develop into a mature trophont within 24 hours and will then rupture and release up to 2,000 free swimming tomites which must find a fish to infect within 2 days or die. Treatment of ich requires multiple applications of chemicals because only the free swimming stage can be killed.

6. Other Protists - There are a wide variety of protozoan parasites. Most of these occur as external parasites of the skin and gills.

a. A healthy fish will almost always harbor a small population of these parasites, but when the fish's natural ability to control this population is disrupted by stress, the population of protozoans can multiply rapidly.

b. A severe infection can interfere with the fish's ability to respire or may open a pathway for a bacterial pathogen to infect the fish.

c. Milk scale disease is caused by *Myxobolus note- migoni*, a parasitic protist which forms cysts under the scales of Golden Shiners giving them a milky appearance. This infection can lead to massive scale loss making the Shiners unmarketable and susceptible to many other pathogens.

d. *Pleistophora ovarae* is a parasitic protist that attacks the ovaries of adult female Golden Shiners. This protist can cause complete sterility in infected females.

### 7. Other Parasites

a. Argulus (fish louse)

b. Lernaea (anchor worms)

c. Flukes (internal)

### 8. Viral Diseases - Golden Shiner virus.

### 9. Fungi

a. Fungal infections can occur internally or externally but the majority of infections will be external.

b. Saprolegnia is the term used to describe an external fungal infection in fish.

c. Fungal infections can be identified by the white or gray mossy patches that form on the fish's skin, gills, or fins.

d. Infections usually begin on the margins of the fins or gills and work toward the center of the fish.

e. Fungal infections not severe enough to kill the host may open a port of entry for another infectious agent, or weaken the fish's defenses enough to allow a parasite problem to develop.

10. The best way for a producer to be sure of the causative agent of a problem is to take some of the sick fish to a diagnostic lab.

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11. Predation and Competition - Birds, snakes, turtles, frogs, wild fish, and some mammals all either compete with or prey on baitfish and should be controlled.

12. Marketing

Baitfish markets are difficult to establish because there are several very large baitfish produce prior to investment in baitfish culture.

**L. What equipment is necessary for the harvest of baitfish?**

**Ask the students if any of them have caught Minnows for bait. Discuss both seining and trapping Minnows for personal use and then relate this to seining and trapping Minnows on the large-scale in production ponds. Use TM 6 and previous information as you discuss equipment used. Use TM 7 as you discuss various harvest techniques. Ask students which techniques would be best or different situations.**

1. Seines or Traps
2. Hauling Tanks
3. Scales
4. Graders
5. Holding Vats
6. Portable Water Pump
7. Buckets
8. Trucks

**M. How are baitfish harvested?**

1. Seining - Seining is a labor-intensive activity that requires that large quantities of fish are marketable at once.

a. Partial Pond - Seining a corner or just a portion of the pond along a bank can be effective for capturing smaller amounts of fish when required. This requires only two or three people and the number of fish caught can be increased by baiting an area with feed just prior to seining or by seining around the aerator. If bait is used then the fish should be held in a vat for a few days prior to shipping long distances to allow the feed to be digested.

b. Entire Pond - Seining an entire pond often requires five or six people. The quantity of fish required must be rather large to merit this effort. Holding vats are used. Catch as many fish as possible and then distribute smaller amounts from the holding vats.

**Use TM 8 as you discuss hauling requirements of baitfish. Visit a baitfish farm or distributor to examine hauling equipment and talk with haulers if possible.**

2. Trapping - Traps are ideal for the small producer who needs only a few fish every day and has little or no holding capacity.

3. Catch Basin

- a. A catch basin at the pond drain allows for the capture of nearly every fish from a pond when it is drained.
- b. Without a catch basin many fish would be lost in the mud and to poor water quality in the shallow water near the drain when the pond is drained.
- c. Often up to 10% of the total pond production remains even after completely seined three times.
- d. Catch basins are being phased out.

**N. What are the holding and grading requirements of baitfish?**

1. Tanks

- a. Concrete, 3-12 m long by 90-15 cm wide, with a standpipe to keep the depth less than 60 cm.
- b. Tanks are constructed in open-ended buildings.
- c. Tanks need to be aerated.

2. Grading - Because different size fish feed on different size baitfish, fish need to be graded by size.

Types of graders:

- a. Panels - Panels with bars at various spacings are dragged through the tanks, letting smaller fish slip between bars.
- b. Box Graders - Fish are placed inside boxes in the tank, and the smaller fish swim out.

**O. What are the hauling requirements of baitfish?**

1. Density

- a. Two to three lbs/gal for hauls less than 6 hours.
- b. One lb/gal if the haul will be longer than 12 hours.

2. Oxygen - At or slightly above saturation.

3. Temperature

- a. Ideal hauling temperature is at or below 60°F.
- b. Fish should be tempered prior to release to prevent temperature shock.
- c. One-half pound of ice will cool 1 gallon of water approximately 10°F.

4. Salt and Other Chemicals

- a. Salt at a rate of 1 lb per 100 gals of water will help reduce stress on the fish.
- b. Finquel at a rate of 10 to 25 ppm will act as an anesthetic, Quinaldine at 10 to 15 ppm will produce the same effect.

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### 5. Hauling

- a. Small numbers are transported in plastic bags.
- b. Larger quantities are shipped in tank trucks. When shipping over large distances, water must be oxygenated.

### **P. Where are baitfish marketed?**

1. Commercial Distributors
2. Personal Distribution to Retailers
3. Direct Sale to Consumer
4. Contract to Established Producers

## **Descriptions of the Two Most Common Baitfish Species**

### **Fathead Minnow (*Pimephales promelas*)**

- Cylindrical body
- Small scales
- Dull color except “rosy reds”
- Males larger than females and have tubercles
  - Total length less than three inches

### **Golden Shiner (*Notemigonus crysoleucas*)**

- Deep, laterally compressed body
- Gold or silver
- Large scales
- Lateral line curves
- Can grow to over 10 inches
- Females often larger than males

# Life Histories of the Fathead Minnow and Golden Shiner

## Fathead Minnow

- The diet consists of algae, higher plants, and insects.
- Spawning begins at 65°F and continues throughout the summer if water temperatures are below 85°F.
- Lays 200 to 500 adhesive eggs on the underside of a submerged object.
- Males guard the eggs.
- Females may spawn over 15 times in one summer.
  - Fatheads generally do not spawn until their second summer.

## Golden Shiner

- Feeds on algae, higher plants, crustaceans, snails, and insects.
- Spawns at temperature between 70° and 80°F.
- Up to 10,000 adhesive eggs scattered on algae mats or vascular plants.
- Nests are not constructed.
- Eggs are not guarded.
- Eggs hatch in about four days.

- Larvae have a diet similar to the adult.

## **What Baitfish Eat**

### **A. Natural**

1. Phytoplankton and plants
2. Zooplankton
3. Aquatic insects

### **B. Formulated**

1. Starter diets
2. Grower diets

## **Baitfish Feeding Techniques**

### **A. Enhancing Natural Feeds**

1. Organic fertilizers
2. Inorganic fertilizers

### **B. Formulated Feeds**

1. Starter diets
  - a. 38% protein
  - b. Flour fine
  - c. High in essential nutrients and vitamins
  
2. Grower diets
  - a. Crumbles or pellets
  - b. 30 to 35% protein

## **Obstacles to the Baitfish Producer**

### **A. Diseases**

1. Bacterial
2. Protozoan
3. Other parasites
4. Viral
5. Fungi
6. Diagnostic labs

### **B. Predation and Competition**

### **C. Marketing**

## **Equipment Required to Harvest Baitfish**

1. Seines or traps
2. Hauling tanks
3. Scales
4. Graders
5. Holding vats
6. Portable water pump
7. Buckets
8. Trucks

## Harvest Techniques

- A. Seining
  - 1. Partial pond
  - 2. Full pond
  
- B. Trapping
  
- C. Catch Basin

## Hauling Requirements

### A. Density

1. Two to three lbs/gal for hauls less than 6 hours
2. One lb/gal if the haul will be longer than 12 hours

### B. Oxygen - At or slightly above saturation

### C. Temperature - At or below 65°F

### D. Tempering to Prevent Temperature Shock

### E. Salt and Anesthetics

1. Salt, of 1 lb per 100 gals of water
2. Finquel at 10 to 25 ppm, or Quinaldine at 10 to 15 ppm
3. Use anesthetic when handling and hauling Golden Shiners

