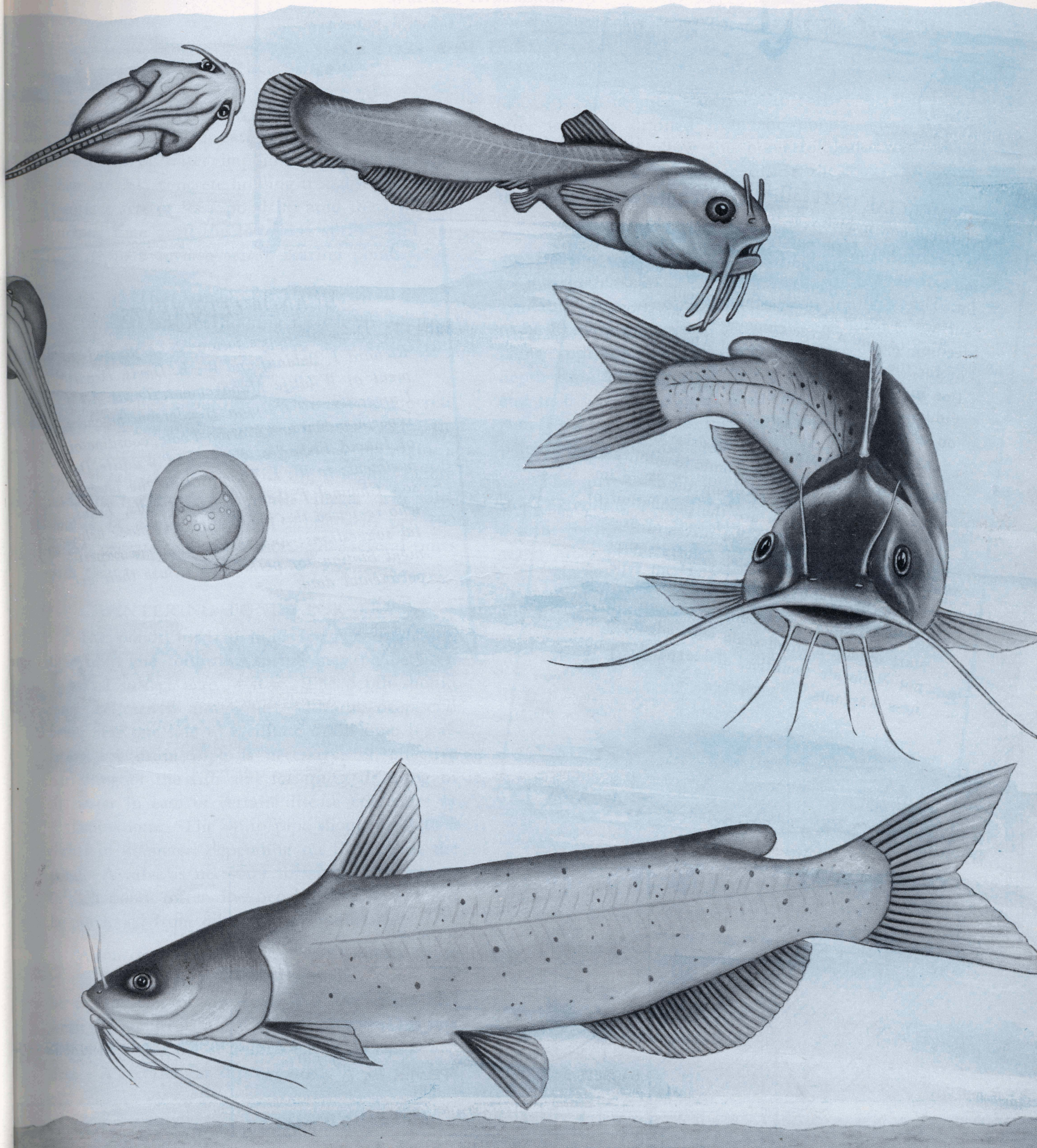
B-1024

CHANNEL CATFISH FARMING



TEXAS A&M UNIVERSITY
TEXAS AGRICULTURAL EXTENSION SERVICE

COMMERCIAL CATFISH PRODUCTION, a relatively new industry, is fast gaining interest in Texas. This farm enterprise involves feeding catfish as one would feed calves in a feedlot. The result is increased pounds of fish per surface acre of water. Supplemental fish feeding can be a large commercial operation, or for the family food supply. The information in this publication is written for the individual who plans to pursue catfish production on a rather large scale.

Before beginning an enterprise like this, be sure to consider the economic feasibility of such in your locality. Among the more important considerations are the population of the consuming area, market prices of dressed fish (prices vary over the State), source of water, topography of land and soil type.

Beginning producers would do well to start out on a small scale with adequate, but not elaborate facilities, and expand as business warrants.

ACKNOWLEDGMENTS

Grateful appreciation is expressed to Richard J. Baldauf and W. B. Davis, Department of Wildlife Management, Texas A&M University; to Harmon Henderson, hatchery superintendent and Marion Toole, coordinator of Inland Fisheries, Parks and Wildlife Department; to W. J. Thompson of the Thompson Channel Fishery, Wichita Falls, Texas, who reviewed this publication and made helpful suggestions; and to the Alabama Experiment Station for permission to use their experimental data.

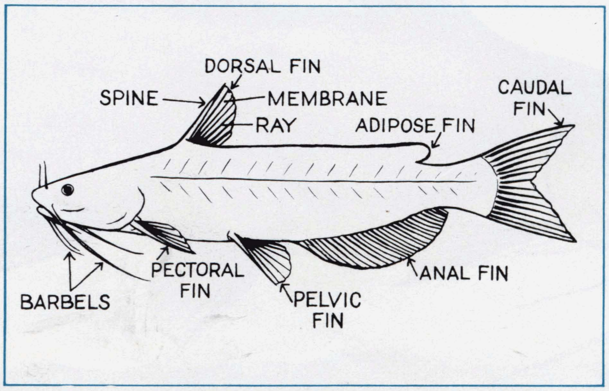
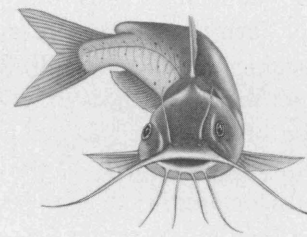


Fig. 1. Parts of a catfish.

Channel Catfish Farming



Wallace Klussmann
Extension Wildlife Conservation Specialist
TEXAS A&M UNIVERSITY

POND CONSTRUCTION

In an intensive catfish farming operation, three kinds of water impoundments are needed. These are: (1) concrete holding troughs, (2) small (1 surface acre or less) ponds to hold the fry from hatching time until the following spring, and (3) large (1 to 5 surface acres) rearing ponds.

HOLDING TROUGHS

An ideal size for holding troughs is approximately 12 to 18 feet long, 3 feet wide and 3 feet deep.

The trough should be constructed of concrete and have a continuous source of fresh water. Install a screened erect drain pipe to maintain a water depth of 2 feet within the trough. Before using the trough, scrub it with vinegar or a solution of ½ pound of glacial acetic acid per 100 gallons of water and rinse thoroughly several times with clean water.

WINTERING PONDS FOR FRY

The ponds used to hold fry from hatching time until the following spring may be between ¼ and 1 surface acre in size. The depth should range between 3 and 6 feet with the deep end being near one side to facilitate drain pipe installation. A drain pipe is necessary for effective harvesting of the fish and for quick draining of the water in case of certain disease epidemics or contaminations. The drain pipe should be 3 to 5 inches in diameter, depending on the size of the pond. A valve is necessary to control the system in each pond (often inexpensive used valves can be purchased from oil or gas companies).

A concrete box constructed below that portion of the drain pipe projecting into the pond will be a valuable aid in collecting the fingerlings when the pond is drained in the spring. This box should be about 6 feet long, 3 feet wide and 2 feet deep. A rectangular dip net made to fit the box (2′ x 3′) can be used effectively to collect the fish after water is drained from the pond. Proper construction will allow the pond to drain completely with the last water filling the box and thus concentrating the fish in this area.

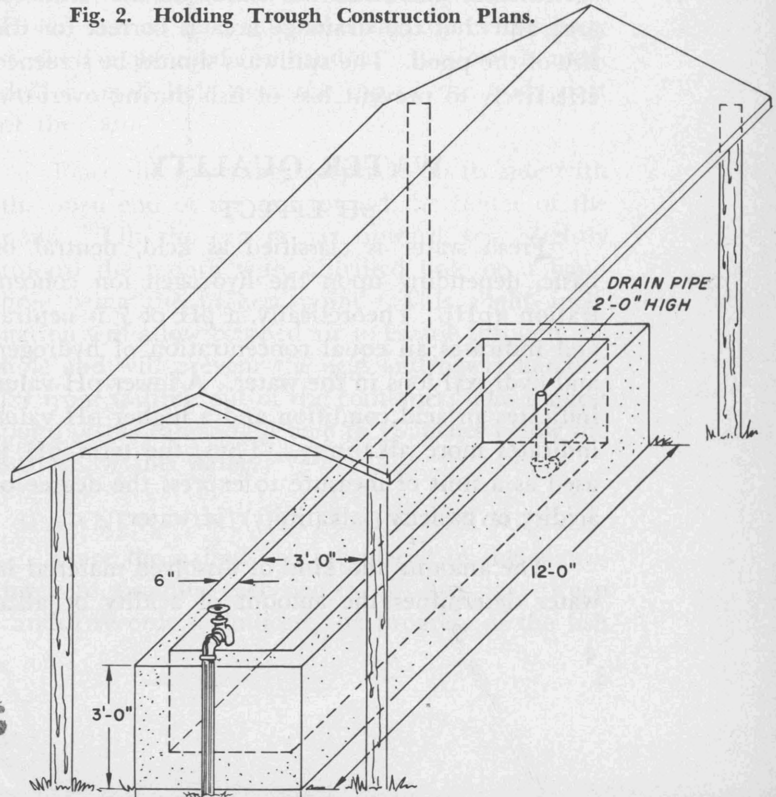
REARING PONDS

Rearing ponds are used to grow the fingerlings to marketable size. Although you can use any available pond to grow fish, practical limits seem to be from 1 to 5 surface acres with the ideal size being approximately 2 to 3 surface acres. The depth should range from 3 feet at the shallow end to 6 feet at the deep end. However, if only runoff water is utilized, increase the depth to compensate for evaporation losses.

The surrounding shoreline should have a 3:1 slope extending below the water level to a depth of 3 feet. Such a shoreline will minimize the shallow water areas preferred by obnoxious plants.

The drain should project into the pond at the lowest point on the pond side of the dam.

Fig. 2. Holding Trough Construction Plans.



The immediate area over the end of the drain pipe in the pond may be graveled to help prevent clogging by mud and silt. About 10 feet of drain pipe should project into the pond beyond the base of the dam. If the pipe end is not covered with gravel, close it to prevent fish from entering and clogging it. Drill holes 1/4 to 1/2 inch in diameter, in the projecting portion of the pipe to allow the drain pipe to carry its full capacity when the valve is open.

WATER SUPPLY

A continuous supply of good-quality water is the most essential part of an efficient operation to rear channel catfish.

Runoff water is not dependable in most instances. Wells or other permanent sources must be available in a large commercial operation. Occasionally, well water is very low in dissolved oxygen. Aerate it by passing it over a series of baffles or by using a spray system for introducing the water into the pond. Ideally, it should be possible to drain and refill a pond within several days.

If possible, do not allow runoff water to enter small ponds containing fry catfish. Such water often contains contaminants which are toxic to young fish. Excessive runoff water can cause overflow of the pond accompanied by loss of fry.

If runoff water must be used, be sure the drainage area is well sodded, that no harmful agricultural chemicals are used on the drainage area and that the drainage area is correct for the size of the pond. The spillways should be screened effectively to prevent loss of fish during overflow.

WATER QUALITY

pH EFFECT

Fresh water is classified as acid, neutral or basic, depending upon the hydrogen ion concentration (pH). Theoretically, a pH of 7 is neutral and indicates an equal concentration of hydrogen and hydroxyl ions in the water. A lower pH value indicates an acid condition and a higher pH value indicates more alkalinity. Thus, the term pH is used as a unit of measure to express the degree of acidity or basicity (alkalinity) of water.

The amount and kind of dissolved material in water determines the amount of acidity or alkalinity, and the ratio of these materials to each other determines the actual pH. Texas has many different soil types which affect pH and water quality. Thus, in a general sense, there are as many different kinds of water as there are soil types.

A pH from 5 to 8.5 is considered safe for fish, while a pH from 6.3 to 7.5 is optimum. A pH above 9.5 usually has lethal effects. Since pH is not static the pond owner should have an inexpensive pH meter for keeping daily records and should pay particular attention to pH changes.

Adding acidic substances to a high pH does not lower the pH effectively. However, lime, (an alkaline material) can be added to acid waters to raise the pH. Occasionally this is very beneficial in certain acidic waters in East Texas. The lime application rate varies from 500 pounds to 2 tons per surface acre. Check the pH after each application to determine if more is needed.

OXYGEN DEPLETION

Photosynthesis, a process by which plants manufacture food, takes place only during daylight hours, releasing oxygen in the process. At night plants actually take oxygen from the water.

In the presence of heavy vegetation, or an abundance of decaying vegetation and a succession of two or three cloudy, windless days, oxygen may become depleted. The fish will show distress and surface, particularly in the early morning. If the depletion is severe, it may lead to a heavy fish kill. The oxygen level always should be about five parts per million.

RELATIONSHIP OF pH AND OXYGEN

Photosynthesis removes carbon dioxide and releases oxygen to the water. This continues after all the free carbon dioxide is removed and then the bicarbonates are used. If all bicarbonates are used then the carbonate is used yielding carbonic acid. The acid ions are exchanges with hydroxyl ions resulting in the formation of calcium hydroxide and a high alkaline end point.

In the presence of abundant submerged vegetation, strong sunlight and complete breakdown of carbonate, the pH can be raised to about 11. This also may result in the supersaturation of water with oxygen, a condition which may cause the gas bubble disease or "popeye" condition.

Fig. 3. Releasing male brood fish into spawning pen.

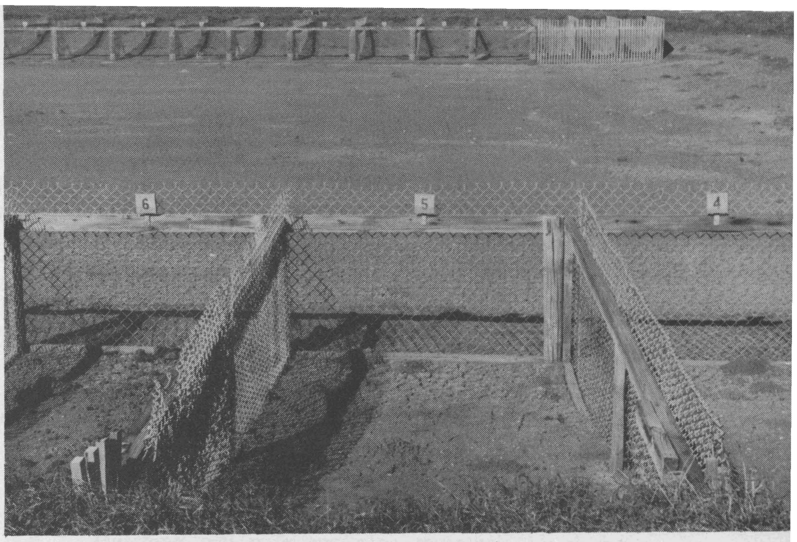


Fig. 4. Hatchery pond showing hatching pen.

WATER SAMPLING AND ANALYSIS

In an intensive production operation it will be advantageous for the operator to be able to effectively sample and analyze water for dissolved oxygen and carbon dioxide.

These measurements are of vital importance in discerning the cause and prevention of fish kills. Ordinarily they should be made when fish are surfacing, dieing or when any other abnormal condition is noticed in the pond. Directions for the construction of a water sampler and simplified analysis technique are given in the appendix.

FINGERLING PRODUCTION

BROOD FISH

The beginner may purchase brood fish from an established dealer or raise them from fingerlings obtainable from state or federal hatcheries.

Select brood fish in much the same way a stockman selects breeding cattle. Consider overall appearance and conformation.

Brood fish should weigh between 3 and 7 pounds. Usually brood fish can be used for several years.

About May 1, place the brood fish in the holding trough and sex and pair them. Although it is often difficult to determine the sex of channel catfish, usually they can be sexed by observing the following characteristics: 1. The head of the male is much broader than that of the female. 2. The vent of the male will protude more than that of the female. 3. The vent of the female becomes inflamed and red prior to spawning.

Then pair brood fish in preparation for placement in the hatching pens. At this point, be sure to pair a larger male with a smaller female. Since the male tends the eggs after spawning, he sometimes has to fight off the female to keep her from eating the spawn.

SPAWNING PENS

Choose one pond as a site for the hatching pens. Construct the pens from chain link fence in water about 3 feet deep. Each pen should be approximately 4 by 8 feet. Embed the fencing about 6 inches into the ground to keep the fish from digging out. One end of the pen should open onto the pond bank.

SPAWNING RECEPTACLES

Ten-gallon milk cans can be used as spawning receptacles. However, crock jars made for the purpose are desirable since they will not rust. Dimensions of crock jars used in the state fish hatcheries are: diameter of the body 9½ inches, diameter of the mouth 8 inches, height 22 inches. Holes, one on each side, near the top of the body of the jar are used for handles. If a can is used, drill a small hole near the top of the body part of the can.

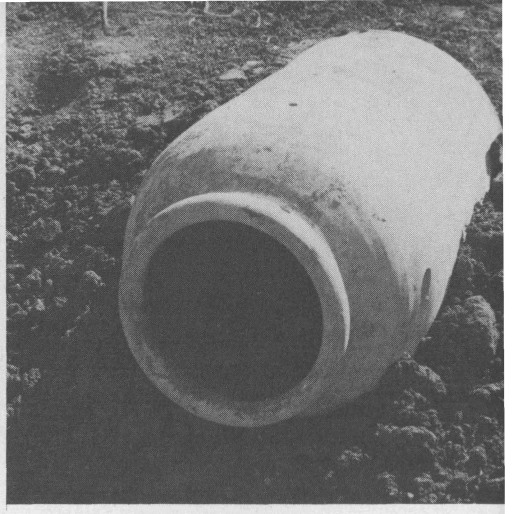
Place the spawning receptacle on its side with the open end of the can toward the center of the pond. Tilt the can or jar upward very slightly toward the mouth with a drilled hole or a hand hole being the highest point. This slight inclination will allow trapped air to escape through the hole and will prevent the eggs and newly hatched fry from spilling out of the container. The highest point of the can should be 8 to 12 inches below the surface of the water.

SPAWNING AND HATCHING PROCESSES

Once the paired fish are placed in the spawning pens, examine each pen every other day. Keep careful records to indicate the progress of the fish

Fig. 5. Spawning receptacles—10-gallon milk can and crock jar.

Fig. 6. Spawning receptacle embedded in bottom of hatching pen.



in each pen. If the water is clear, it may be possible to observe the fish visually; however, it usually is necessary to feel inside each container to determine if the male is present.

Occasionally a nesting male will be vicious and bite an open hand thrust into the jar. A piece of rubber hose or some similar soft object can be inserted by hand into the jar or can. If the male is inside he will either bite the hose and can be pulled out or will leave the jar voluntarily. Now it is safe to examine the bottom of the nesting container with the bare hand. If eggs are found, the female can be removed if it can be done with little disturbance. Usually removal of the female is not necessary. Record the date when eggs are found.

It is not necessary to check the jar again until the sixth day after the spawn was deposited. The eggs should hatch between 5 and 10 days. In water 80 degrees F., the usual hatching time is 7 days. After the sixth day, examine the container as outlined above until fry are felt in the jar. After hatching occurs, instead of feeling a large jelly-like mass of eggs, you will feel movement of small fish.

When fry are found, lift the jar from the hatching pen and carry it to the holding trough. Place the container with the fry still inside with the open end toward the incoming fresh water. Keep water flowing through the holding trough as long as it holds containers with fry. Hold fry in the holding trough 3 or 4 days or until the yolk sack is absorbed and pigmentation appears. When the yolk sack has been absorbed, dip the fry from the holding trough and place in the "wintering" or holding pond until spring. Stocking rates of the fry should be about one spawn per ¼ surface acre but not to exceed three spawns per pond. Ponds 1 surface acre or smaller are recommended for holding fry over the winter.

FEEDING THE FRY

Feeding begins when the fry are placed in the "wintering" pond. At first, feed the fry sparingly at the same place in the pond and at the same time. Feed the fry once a day, 6 days per week. Use about 2 pounds of ground meat scraps or tankage per spawn. Within 20 to 25 days, the young catfish should begin to "top" or surface when food is cast on the water. After they begin topping, it is easier to judge how much feed to give them. They should be given all the feed they will eat but not an excess. Overfeeding results in uneaten meat scraps which will decay in the pond and cause disease outbreaks.

Continue the diet of tankage until the young fish are about 2 to 3 inches in length. At this time change the feed to a 1:1 ratio of tankage and pelleted feed. Use the same pellets as described and recommended for use in rearing ponds. This ratio can be continued until the fish are about 3 or 4 inchees long or until they are placed in the rearing ponds next March.

The rate of feeding will increase rapidly during the summer months but will decrease considerably during the winter. A feeding rate of 1 percent of the total weight of channel catfish in the pond will allow fingerlings to grow slowly but will keep them in good condition.

In the spring or about March 1, remove the fingerlings from the wintering ponds and place them in larger rearing ponds.

RATES OF STOCKING REARING PONDS

The maximum recommended stocking rate in an intensive operation is about 2,500 channel catfish per surface acre. The beginner should reduce the stocking rate to about 1,500 channel catfish per surface acre. This reduced rate is recommended for several reasons: 1. The beginner may not be able to recognize danger indicators that are sure to appear in crowded ponds; 2. there is less chance for disease and parasitism in less crowded ponds; 3. there is less danger of oxygen depletion where feeding rates are lower.

With experience and knowledge, the fish producer can increase safely the stocking ratio upwards to the level of 2,500 per surface acre. One recent experiment indicated that a stocking rate of 1,500 per surface acre gave the best growth rate with efficient feed utilization. Remember, as the stocking rate increases the growth rate will decrease. This means that it will take longer to grow the fish in a pond containing 2,500 fish per surface acre to an average weight of 1 pound than it will for fish in a pond containing only 1,500 fish per surface acre.

If the fish are to be carried beyond the 1 pound average before marketing, it may be profitable to reduce the stocking rate to 1,000 or less per surface acre.

FEEDING IN REARING PONDS

The fingerlings may be started on a diet of pelleted feeds only after placement in the rearing pond.

Formula for Pelleted Channel Catfish Feed

	By weight
Soy bean oil meal (44% protein)	35%
Peanut cake (53% protein)	35%
Fish meal (60% protein)	15%
Distillers dry solubles (24% protein)	14%
Bentonite clay (binding material)	1%

Feed mixed according to this formula will be approximately 46 percent protein, 25 percent carbohydrate and 5 percent fat. This recommended formula was developed through research at Auburn University, Auburn, Alabama, and has proved to be an acceptable feed which gives good production in Texas waters and climate. Other feedstuffs may be cheaper in certain areas of the State and may be substituted if the resultant formula contains 33-40 percent protein and is palatable. Fish meal or ground meat scraps (tankage) seem to be essential in all fish feeds.

Bentonite clay is added to prevent the pellets from dissolving too quickly. With 1 percent bentonite as recommended, the pellets will dissolve in water in about 5 minutes.

The feed must be pelleted with the pellets approximately ½ inch by ¼ inch in size. This size is suitable for large and small fish. The use of unpelleted or dry mix feeds is not recommended since the conversion rate of pounds of feed to pounds of fish is very low and there is a greater possibility of oxygen depletion resulting from the decay of uneaten feed.

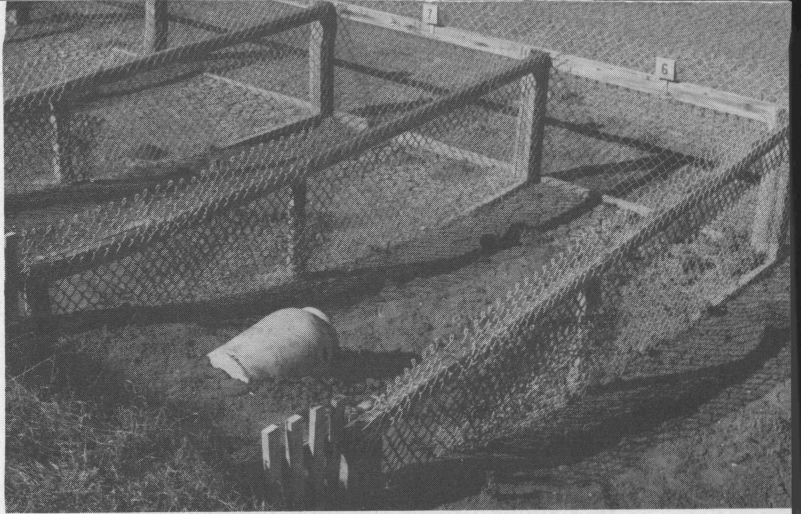


Fig. 7. Hatching pen with spawning receptacle in place.

Clean the pelleting dies used by the feed mill with a vegetable oil rather than petroleum products, which ordinarily are used. Occasionally, such petroleum products can contaminate the first portion of the feed that passes through the dies after cleaning. Local feed mills usually possess pelleting machinery and can obtain the products used in this prepared feed.

Other feeds that have been tried and found suitable are chopped fish, chicken entrails, beef liver and beef heart. Most commercial feed producers manufacture a prepared fish food and commercial feeds are recommended for small operations where cost of pelleting small amounts of feed is not economical. However, many are too high in carbohydrate content. If a commercial feed is used, choose a high protein feed in pelleted form.

FEEDING RATES IN REARING PONDS

The amount of feed utilized by the fish depends primarily on water temperature and the size of the fish. However, the rate should not exceed 25 pounds per surface acre of water regardless of the number and weight of the fish. Fish grow best when the water temperature is above 70 degrees F. Typically, the amount of feed taken by the fish will vary directly with the temperature.

Use the table below as a guide for feeding channel catfish from fingerlings to market or harvest size. Fish should not be fed more than they will eat in a 24-hour period.

SUGGESTED FEEDING RATES

Water Temperature	Amount of feed
Above 70° F.	3% of estimated total weight of fish
60° F. to 70° F.	2% of estimated total weight of fish
45° F. to 60° F.	1% of estimated total weight of fish
Below 45° F.	Usually no feed*

*A small amount of feed may be necessary if low temperature is prolonged. In cold weather growth will be slow or nonexistent. During extended low water temperatures in the winter a certain amount of feed is necessary to maintain weight.

If this feeding guide is used, the estimated total weight of all fish in a given pond must be determined each month. A simple procedure can be followed: 1. Collect by seine or other method approximately 100 fish from the pond. 2. Count and weigh the fish. Return the fish to the pond as soon as possible. 3. Obtain the average weight per fish by dividing the number of fish collected into the pounds of fish collected. 4. Obtain estimated total weight by multiplying average weight of a single fish by the total number stocked in the pond. 5. Calculate pounds of feed needed by multiplying the estimated total weight by the percentage of required food indicated in the above table.

Growing fish should be fed 6 days a week and at the same time and place. During cool weather, feed the fish when the highest daily temperature occurs (approximately 3 p.m.). Continue feeding until the fish are the desired size.

TREATMENTS FOR PARASITES AND DISEASE

Although the best disease preventive is good sanitation and management, it is sometimes necessary to treat fish for various parasites and diseases. This is particularly true when catfish are held in crowded conditions for long periods of time.

Channel catfish can become infested with external protozoan parasites, gill flukes, tapeworms and other various intestinal parasites. Experimentally, gill flukes and external protozoa have been controlled by treatment with potassium permanganate followed by treatment with formalin. Tapeworms and various other intestinal parasites have been controlled by incorporating di-n-butyl tin oxide in the feed.

The normal treatments used are as follows:*

Potassium Permanganate treatment: Place the fish in a 10 parts per million (p.p.m.) potassium permanganate solution for one hour. Reduce treatment to 4 p.p.m. for one hour for small fingerlings. Following this, run fresh water into the holding tanks until the pink color of the permanganate disappears. Exposure to the permanganate for longer than the recommended time may kill the fish.

Formalin treatment: Place the fish in water containing 15 p.p.m. of formalin for 5 to 12 hours.

Acriflavin (neutral) treatment: Place the fish in water containing 1 p.p.m. acriflavin for 5 to 12 hours. This can be done subsequent to the formalin treatment, or concurrently with it as acriflavin and formalin both can be added to the same water with good results. Do not add acriflavin to water containing potassium permanganate.

When catfish are transported for long distances, 1 p.p.m. acriflavin can be added to inhibit the growth of bacteria in the water and on the fish.

Di-n-butyl tin oxide treatment: This chemical can be incorporated into the pelleted or ground feed to the extent of 0.3 percent for control of tapeworms and other intestinal parasites. The medicated feed should be fed for 3 days at a rate of 3 percent of body weight of the fish each day.

The materials used in the treatments usually can be purchased from chemical supply houses or from fish farm supply dealers.

Normally, the treatments using water can be made in the holding thoughs, provided they are rinsed thoroughly with clean water before using for other purposes.

FERTILIZATION

Use of commercial fertilizers is recommended when needed to initiate and maintain a desirable plankton population or "bloom."

Plankton serves as an important link in the natural food chain as well as inhibiting the penetration of sunlight and thereby controlling the growth of undesirable aquatic vegetation.

A good plankton growth usually results in ponds where heavy supplemental feeding is practiced even in the absence of inorganic fertilization. In such ponds, it may be necessary to add additional inorganic fertilizer. Normally this is not necessary.

A suitable fertilizer program for the rearing pond is one application of fertilizer as the rearing pond is filled about 2 weeks before stocking. And one succeeding application about 2 weeks after stocking. However, if the plankton bloom remains below the desired level, several more applications may be necessary.

The optimum amount of plankton will cause pond water to turn brown or green. A further test is to extend the hand and arm into the water. A sufficient amount of plankton will make the water turbid so that the hand is not visible when submerged about 18 inches. Turbidity should be

*Swingle, H. S., Experiments on Growing Fingerling Channel Catfish to Marketable Size in Ponds. Proc. Am. Conf. S.E. Am. Game & Fish Comm. 1958.

the result of thousands of microscopic plants and animals—not the result of suspended clay particles or silt.

A suggested beginning application rate for the rearing pond is 50-100 pounds of 20-20-5 or similar ratio per surface acre.

Nitrogen and phosphorus probably are the most important elements with respect to plankton production, therefore, fertilizer used should contain a comparatively large amount of these elements.

A pH of 6.5 is optimum for the release of inorganic compounds supplied in commercial fertilizer.

The use of organic fertilizer (barnyard manure, cotton seed meal, etc.) increases the bacterial, rotifer and crustacean population but does not increase the unicellular algae to where turbidity will smother out undesirable vegetation unless large quantities are used.

HARVESTING

The only effective means of harvesting is by draining the pond. If a large pond is drained, you may need a small pond available to serve as a holding area for some of the fish until they can be marketed.

Use a net or seine to collect fish from ponds when a clean, shallow seining area exists in the pond. Feed the fish in the seining area a short time before they are to be collected to concentrate the fish and increase the catch.

Several kinds of traps have been tried, but most have proved ineffective in collecting large numbers of catfish.

MARKETING SIZE

The optimum size for market varies in local areas. Generally, fish averaging about 1 pound live weight are considered ideal in most localities. It is up to the producer to determine the size of the fish desired by his customers. Normally, channel catfish attain a weight of around 1 pound within approximately 14 to 18 months.

DRESSING OPERATION

Forty to 45 percent of the total weight of a fish is lost in dressing (removal of head, viscera and skin).

Cost of dressing varies with labor cost and time required to complete cleaning. With some

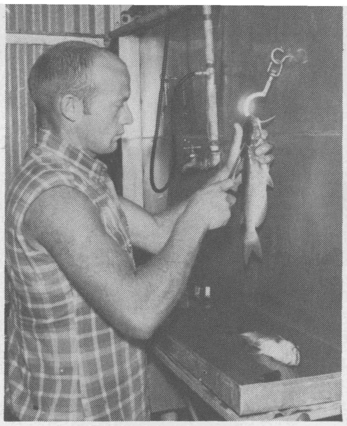


Fig. 8. Operator demonstrates essential dressing facilities.

experience, a 1-pound fish can be "dressed" in 1 minute.

Adequate facilities for dressing include running water, receptical for waste, drain board, skinning hook and skinning pliers.

A kitchen-type arrangement is suitable. Mount a sink at a convenient height with drain boards on each side which are large enough to permit normal cleaning activities. Mount a stainless steel hook, used to hang the fish while skinning, about 2 feet above the sink or at a convenient skinning height.

PROCEDURE

Kill or stun the catfish with a sharp blow a little behind the center of the head from an ordinary hammer.

Hang the fish by passing the point of the hook behind the bone of the lower jaw. Cut the skin around the fish behind the head to the level of the pectoral fin.

Use skinning pliers to pull the skin backwards. As pieces pull off, reach for a new hold at the most anterior (toward the head) edge of the remaining skin and pull backward.

Usually if skinning begins on the back or dorsal side, a small "V" shaped area of skin will remain on the forward portion of the abdomen. This skin can be removed easily by pulling toward the head.

Remove the pectoral fins and associated internal bones along with the head by cutting the flesh beneath the pectoral fins and by breaking the vertebral column just behind the head. It usually is not necessary to remove the dorsal, anal and tail fins.

Slit the abdominal wall and remove the viscera.

Wash the dressed fish thoroughly and pack them in crushed ice until delivered. Freezing fish over long periods of time detracts from the flavor of the flesh.

APPENDIX

Water Sampler*

The water sampler as shown in Figure 9 uses the bottle-train method for collecting water. The bottles are connected by a system of tubing that allows the first bottle in the train to be flushed twice, retaining the water that fills it for the third time. The water in the middle bottle is suitable for the carbon dioxide determination. Since the third bottle is filled only once, discard this water because it came in contact with the gases present in the empty bottles.

To make the sampler, the following equipment is needed:

3—B.O.D. Bottles, 300 ml. capacity
12—Barnes Dropping Bottles
2 ft.—rubber tubing, diameter to fit glass tubing
20 ft. of plastic clothes line or similar material
4 lbs. sheet of lead
1—1/8 in. sheet of aluminum 13 1/4" x 11 1/2" in size
1—tuberculin syringe, 1 cc capacity with 0.01 subdivision

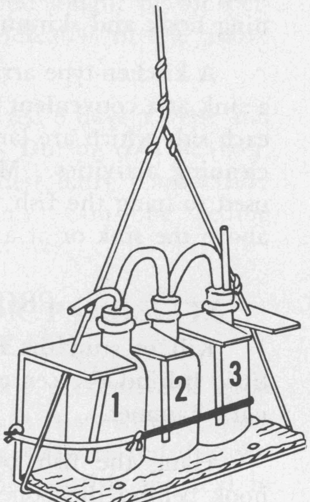


Fig. 9. Train Bottle Water Sampler.

To make the sampler (Figure 9) take the two-hole No. 3 stoppers. Into one hole of each, insert a piece of glass tubing so that it is exactly flush with the small end of the stopper. The tubing should extend about one inch above stoppers 1 and 2 and 4 inches above stopper 3. Into the second holes in stoppers 2 and 3, insert glass tubing long enough to extend from 1/4 inch above the bottom of a B.O.D. bottle to about one inch beyond the top of the stoppers. In stopper 1, this tube should extend far enough above the top of the stopper to be bent so that the open end is turned down about one inch below the top of the bottle when the stopper is in place.

The tubes in stopper 2 are connected with the short tubes in stoppers 1 and 3 by pieces of rubber tubing long enough to allow the stoppers to be placed in three B.O.D. bottles arranged in a row. When the sampler is in use, water enters through the tube that has been bent downward and air is discharged from the long piece of tubing in the other end bottle.

Calibrate the three B.O.D. bottles by carefully pouring 200 ml. of water into each and marking water height with a pencil line on the ground glass.

The rack is made from the 1/8" sheet aluminum 13 1/4 by 11 1/2 inches in size. The metal is bent at right angles along the longer side, 4 inches from each end. When the metal is bent in this manner, the devise is 5 1/4 inches high—just high enough to allow B.O.D. bottles to be slipped in and out readily. Cut three slots for the necks of the bottles in the top of the rack. Place slots at intervals which allow the sides of the bottles to touch when in place. Bolt the four pounds of sheet lead to the base of the aluminum bottle holder. This is enough weight to sink the three stoppered bottles rapidly. The bottles are held in place by a piece of rubber tubing: Attach one end to the sampler. The other end should have a string or wire loop that slips on or off a small bolt-hook to facilitate removal and replacement of bottles.

The hand line can be made from a length of plastic clothes line with a wire core. Knot the line to give a good handhold. Knots at one foot intervals can be used to calibrate the line. Attach the hand line to the sampler by means of a bridle of the same material.

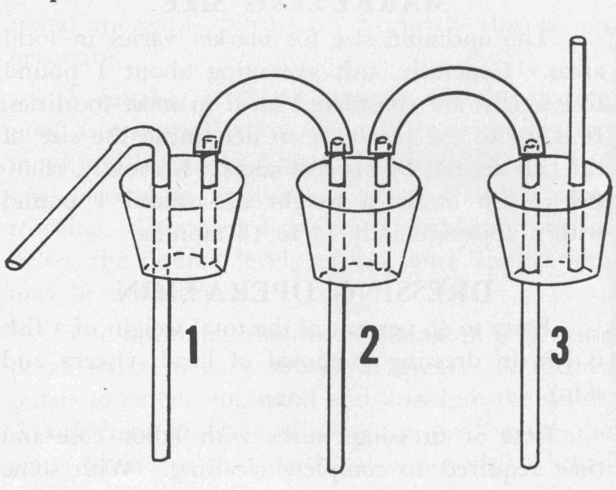
To collect water, fasten the B.O.D. bottles in place with the rubber tubing and insert the train of stoppers. Lower the sampler rapidly to the desired depth by counting the number of knots on the hand line. Cessation of rising bubbles (usually in about 5 minutes) indicates that the bottles are full. Retrieve the sampler. Remove the rubber stoppers and quickly replace with the ground-glass stoppers corresponding in number to each bottle.

Oxygen Determination

The sulfamic acid modification of the Winkler method is used.

The chemical solutions necessary may be purchased from various chemical supply stores or prepared from pure chemicals if accurate laboratory scales and distilled water are available. Chemical solutions necessary are:

Fig. 10. Arrangement of tubing and stoppers for water sampler.



***Altered and reprinted from Progressive Fish Culturist, January 1953. Techniques developed by H. S. Swingle and M. C. Johnson, Auburn University.**

A. *Sulfamic acid solution:* 80 ml. distilled water plus 20 ml. concentrated sulfuric acid plus 4 grams sulfamic acid. Shake until dissolved. Store in the dark.

B. *Manganous sulfate solution:* Dissolve 480 grams manganous sulfate and dilute to 1 liter with distilled water.

C. *Alkaline potassium iodide solution:* Dissolve 500 grams sodium hydroxide and 150 grams potassium iodide and dilute to 1 liter with distilled water.

D. *Concentrated sulfuric acid.*

E. *$Na_2S_2O_3$ titre* (Standard 0.025 normal sodium thiosulphate solution): Buy already prepared, or make by dissolving exactly 6.205 grams C.P. recrystallized sodium thiosulfate ($Na_2S_2O_3$, 5 H_2O) and diluting to exactly 1 liter with freshly boiled and cooled distilled water. If stored in the dark, this will remain reasonably accurate for 2 to 3 months. Add 1 ml. chloroform as a preservative.

F. *Starch solution:* Add 2 grams soluble starch to 100 ml. water. Heat until transparent and add a small grain of thymol for a preservative.

Barnes bottles are marked (Figure 11) A, B, C, D, Starch, and $Na_2S_2O_3$ titre, to correspond with the solutions just listed. The pipettes in the Barnes bottles deliver approximately 0.5 cc. if the rubber bulb is squeezed tightly at each filling, and there is no reason for complete accuracy *except in the amount of $Na_2S_2O_3$ titre used. Consequently,* the number at the bottom of each bottle label represents the number of pipettefuls of each solution that must be added during the analysis. For the sake of brevity, as well as accuracy, these will be referred to technically as "squirts."

Procedure: Collect water sample in B.O.D. bottles as directed in the section on water sampler (Figure 9), bottle No. 1 would be used for oxygen analysis because this bottle has refilled 3 times. Remove this bottle and immediately insert the glass stopper. Then:

1. Add 2 squirts of solution A. Replace stopper and mix by inverting bottle. Let stand 30 seconds.

2. Add 2 squirts of solution B. Replace stopper and mix by inverting bottle.

3. Add 6 squirts of solution C. Mix by inversion 6 or 8 times. Let stand until precipitate settles (usually several minutes).

4. Add 2 squirts of solution D. Mix by inversion. The precipitate should dissolve. If it does not, add a little more of solution D and mix thoroughly.

5. Pour out part of the contents of this B.O.D. bottle slowly and carefully *down to the pencil line* that marks 200 ml.

6. Fill the 1-cc. tuberculin syringe from the bottle marked $Na_2S_2O_3$ titre. Discard this and refill syringe. Titrate the 200-ml. sample in the B.O.D. until the sample becomes a faint yellow.

7. Add 4 squirts of starch solution and continue the titration with $Na_2S_2O_3$ until the blue color just disappears.

8. Each 1cc. of $Na_2S_2O_3$ titre used equals 1 p.p.m.. O_2 in the sample.

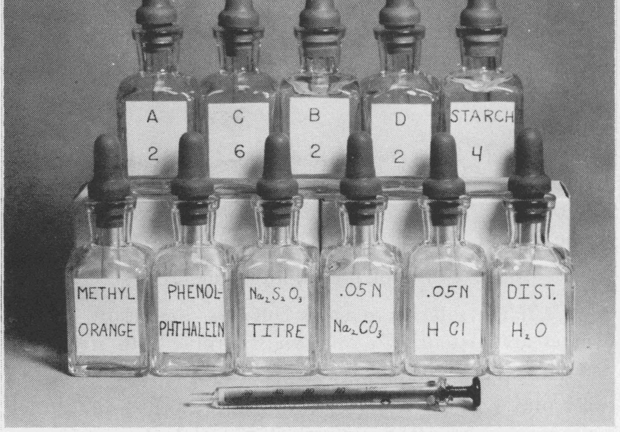


Fig. 11. Labeled Barnes bottles for solutions used in oxygen and carbon dioxide analyses.

9. Wash out the syringe with distilled water before replacing in the kit.

Determination of Carbon Dioxide, Bicarbonates and Carbonates

Most operators will find it advantageous to purchase the prepared standard 0.05 normal sodium carbonate and 0.05 normal hydrocloric solutions from chemical laboratory supply companies.

1. *0.05 N. sodium carbonate:* Purchase this solution in amounts not exceeding 500 ml. and keep tightly stoppered in the laboratory: Refill the Barnes bottle in the water analysis kit *(Figure 11) with fresh solution from this supply for* each field trip, as this solution takes up carbon dioxide upon exposure to the air. Purchase a fresh supply each season.

2. *0.05 N. hydrochloric acid:* This solution will keep indefinitely in a tightly stoppered bottle. That in the Barnes bottle (Figure 11) should be replaced at monthly intervals.

3. *Phenolphthalein solution:* Can be purchased already prepared or made as follows: Mix ethyl alcohol and distilled water half and half. Fill Barnes bottles with this mixture, add about .02 gram phenolphthalein powder (or the amount that can be held on the tip of a knife point), shake, and label.

4. *Methyl orange - Xylene cyanole indicator:* Buy the dry powder mixture. Place in Barnes bottle the amount that can be held on the tip of a knife point, fill the bottle with distilled water, shake, and label.

Procedure: For the determination of free CO_2, use the middle bottle, from the sampler. Pour out water carefully down to the 200-ml. pencil line. Then proceed as follows:

1. Add 2 squirts of phenolphthalein. If the solution turns pink, no free CO_2 is present. If the solution remains colorless, proceed with No. 2.

2. Titrate with 0.05 normal carbonate, using the tuberculin syringe, until the solution turns light pink.

3. The number of cc. of the 0.05 N. sodium carbonate used x 5.5 = p.p.m. of free CO_2 in the sample.

4. Wash out the syringe with distilled water before replacing in the kit.

For the determination of bicarbonate and carbonates, the water in the B.O.D. bottles on the right in the sampler may be used. This bottle has been filled only once, but this will have little effect upon the bicarbonate and carbonate content of the water. Pour out water carefully down to the 200-ml. pencil line. Then proceed as follows:

1. Add 2 squirts of phenolphthalein.

2. If the solution remains colorless, practically no carbonates are present. In this case, continue with step 4.

3. If the solution above becomes pink, titrate, using the tuberculin syringe, with 0.05 N. hydrochloric acid, adding a drop every 2 to 3 seconds until the pink drop color disappears. Record the cc. of 0.05 N. HCl as P (phenolphthalein alkalinity).

4. To the water sample from either step 2 or step 3, add 10 drops of methyl orange - xylene cyanole.

5. Titrate, using tuberculin syringe, with 0.05 N. HCl to the end point (gray color). Record the cc. of 0.05 N. HCl required as M (methyl orange alkalinity).

6. Calculation:

a. If M $=$ O cc. P represents OH alkalinity; P (cc. of 0.05 N. HCl) $\times$ 10 $=$ p.p.m. OH alkalinity as NaOH.

b. If M $-$ P $=$ O, then no bicarbonates are present and titration represents carbonates. P (cc. of 0.05 N. HCl) $\times$ 15 $=$ p.p.m. CO_3—in sample.

c. If M $-$ P $=$ X cc., then;

P (cc. of 0.05 N. HCl) $\times$ 15 $=$ p.p.m. CO_3 in the sample; (M $-$ P) or X (cc. of 0.05 N. HCl) $\times$ 15.25 $=$ p.p.m. HCO_3 in the sample.

REFERENCES

Clemens, H. P. and Kermit E. Sneed, Spawning Behavior of the Channel Catfish, *Ictalurus punctatus*, Special Scientific Report—Fisheries No. 219, U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Clemens, H. P. and K. E. Sneed, Lethal Doses of Several Commercial Chemicals for Fingerling Channel Catfish, Special Scientific Report—Fisheries No. 316.

Davis, Jackson, Management of Channel catfish in Kansas, State Biological Survey & Forestry, Fish and Game Commission, Misc. Pub. No. 21. 1959 University of Kansas, Museum of Natural History.

Hutchens, Lynn H. and Robert C. Nord, Fish Cultural Manual, U. S. Department of the Interior, Fish and Wildlife Service, Branch of Game-Fish and Hatcheries, Region 2, Albuquerque, New Mexico.

Swingle, H. S., Experiments on Growing Fingerling Channel Catfish to Marketable Size in Ponds, Agricultural Experiment Station, Alabama Polytechnic Institute, Auburn, Alabama.

Toole, Marion, Raising Catfish in Texas, Parks and Wildlife Department, John H. Reagan Building, Austin, Texas

Cooperative Extension Work in Agriculture and Home Economics, Texas A&M University and United States Department of Agriculture cooperating. Distributed in furtherance of the Acts of Congress of May 8, 1914, as amended, and June 30, 1914.