MINNOW FARMING IN THE SOUTHWEST

By

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Bachelor of Science

Oklahoma Agricultural and Mechanical College

Stillwater, Oklahoma

1952

Submitted to the faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1956

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PREFACE

The demand for bait minnows has increased, causing numerous inquiries concerning propagation on a commercial basis. Persons who desire to enter the business should be aware of some of the pitfalls which they may encounter.

The purpose of this study is to present ideas concerning the maintenance, development, and management of a bait minnow farm in the Southwest.

The writer wishes to express his appreciation to Dr. Roy W. Jones, Dr. H. I. Featherly, and Professor Fred LeCrone for their helpful advice and criticisms and especially to Dr. W. H. Irwin, under whose supervision the work was done. Indebtedness is also acknowledged to his wife, Letha, for her assistance in preparing the report and to Mr. W. H. McGimpsey, owner of McGimpsey Fisheries, Langley, Oklahoma for informative materials and for permission to use photos of equipment shown in this paper.

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INTRODUCTION

This report is intended to serve as a source of information for persons interested in the bait minnow business in the Southwest and concerns the propagation of three species. Included in the report is information gathered from several sources. Dr. W. H. Irwin contributed his notes on experiences attained over a 10 year period during which he and his associates experimented with minnow raising. The writer worked two summers as operator and manager of a minnow farm for W. H. McGimpsey of McGimpsey Fisheries, Post Office, Rt. 3, Vinita, Oklahoma. A three year period of study was used to assemble the information. During this period many minnow farms were visited and their owners and managers consulted. Attention is called particularly to the cost items, management practices, and possible returns.

Fishing areas are being increased in the Southwest (1) by the construction of numerous farm ponds and (2) by the construction of large impoundments both for flood control and for city water supply. The increased sale of fishing licenses is evidence of increased numbers of fishermen.

Commercial minnow dealers still obtain from the streams a large percentage of the bait minnows found on the market. The demand for bait minnows is becoming greater each year because of the increased number of fishermen. Many conservationists believe that the continued harvest of stream minnows is harmful because it depletes the native food of the game fishes. Because of the harm involved, the seining of stream minnows will

likely be curtailed. Stream minnows are not always obtainable when they are needed. Often flood, low water, stream pollution and dispersion make the harvest of stream minnows unprofitable. A constant source is needed, which must be supplied by commercial production.

Drouth conditions of the past few years have emphasized the need for a dependable source of bait minnows. Decreased stream flow has caused a shortage of wild bait minnows. Especially is this true for the seasons of peak demand.

The construction and operation of a minnow farm requires the investment of a considerable sum of money if it is to be a profitable business. The operation of the plant involves a great deal of time, hard work, and technical knowledge for even limited success.

Persons who consider raising minnows for profit should be aware of the fact that although good money can be and has been made in the business, the investment can also be lost. Disease epidemics, unusual weather conditions (drouth, floods, or high temperatures), over-feeding or over-fertilization, and market fluctuations are items which have been disastrous to the business. Accurate records which would enable the operator to distinguish between good and poor methods should be kept of all phases of the minnow farm activities.

This report will, in so far as is deemed important and possible, cover details concerning the over-all development, operation, and maintenance of a minnow farm plant. References cited provide additional information and practices.

LOCATION OF A MINNOW FARM

The location of the minnow farm is important. The minnow farm should be so located that land and water will be available for present needs and for future expansion.

Three important items to consider in the selection of a site are water supply, type of soil, and topography of the area. Very few perfect locations will be found but a site should be chosen which will provide the best qualifications for the above-mentioned items.

Water Supply

An important or limiting factor involved in minnow farming is a suitable and adequate water supply. Unless sufficient water is available to permit the maintenance of the desired water level and the draining and filling of the ponds several times during the season, production on the area will be curtailed.

Water for the operation of the minnow farm may be obtained from a number of sources. One should keep in mind that the water supply must be adequate at all seasons for all years and should have a low mineral content. The principal sources of water for minnow farms are springs, streams and reservoirs.

Many people consider springs the most desirable and dependable source of water, but even springs decrease their flow during long periods of drouth. There are few areas in the semi-arid Southwest that have springs capable of serving a minnow farm throughout the year.

Water pumped from creeks or from rivers may be of sufficient volume during part of the year but if one checks the characteristics of stream-flow data for the Southwest he will find that few streams maintain a constant flow or sufficient water for continuous operation during all seasons of each year.

The elimination of undesirable fish from stream water requires straining. Screening by wire is impracticable. Screen wire that permits a ready water flow will permit the passage of eggs and larvae of fish. Screen wire that will stop the fish will soon clog. Gravel filters have been successfully used but require constant attention.

The problems involved in pumping water from a stream should be examined. The operational and maintenance costs and damages that may be inflicted on pumping systems when the streams are at flood stage may be too great.

Perhaps the most usable source of water for a minnow farm in the Southwest will of necessity be runoff water impounded in reservoirs. Therefore, careful selection and planning should be done before a minnow farm site is chosen and money is invested.

Once a watershed is selected and a reservoir is constructed it is difficult to increase the volume of the water supply to provide for expansion. The following items are important considerations: rainfall, area, and runoff volume of the watershed.

Rainfall data can be obtained from the United States Weather Bureau offices or from the United States Department of Agriculture Yearbook for 1941. The yearbook contains rainfall statistics for all states to the year 1938.

The runoff from the watershed must be sufficient to fill the reservoir. Data on average annual runoff can be obtained from state water

resource agencies. If, for example, runoff data indicates the rate of annual runoff is 1 inch, then 12 acres of watershed will be required to catch 1 acre-foot of water in a reservoir. If the rate of runoff is 7 inches, then some 12 acres will produce 7 acre-feet of water.

Evaporation Losses

The construction of a deep rather than a shallow reservoir will decrease water loss from evaporation. Evaporation will take place from all exposed water, including reservoirs and minnow ponds. In central Oklahoma evaporation has been measured to average 4 feet per year from water surface. (A Report to the Governor of Oklahoma on the Problem of Municipal and Industrial Water Supplies for Oklahoma, 1953.) It is therefore evident that the water loss from ponds must be replaced regularly to maintain a proper depth for good minnow production. In drouth years the evaporation loss may be sufficiently great to deplete the water source from springs, streams and reservoirs.

Excess water from the watershed must be controlled. An over-sized watershed or excessive rainfall could damage the reservoir and the minnow ponds if means are not provided to handle the excess water.

Nature of the Soil

The soil of the area must be of such a nature that water loss by seepage is low. Seepage losses of water from ponds will be nominal if the proper subsoil is present on the chosen area. However, if the area chosen does not contain the proper amount of clay in the subsoil, excess seepage can be somewhat controlled by several methods.

Plowing or disking the pond bottoms before filling with water, or disking along the water's edge as the pond is being filled serves to permit

the clay particles, when present, to be carried into the holes of the porous soil. This will reduce seepage to some extent.

Some hatcherymen have made use of hogs to aid in sealing pond bottoms. This practice consists of fencing the pond and partially filling it with water, then allowing the hogs to stay in the area for several weeks. The hogs seem to do a fair job of sealing the pond bottom as well as adding fertility to the water.

Bentonite, a clay product, is also useful for sealing ponds to prevent seepage. Some hatchery operators work the bentonite into the soil of the bottom and banks before filling the pond with water. Other operators simply scatter the powdered bentonite over the surface of the water and allow it to settle to the bottom. Local Soil Conservation Service engineers can be of assistance in determining the amount of bentonite needed and the best method for its application.

Probably one of the better methods of applying bentonite is the following, suggested by L. M. Duncan (1947).

1. Disk the soil, overlapping 50%, cutting 6 inches deep with a tractor-drawn tandem disk.

2. Harrow the soil with a spike-tooth harrow, overlapping 50%.

3. Mark off the area in blocks so that the bentonite can be evenly distributed.

4. Distribute the bentonite evenly over the area.

5. Redisk the soil, cutting 3 inches deep, overlapping 50% on each circuit of the pond to mix the bentonite and soil.

6. Compact the soil with a sheepsfoot roller drawn by a caterpillar tractor.

A water loss by seepage of 48 inches in 24 hours in a pond of 0.8 acre in size was reduced to 2 inches of water loss for the same period by

the application of bentonite in accordance with the method described above. (Duncan, 1947.)

Topography

The topography or lay-of-the-land will determine to a great extent the final planning and construction of a minnow farm plant. Preferably the plant should be built on land sloped sufficiently to allow water to flow by gravity to the ponds during the filling process and from the ponds in the draining process. Ponds should not be constructed in a hollow or on bottom land where they may be inundated by high water.

An area on which the ponds can be constructed in a compact unit will allow daily management practices to be carried out more efficiently. Other advantages of compactness are generally decreased costs for the installation of inlet and drain pipes, decreased costs in the construction of the ponds, and better control of predatory birds, reptiles and mammals.

SIZE AND COST OF A MINNOW FARM PLANT

Ponds totalling 10 surface-acres of water properly constructed and receiving fair management should produce a minnow crop of sufficient value to support the business and an average sized family. Ponds under good management have produced over 500,000 fathead minnows per surface-acre. (Dobie, Meehean, and Washburn, 1948.) Such high production cannot normally be expected.

Water of 1 surface-acre and not deeper than 3-1/3 feet can be expected to produce 100,000 fathead minnows of saleable size. This is not a maximum crop but with experience a minnow producer should be able to increase production above this figure.

Under normal conditions the minnows should wholesale at one cent each, which (if based on a production of 100,000 minnows per acre for 10 acres) would gross $10,000 per year. A ten thousand dollar income will not pay the cost of the land, cost of pond construction, cost of equipment, and the cost of supporting a family all in one year. The costs of land, pond construction, and equipment should be amortized over a period of several years.

Water Depth

In the Southwest ponds with water deeper than 3-1/2 feet are likely to have a lower carrying capacity during the summer than the more shallow ponds. Fertilized ponds have been found to contain little or no oxygen in the water at or below a depth of 4 feet. Since a large part of the

minnow food grows on the pond bottoms, a layer of oxygen-free water covering the bottom will decrease the food production and the feeding area of the pond. Thus, instead of increasing food and feeding area, the deeper water will usually decrease production.

The following are important aspects concerning water depth.

1. Small minnows prefer and seem to need shallow water in which to feed.

2. Minnows tend to feed heavily on the bottom.

3. A shallow pond provides a higher percentage of water in contact with air and a higher percentage of bottom area for feeding.

4. Fertilizers and supplemental foods tend to remove the oxygen from the water.

5. Wind action on the water adds oxygen but only as deep as the water is stirred.

6. A layer of oxygenless water is usually evident first at the bottom of the pond and can increase in thickness until it includes the entire pond water.

7. A layer of oxygenless water not only prevents feeding at the bottom but decreases the growth of food on the bottom. Thus, in deep water the bottom pasture area is decreased drastically.

8. Green plants, microscopic or rooted forms, release oxygen into the water during daylight hours but do not do so at night. The animals, plants, and fertilizers continue to demand and use oxygen from the water throughout the night, hence it will be during the hours of darkness, just before dawn, that the water is most likely to become dangerously low in oxygen.

9. Fish kills in highly fertilized ponds are apt to be associated with cloudy days. The oxygen content of the water will be decreased by

morning and oxygen replenishment through photosynthesis will be slight during a cloudy day. Thus the pond enters the second night with a low oxygen content.

10. Reasonably shallow water makes the harvest of minnows by seines possible.

Method of Filling with Water

Each pond should be equipped with a pipe which is connected with the water supply system. Large inlet pipes permit rapid filling or flushing of ponds and may often save large quantities of minnows during the harvesting process when minnows are crowded in a small volume of water. A large volume of water is also essential when the minnows are in distress from a shortage of oxygen because of over-feeding, over-fertilization, low water, cloudy weather, and from over-treatment with chemicals.

Ponds of 1/4 acre should be provided with a 4-inch inlet pipe opening near the drain or low spot in the pond. The type of pipe will be determined by preference, availability, and cost. Spiral-welded steel pipe, clay tile, asbestos-cement pipe, or used oil well casing are acceptable. Valves or some other device should be used to regulate the inflow volume. Because of the high cost of 4-inch valves, some operators have used various devices to reduce the opening to the desired size. An assortment of bushings, caps, and nipples can be assembled and transferred from pond to pond as needed. Another method is to weld into a 4-inch cap or plug several sizes of short nipples which can in turn be fitted with caps or plugs thereby eliminating a valve. (Fig. 1.) When only a small stream of water is desired, a hole can be drilled in one of the caps or plugs on the nipple and the hole stoppered with a wooden plug.

Method of Draining

Each pond should have an individual outlet which will enable the operator to drain the pond independently of all others. Some hatcherymen utilize the water drained from one pond to fill another. This is not considered a desirable practice because diseases or parasites can be spread to the other ponds. If, however, one thinks that the water is safe to use a second or third time, the water can be transferred by the use of siphons or pumps.

The larger types of drains and pipes will pay dividends to the minnow raiser when the investment is considered over a period of time. Experienced operators have found the larger pipes and those of durable material to be the best investment. Spiral-welded pipe, asbestos-cement pipe, and used oil field casing pipe have all been successfully used.

Several types of drains are used by hatcherymen and each type has its particular advantage. One frequently used is the Canfield. (Fig. 2.) This consists of two pieces of pipe, one through the dike at the level of the pond bottom, the second attached to the first at the inner end by an ell and cut to a length that will regulate the water level when in an upright position. The second pipe can be turned down for draining the pond. The chief advantage of this type of drain lies in the low cost, but this advantage is offset by the increased difficulty of seining encountered when harvesting the fish.

Perhaps one of the better drains is a box-like concrete drain set into the pond dike so that seining operations will not be hindered. This concrete box (approximately 30 inches square and 60 inches in height) with a pipe leading off the bottom, as shown in Figure 3, has two slots on each of the sides. Screen wire of the mesh size needed is tacked on a

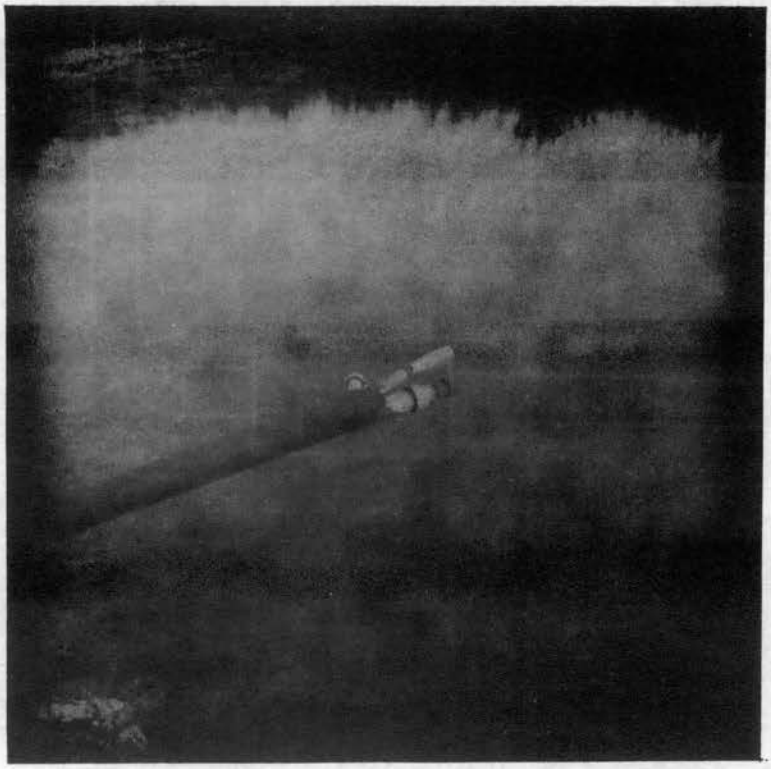

Figure 1 Adaptable Inlet Pipe

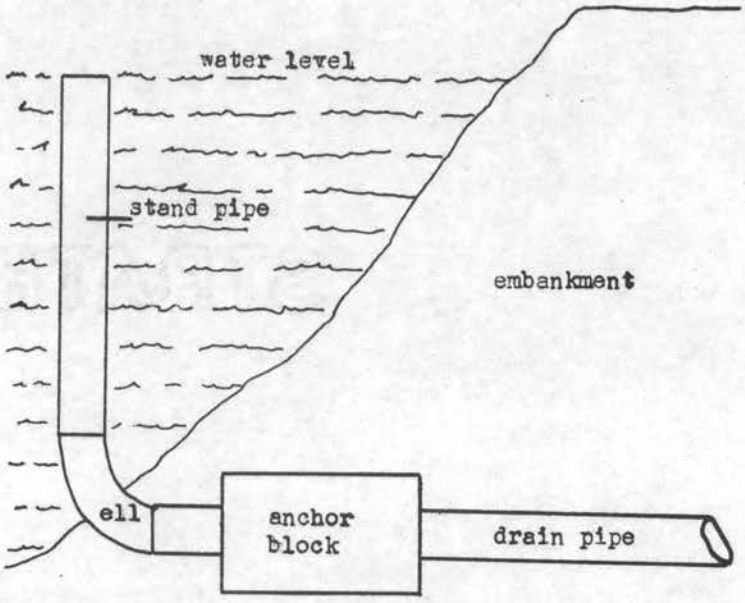

Figure 2. Canfield drain

wooden frame which is placed in the outside slots. The inside slots are made to allow boards 2 inches in thickness of varied widths to be placed one on top of the other to maintain the desired water level. These boards should be treated to prevent rot and finished to fit snugly enough to prevent excessive seepage.

A surveyor's level should be used to make certain that the drain is placed in the lowest part of the pond. Ponds that do not drain completely are difficult to manage.

Construction of a Water Supply

Several bulletins have been published which give detailed information on the construction of reservoirs (ponds) and dams. Because of this, the subject will not be discussed in detail.

Professional help or advice on pond or dam construction may be obtained from local Soil Conservation Service Agents, County Agents, or professional engineers.

However, the following items are important and should be considered with regard to the construction of a water supply.

1. The water supply must be ample to fill all ponds at least five times during the season.

2. A supply pond or reservoir should be constructed with a water capacity that will permit expansion of the minnow farm plant.

3. Some method or structure should be used to control the amount of water which may enter a reservoir thereby eliminating or controlling the overflow. The watershed should be terraced to control the water flow. The terraces can be so arranged that a main terrace carries the runoff water to a point near the reservoir and on beyond to the runoff ditch.

A gate built in the terrace at the proper location can be opened to permit water to enter the reservoir when needed and closed to divert the water around the reservoir when not needed.

4. A suitable spillway and runoff ditch which will divert the overflow waters around the minnow ponds should be incorporated.

5. A drain pipe with a valve attached should be installed to control the water released to the minnow ponds. A pipe 8 inches in diameter should be suitable for a minnow farm of 10 surface-acres of water.

6. Species of fish other than those being reared in the minnow ponds should not be permitted in the water supply. Filters, screens, or other barriers may have to be installed where the danger exists of other fish entering the water supply.

Buildings and Equipment

A building 14 feet wide by 18 feet long situated near the dispensing pond will suffice for a shipping room. The building should be supplied with running water and have a cement floor with drains installed to facilitate cleaning.

Holding tanks (made of cement, metal, or wood, 4 feet wide by 6 feet long by 2-1/2 feet deep) will provide temporary minnow storage in the building. Several retainers (18 inches by 30 inches by 30 inches deep) formed of screen mesh wire may be used in the larger tanks for holding smaller numbers or for different sizes or kinds of minnows.

A list of equipment useful in the shipping room would include the following: a sorting table, scales for weighing minnows, dipnets, containers, and water pumps or agitators to insure water circulation and aeration. Additional space will be needed in which to store feed, fertilizer, and equipment.

Cost of Constructing a Minnow Farm Plant

A properly constructed and equipped minnow farm plant entails an investment of a considerable sum of money. Because costs of construction and materials vary in different areas, cost figures are not given.

> Probably an average figure, including dirt moving and the cost of buying and laying the inlet and outlet pipes and concrete will run at least $1,000 per surface-acre of water. Naturally, some of these costs can be cut by doing part or all of the construction work yourself. (Martin, 1955.)

The figure given above compares favorably with estimates given the author by several other minnow producers. Costs of course can be kept lower by the use of second-hand pipe for inlets and drains, the omission of expensive devices, and by careful planning.

To avoid blunders, high costs, and false economy the prospective builder should visit a number of successful farms before starting construction.

Construction of the Ponds

> Ponds from 0.1 to 0.3 acres in size are most desirable for minnow production; however, slightly larger or smaller ones are quite satisfactory...Because of the difficulty in handling large numbers of minnows while draining, ponds exceeding one acre are impracticable. (Prather, Fielding, Johnson, and Swingle, 1953.)

Ponds 1/4 acre in size will be more easily handled by beginners than will larger ones. Sketches in Figure 4 represent ponds 50 feet wide by 200 feet long, or approximately 1/4 acre.

Ponds need not be deeper than 3-1/2 feet at the deep end and sloped to about 1-1/2 feet in depth at the shallow end for good production. (See Water Depth.) Weeds can be controlled better if the edges of the pond slope rapidly to a depth of 1-1/2 feet.

The pond bottom should be sloped from the sides and shallow end

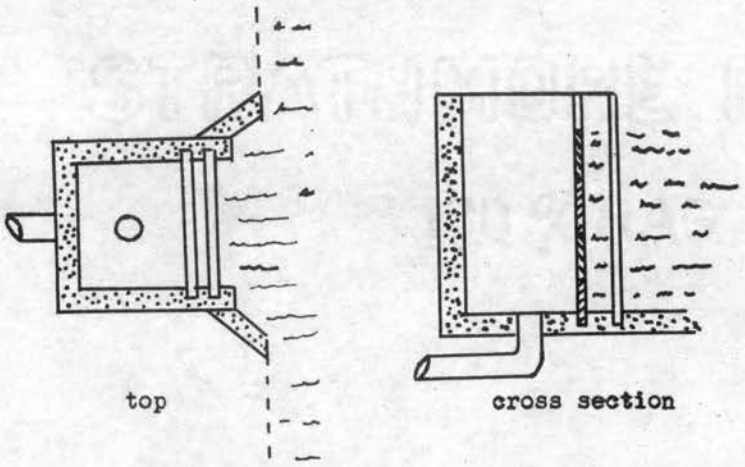

Figure 3. Box drain

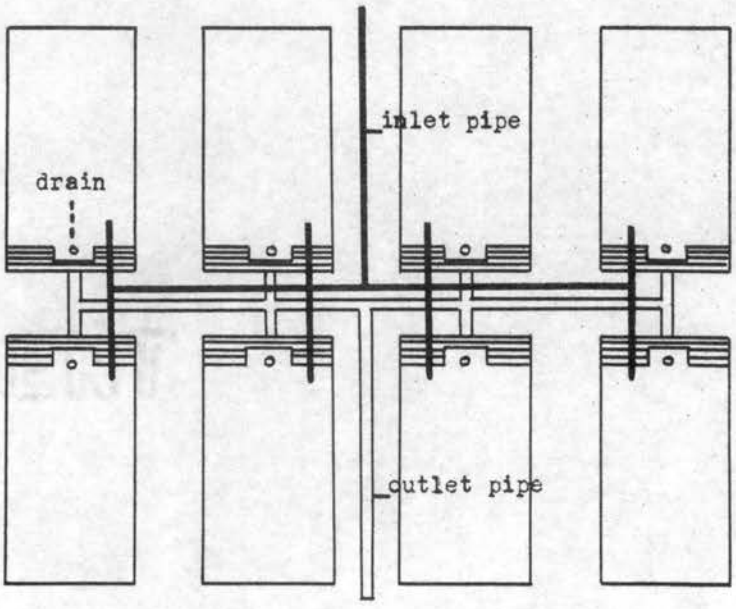

Figure 4. Pond arrangement

toward the outlet. The slope need not be greater than that required for water to flow. Pond bottoms should be free of holes, stumps, or obstructions which would hinder the harvest of minnows.

Pond Shape

The shape of the pond is important because a longer shoreline increases the productivity of a given volume and body of water. (Welch, 1952.) This means that a long narrow pond will generally be more productive than a square one of the same surface area.

The sketched layout (Fig. 4.) shows ponds that are long and narrow, thus providing a long shoreline in relation to total area. More efficient use of drain and inlet pipes is realized if ponds are arranged as shown. Narrow ponds make the harvesting of minnows by seining relatively easy.

Land configuration will determine to a great extent the shapes, sizes, and positions of ponds which can be constructed. Areas which will accommodate triangular-shaped ponds should be so used. Triangular-shaped ponds often produce exceptionally good crops of minnows, possibly because of the increased length of shoreline with respect to the amount of water impounded.

KINDS OF MINNOWS USED AS A CROP

Species of minnows generally considered to be the most suitable for propagation and use as bait include (1) Fathead minnow, Pimephales promelas, Rafinesque (sometimes called the blackhead minnow), (2) Bluntnose minnow, Pimephales notatus (Rafinesque,) and (3) Golden shiner, Notemigonus crysoleucas (Mitchill).

Fathead Minnow

The fathead minnow which is probably one of the easiest fish to culture, lives quite well in a minnow bucket and is fairly hardy on a hook. The smaller sizes are in demand for crappie and the larger for bass baits.

The natural food of the fathead minnow consists of microscopic plants and animals. These minnows reach a maximum length of about 3-1/2 inches and can be utilized for breeding stock when they are as long as 2-1/2 inches. Males are generally larger than females of the same age and are distinguishable (during the breeding season) by the presence of tubercles on the head and a dark-colored pad between the back of the head and the dorsal fin. The males choose the nest sites and care for the eggs during incubation.

Spawning occurs when the water temperature reaches 64° to 70° F. The females deposit adhesive eggs on old lumber, tile, rocks, concrete, metal or any object that provides space for the activity of the male. Markus (1934) found that one average sized female had deposited eggs on the same nest over a period of about two months and 4,144 offspring were

recovered. He also found the average length of the incubation period to be about five days and that the mortality of the adult minnows was very high after the spring spawning period.

Fathead minnows, sexes approximately equal, should be stocked in brooder ponds in the spring at the rate of 800 to 1,000 per surface-acre, depending upon the fertility of the water and the supplemental feeding that will be done. The brood stock should be sold as soon as possible after they have spawned.

Rearing ponds should be stocked at the rate of 100,000 to 200,000 per surface-acre, likewise depending upon the water fertility and supplemental feeding. Fry 1 inch long seined from brooder ponds and transferred to rearing ponds can be expected to have a 20 to 25 percent mortality. The minnows in rearing ponds should be checked frequently. If the growth rate becomes slow, remedial measures must be taken. Conditions leading to good or poor growth rates should be determined and future management practices governed accordingly. As soon as minnows are of salable size (usually around 2 inches or longer) they should be harvested.

Bluntnose Minnow

The bluntnose minnow resembles the fathead minnow in appearance and in breeding and spawning habits, but in general seems to be less prolific and will withstand less crowding in minnow containers. (Dobie, et al., 1948.)

The bluntnose has diversified food habits with no change of food preference throughout life except for size of food particles. It feeds upon plant and animal plankton both on the pond bottom and in open water. Vegetable matter consisting of blue-green algae (unicellular and small filamentous forms), and animal organisms composed of Cladocera, Ostracods,

Cyclops, and midge larvae were found to be part of the diet of bluntnose minnows. (Kraatz, n. d.)

Breeding behavior is similar to that of the fathead minnow. Spawning occurs when water temperatures reach 70° F. and on objects like those listed for fatheads. The incubation period is from 2 to 5 days.

Brooder ponds should be stocked at a somewhat higher rate with bluntnose minnows than with fatheads, but the rearing ponds may be stocked at a comparable rate.

Golden Shiner

The golden shiner is a popular bait minnow because of its large size and bright color. It can be found naturally in lakes and sluggish waters east of the Rocky Mountains. Large shiners are in demand by bass and pike fishermen while smaller ones are used as bait for perch, crappie, and sunfish. Shiners 8 to 10 inches long are not uncommon and they may have a life span of 5 to 8 years.

The golden shiner can be raised in ponds but when compared with goldfish and fatheads it is the least desirable commercially. It is a soft minnow and even when handled under favorable conditions bruises easily and is subject to heavy fungus infection. In warm weather it cannot be handled at all without heavy losses. Since the production rate of fatheads or goldfish is two to four times that of golden shiners from an equal pond area and bring virtually the same price per thousand, golden shiners are the least profitable to raise. (Prather, et al., 1953.)

Shiners may reach maturity and spawn when they have reached a length of 2-1/2 inches but brood stock five or more inches long will generally give better results. The fish are prolific spawners and may spawn throughout the summer months. Adhesive eggs are deposited on aquatic vegetation when water temperatures are from 60° to 80° F. Hatching occurs in about 10 days. No protection is given the eggs or fry by the parents, but instead the adults may become predators on their own fry.

At the Bureau of Fisheries hatchery at Fairport, Iowa, this species has been grown to a length of 4 inches in a single summer...With little effort one may produce 50,000 salable bait of this species per acre of water. (Markus, 1939.) In Michigan and Iowa this species has been produced at a rate of more than 200,000 an acre in fertilized ponds. (Dobie, et al., 1948.)

Martin (1955) states, "There is some evidence that larger and slightly deeper ponds are better for the culture of golden shiners than small ponds." He favors a pond 150 feet by 300 feet with the long axis placed to catch the prevailing winds which better aerate the pond waters. He suggests that since golden shiners eat the supplementary feed only on the surface, one should use caution in feeding shiners to prevent an excess of food which on decaying may result in a fish kill.

Shiners should be stocked in brooder ponds at a rate of 500 to 1,000 per surface-acre. The females will be somewhat larger than the males of the same age. If brooder ponds are provided with spawning mats (made of fibers or Spanish moss) and are free of debris and filamentous algae, the mats with the eggs may be collected about dawn and transferred to other ponds to hatch. If the egg transfer method is not used, the fry should be seined and stocked in rearing ponds at a rate of 100,000 to 200,000 per surface-acre. Ponds in which shiners are placed should be free of parasites and other species of fish.

MANAGEMENT OF THE PONDS AND THEIR WATERS

A plan of pond use should be made in order that brooder and rearing ponds can be efficiently handled. In general, one pond should not be drained into another. Discarding fertile water is a waste of water and fertilizer but the mixing of different pond waters may result in an increase in parasites and diseases. The re-use of water should be exercised only in the absence of disease and parasites and then only when the water supply is critically low. Young minnows are more susceptible to infection than are the older specimens. Ponds should be stocked to permit an operator to drain the water from ponds with younger fish into ponds with older fish.

A few ponds should be selected for brooder ponds, a few set aside as holding or dispensing ponds, and the remainder utilized as rearing ponds. Dispensing ponds should be situated near the service building to facilitate counting, sorting, and selling minnows.

Brooder Ponds

Brooder ponds must provide facilities suitable for the spawning of minnows. Fathead and bluntnose minnows deposit their eggs on rocks, tile, old lumber, sticks or similar objects beneath the surface of the water. Boards placed horizontally and staked at or near the surface in shallow water provide excellent spawning sites. Shingles slanted into the pond bottom in shallow water will also serve as spawning aids. Since golden shiners spawn on filamentous algae or other aquatic vegetation, spawning

mats constructed of fibers or Spanish moss may be used where needed in shiner ponds.

Uniformity of minnow size and population numbers can be controlled better by the use of brooder ponds from which the fry are trapped or seined and placed in ponds reserved for rearing. Fathead and bluntnose minnows are intermittent spawners and may continue to spawn throughout the summer months which may result in an over-population and a variety of sizes. As golden shiner adults are known to be predaceous on their young, better results will be attained by moving the young to another pond.

The fry should be trapped or seined from the shallow water of the brooder ponds and transferred to rearing ponds when they have reached 3/4 to 1 inch in length. Fry should be stocked at a rate of 100,000 to 200,000 per surface-acre of rearing pond water depending upon the fertility of the water and the amount of supplementary feeding to be done.

Rearing Ponds

Rearing ponds, like brooder ponds, should be freed of parasites, diseases, and predators before minnows are stocked. If the ponds have remained dry for some time treatment may not be necessary but ponds that do not become dry over winter should be poisoned before stocking. Five percent rotenone powder applied at the rate of 1-1/2 pounds per acre-foot and thoroughly mixed in the pond water should destroy predatory fish present. Calcium hypochlorite is an effective agent for the control of crayfish and some other forms.

Put 6 to 8 inches of water in the deep end of the rearing pond and stock with the desired numbers of minnow fry, fertilize if necessary, then fill slowly by increasing the water depth 1 inch per day. Most operators expect to produce salable minnows in 5 months but it seems possible to

reduce this time to as little as 1 month if proper growth can be maintained. Supplemental feeding and/or fertilizing may increase minnow production and growth, but caution in their application is essential.

Minnows too small for sale as bait in the fall or minnows kept for brood stock can be stocked in over-winter holding ponds. Minnows stocked in these ponds may be crowded somewhat more than in ponds during the summer season. Some supplemental feeding will probably be desired to carry the minnows through the winter and to promote growth of the small ones to prepare them for early market.

Dispenser Ponds

Dispenser ponds provided with screens (screen-covered frames) offer separate enclosures where minnows of assorted sizes and kinds may be held awaiting disposal. These ponds need not be large. A pond 50 feet wide, 100 feet long, and 4 feet deep will provide ample space for holding minnows in a number of screens. The pond should be deep enough to provide at least 1 foot of clearance below the bottom of the screens to permit waste products to drop through the screen and away from the minnows.

A series of stalls, constructed from lumber or pipe, along both sides of a catwalk will provide racks for the screens. The catwalk should be about 3 feet wide so that one end of the screen holding the minnows can be pulled from the water onto the catwalk and the minnows dipped by means of a scap net. (Fig. 5.)

Metal or wooden frames (Fig. 6) forming a box 30 inches wide, 30 inches deep, and 60 inches long, covered except for the top with fine mesh hardware cloth will serve as live bait screens in a dispenser pond. Stalls 34 inches wide by 80 inches long will provide sufficient clearance for easy use of screens.

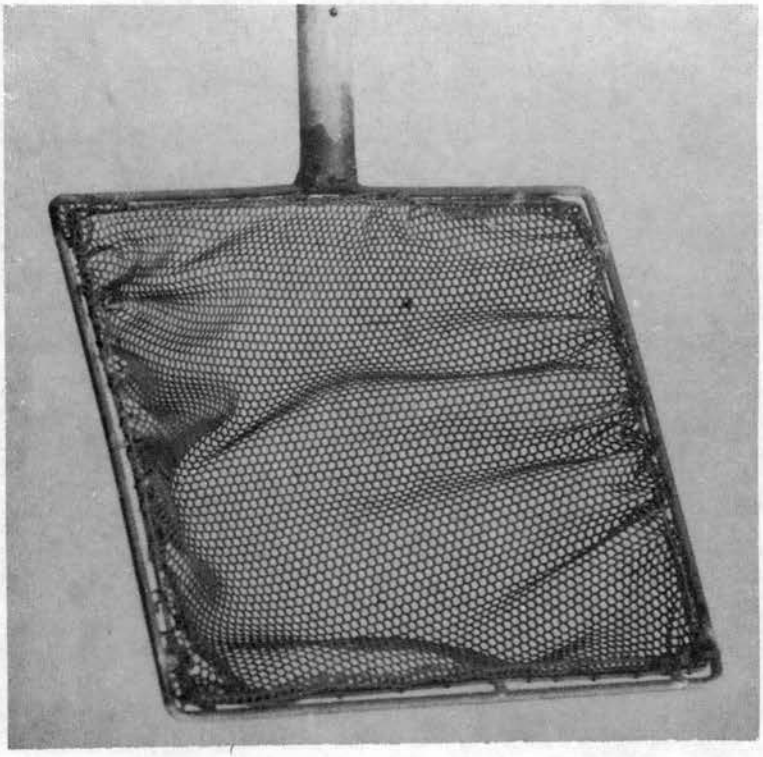

Figure 5. Scap Net

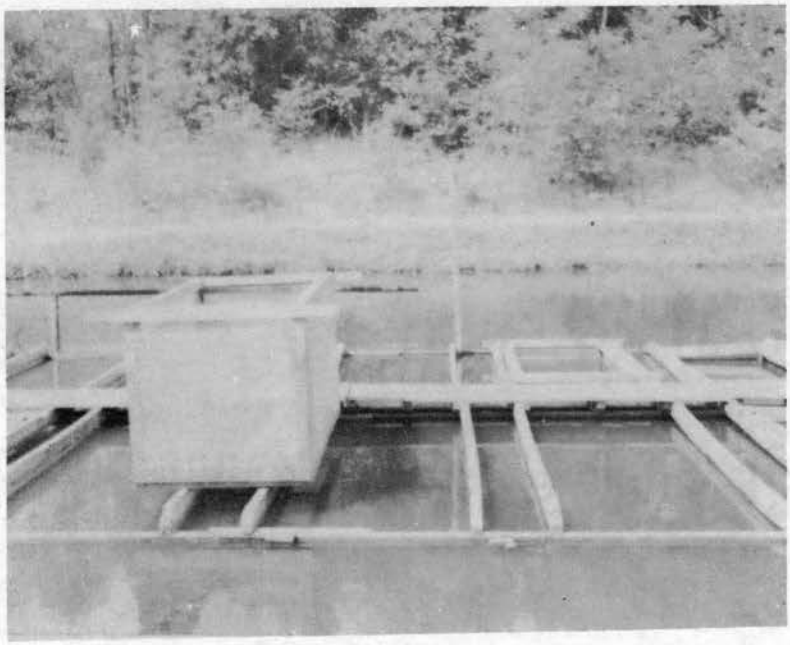

Figure 6. Live-bait Screen

Water Level

Maintenance of a suitable water level in a pond is essential for the proper growth and reproduction of minnows. Brooder ponds, especially during the breeding season, should be maintained at a constant water level.

Evaporation and seepage of pond waters will be determining factors in the amount of water which must be kept flowing into a pond to maintain the desired water level. Seepage of water has an added undesirable feature in that the fertility of the pond in the form of nutrients can be carried away or otherwise made inaccessible.

Minnows seem to feed better and grow faster when the water level of a pond is rising. Because of this fact, certain management procedures which make use of a rising water level are beneficial.

Manipulation of the water level of a rearing pond is sometimes beneficial when the minnows are not feeding or growing properly. Minnows can often be induced to resume feeding and growth by suddenly decreasing the water level (by draining part of the water) then filling the pond again by slowly adding the water until the pond level is brought back to normal.

Pond Fertilization

Artificial fertilization of ponds is a process that began with ancient civilizations. "The Chinese reputedly fertilized carp ponds more than 2,000 years ago, developing the process as an art rather than as a science." (Schaeperclaus, 1933.)

Basically, water fertilization and soil fertilization programs are done for similar reasons in that the desired result is an increase in the availability of proper foods for plants or animals.

As the soil of the watershed of the impounded water exerts a controlling influence on the presence of or the quantity of soil nutrients, one might consider the needs of this watershed soil with respect to the type of nutrients needed for pond fertilization.

Fertilizers added to water contribute to the development of microscopic plant organisms (phytoplankton) which serve as food for minnows, either directly or indirectly. The small plants may be eaten by microscopic animals (zooplankton) and the zooplankton eaten by the minnows.

Bloom refers to a visible crop of microscopic organisms generally consisting of one-celled algae. Blooms, when formed, increase the turbidity of the water and usually give the water an apparent brownish or greenish coloration. Turbidities thus produced can be used as indicators for the fertility of water.

Just as soil fertilization needs differ for various localities, so will pond fertilization needs differ. Formulas successful in one area will not necessarily produce the same results in another area, therefore, the proper fertilizers for each body of water must be determined.

Because of the variations in pond waters, only general procedures are suggested. Each minnow producer by experimentation can find practices which will give improved results. By keeping records of the fertilizers used, their amounts, and the resulting production, progress can be made.

Fertilization of minnow ponds is done primarily for the purpose of providing nutrients in sufficient quantities for good plant growth. The water may be deficient in certain necessary compounds or later may become deficient from plant use.

Nitrogen, phosphorous, potassium, and calcium are among the chemical elements generally considered as important in plant growth. Little is known of the importance of some of the other elements. A formula of

6-8-4 of an inorganic or so-called complete fertilizer simply refers to the percentage relationship of the nitrogen, phosphorous, and potassium in that order.

Different specific recommendations for the application of fertilizers are given by different authors, but the solution to proper fertilization will rest with the water concerned. Some fisherymen prefer the use of organic fertilizers, some prefer the use of inorganic fertilizers, while most prefer a combination of the two types.

Unfortunately, however, it is at present impossible to make definite recommendations regarding which fertilizer to use. The fish-culturist should select one which seems best suited to his needs. Only by experimentation can he determine which will consistently give best results under the given conditions. (Davis, 1953.)

Organic Fertilization

Recommendations for the use of organic materials for fertilization include such items as fish meal, cottonseed meal, grasses, leaves, hay and the various kinds of manure. Recommendations for the use of manure range from 30 pounds per acre to over 1 ton per acre, depending on the initial fertility of the water and the kind of manure.

Manure containing small quantities of plant fibers will be stronger than equal quantities of grasses, leaves or hay. Also, manures derived from animals such as chickens or hogs which were fed largely on grains will be stronger than manure derived from animals fed upon hay.

Organic fertilization adds to a pond most all of the foodstuffs which are required in the metabolic cycle.

Stable manure and compost are spread upon the pond bottom in the distribution of fertilizers. They retard at the same time a luxuriant plant growth. For the production of daphnidae, Naumann advises a first time application of manure in a concentration of 5:1,000 (about 20,000 to 30,000 kg per hectare, 17,813 to 26,720 pounds per acre), and then every week in a concentration 1:1,000 in flat ponds. (Schaeperclaus, 1933.)

Fertilization of rearing ponds in hatcheries should begin some 3 weeks before the fry are introduced.

Organic fertilizer should be applied at the rate of 50 pounds per acre at weekly intervals. Should the water become turbid from decay of organic matter, the period between applications should be increased to prevent oxygen depletion. (Davis, 1953.)

Inorganic Fertilization

Pond fertilization experiments have been conducted quite extensively in Alabama by E. V. Smith and H. S. Swingle but recommendations for that part of the United States may not necessarily produce the same results in other areas.

Fertilized ponds produced 500 to 600 pounds of fish per acre as compared to 100 to 200 pounds in similar unfertilized ponds. Applications of 100 pounds of 6-8-4 fertilizer plus 10 pounds of nitrate of soda per acre are suggested with 10 to 14 applications per year. Begin fertilization in the spring and make the last application in September or October. (Swingle and Smith, 1942.)

With inorganic fertilizers, application of 100 pounds per acre should be made at weekly or ten-day intervals until a waterbloom develops... After a waterbloom is established, only enough fertilizer should be added to maintain the bloom. (Davis, 1953.)

Combination Fertilization

If barnyard manure is to be used it should be applied at a rate of 400 to 1,000 pounds per acre, depending on the fertility of the pond. Applications should be started in the spring 2 weeks before the pond is to be stocked with minnows so that a heavy bloom is available for the adults or young of plant-eating minnows.

During the growing season the bloom should be maintained by the addition of commercial fertilizer at the rate of about 300 pounds per acre per season. The applications should be at 2-week intervals or as often as needed to keep up the bloom. (Dobie, et al., 1948.)

The aforementioned citations illustrate the fact that fertilization methods are not standardized procedures. Fertilization practices could probably be better understood by having an analysis of the water or watershed soil made to determine what nutrients are lacking, then one should proceed cautiously in the application of fertilizer to furnish the needed nutrients.

Any fertilizer or combination of fertilizers added to the pond that establishes a bloom of one-celled plants will be of benefit. Care should be taken not to add more fertilizer than is needed because excessive fertilization can bring about an oxygen depletion with a resulting loss of minnows. Over-fertilization is a waste of materials and money.

A rough index of light penetration determined by the use of a Secchi Disk (a metal disk divided into quarters and painted alternately black and white) is considered an index to the fertility of water. This index of fertility is useful only when the turbidity of the water is produced by the presence of plankton and not by the presence of suspended soil particles.

In general, if the Secchi Disk becomes invisible in the water at a depth of 8 to 10 inches, the bloom in the pond is sufficient for good minnow growth.

Experience can permit operators to increase pond fertility and therefore minnow production beyond the standards stated above, but the danger of fish-kill is also increased. Only experience can reveal the danger symptoms from over-fertilization.

Proper fertilization not only increases the amount of microscopic food plants in the water but is also an aid in controlling obnoxious plants and in precipitating the soil from muddy water.

Supplemental Feeding

At least twice as many fish can be raised per acre of water by artificial feeding. (Dobie, et al., 1948.)

The process of supplemental feeding is one which should be undertaken with extreme caution by the beginner in the minnow rearing business. An over-abundance of food added to the water can bring about an oxygen depletion and resulting loss in minnows.

Supplemental feeding, particularly during the hot summer months, calls for close surveillance of the ponds to make certain that the amount of food being fed does not exceed the amount being utilized by the minnows.

Day by day weather, water temperature, minnow size, and a great many other factors exert a controlling influence on the amount of food which may be fed with safety to the minnows in a pond.

It is a safer practice to begin the supplemental feeding program by administering only a small amount of food. This amount may be increased in a few days if the fish are consuming all that is being placed in the pond. Periodic increases in the amount of food supplied can be introduced until the maximum amount of food that a pond can safely take is reached.

The prepared mixture of food is generally scattered daily at the same time and at the same place on the surface of the water along the shallow end of the pond.

A few hours after feeding or even the next morning an inspection of the pond area where the food was placed will reveal the degree of food utilization by the minnows. If all the food is being eaten the amount may be increased. Cloudy days or days with a minimum of sunshine can upset the feeding program. It may be necessary to reduce or suspend feeding for a few days.

Food formulas vary widely, depending a great deal on the availability and cost of materials to be used. Some hatcherymen are supplementing regular food formula by the addition of some of the antibiotics which are now present in livestock feed. However, no published data on amounts or types being used are available at present.

Many materials are being used to prepare mixtures suitable for supplemental minnow feeding. A list of these would include the following: cottonseed meal, cornmeal, oatmeal, soybean meal or cake, peanut meal, bone meal, fish products meal, red dog flour, wheat shorts, hog supplement, poultry laying mash, dog food, meat scraps, middlings, ground crayfish, and many others. A feed formula having protein content of from 25 to 40 percent seems to give efficient production of minnows.

Examples of food formulas can be obtained from Circular 12, a publication of the United States Fish and Wildlife Service, and from Circular 112, a publication of the Agricultural Experiment Station of the Alabama Polytechnic Institute.

Changing the ingredients of a food for minnows should be done by a gradual substitution of the new food. Why minnows will not change directly from wheat to corn flour is not known. It may be the taste, odor or indigestion, yet by gradual substitution a change can be made from the one to the other. Other ingredients may cause similar results.

Weed Control

Pond plants are used by minnows for food, shelter, and for spawning sites. Unicellular and filamentous algae are plants better adapted for these purposes but they too may become obnoxious.

Though suitable also for some of these functions, submerged plants should not be encouraged because they are difficult to control and may take over the whole pond at the expense of fish production. Too many

plants will choke the pond to the extent that an oxygen depletion may occur on hot, still nights. Submerged plants often completely cover the shore feeding and nesting areas and make them unsuitable for the fish. A heavy growth of plants uses up a large percentage of the pond fertility in a form that is not available to the fish as food, and a pond choked with weeds is extremely difficult to harvest. (Dobie, et al., 1948.)

The most practical method of controlling submerged vegetation is by heavy fertilization. Since plants require sunlight to become well established, fertilization to produce a heavy plankton bloom before the submerged plants start to grow will provide shade and hinder plant development. If vegetation cannot be controlled by fertilization, the next best method is by cutting with a hand scythe. The vegetation should then be raked from the water to prevent oxygen depletion when decay begins. Vegetation may often be removed from a pond by dragging a rope or wire cable through the pond much in the manner as one would use a seine.

Weeds can be killed by solutions of copper sulphate and sodium arsenite that are too weak to kill the fish, but this method should be used only as a last resort because either of the chemicals will kill most of the minnow food organisms. These chemicals should not be used without the supervision of a trained biologist. (Dobie, et al., 1948.)

If chemicals are to be distributed in pond water, a device similar to the one shown in Figure 7 will prove useful. The small floating raft supports a container holding the chemical solution to which is attached a valve-controlled T-shaped spray boom. The raft, when outfitted with a strong cord at either end and operated by two persons, can be towed back and forth over the pond surface and will dispense the solution quickly and evenly. Some type of reel in the hands of each of the two operators may speed the process.

Diseases and Parasites

The crowded conditions under which minnows are held in storage for shipping and retail sale present optimal conditions for development of serious outbreaks of diseases or parasites.

Prevention of the occurrence of these diseases or parasites is the best cure or control. Items of importance in the prevention of diseases and parasites are the use of proper sanitation, care when handling minnows to prevent bruises and loss of scales, and careful selection of disease and parasite free stock. Those commonly causing the most damage to minnows on farms are anchor worms (parasitic copepods), black grub (black spot), tapeworm, ichthyophthiriasis (ichth), and fungus disease such as tail rot.

One of the most common decimating diseases in crowded holding tanks is tail rot.

Terramycin at a concentration of 1 milligram per gallon of water has given satisfactory results both for the prevention and the cure of tail rot. Experiments with some of the other "mycins" did not give as satisfactory results. (W. H. Irwin, unpub.)

Specific information on the detection and control of these and other fish diseases and parasites, as well as methods for use in pond sterilization can be found in the book, CULTURE AND DISEASES OF GAME FISHES, written by H. S. Davis and published in 1953 by the University of California Press at Berkeley, California.

Predators of Minnows

Kingfishers, herons, ducks, turtles, snakes, and insects are known to be predators of minnows. Also certain other fishes and frogs are detrimental to a minnow crop.

Control measures consist principally of preventive measures. All fish should be removed and kept from the water supply. Turtles can be trapped, frogs hunted and their eggs removed. Snakes must be hunted and ducks should be discouraged from feeding on the ponds.

Herons do not usually alight in the water; a low chicken-wire fence close to the edge of the pond or very steep banks around the pond will keep the birds out. Sometimes several wires around the pond will work as well...The hatchery operator should try to keep predatory birds from his

pond, as the heron spreads the yellow grub and the kingfisher is host to the black grub. (Dobie, et al., 1948.)

Kingfishers attack from posts or dead trees that overlook a pond. Removal of posts or trees should help to discourage the birds. (Dobie, et al., 1948.)

Harvesting the Crop

Minnows may be harvested from a pond by any one of several methods, depending on the number needed. A pond may be seined or trapped when only a part of the crop is to be harvested, but must be drained in order to harvest the entire crop.

Dip nets or scap nets, seines, traps, or trapnets are some of the items of equipment used to harvest minnows. Dip nets or scap nets (Fig. 5) of varied sizes and shapes are useful in handling, sorting, and transferring minnows. Small-mesh netting material, soft in texture (to prevent injury to minnows), is supported by a rigid frame attached to a handle. The piece of netting should be somewhat larger than the frame in order to form a shallow pocket. A dip net 9 inches square is suitable for dipping from a screen, but a dip net used when dipping from a pond should be larger.

Minnow seines are generally classified into three types depending on the kind of weave used in construction. (1) The "common-sense" net made of woven threads will not withstand prolonged or severe use. (2) The "knotted" seine with each mesh individually tied is more sturdy. (3) A third type, of fine woven fabric called "birds eye" or bobbinet cloth, is better for handling small minnows or those easily injured. (Dobie, et al., 1948.)

After each use seines should be thoroughly dried, the holes repaired, and stored on a rack or reel in a cool dry place. When used often in

water containing considerable organic matter, seines should be treated with copper oleate, tannin, or some other preservative.

Traps and trapnets are of varied sizes and shapes and are discussed in following paragraphs.

Seining

Good seining methods and proper equipment will minimize loss of minnows harvested by the seine. Minnows are easily scaled and rough handling or seining will injure areas where exposure to fungus or fin rot is possible. To prevent injury, seines of soft fibers are desirable for golden shiners and small minnows.

When seining a pond it is preferable to land the seine on a firm bottom to prevent stirring silt which might cause discomfort to minnows. The seine with the minnows should not be removed to the bank but should be bagged and moved to deeper water at once. There the minnows may be dipped with a scap net. To prevent injury never pour minnows from the seine.

During hot weather better results are obtained if minnows are seined only during the cooler parts of the day. They can then be transported to holding ponds or to screened live-boxes in a holding pond where they can be held awaiting disposal.

Trapping

Minnow dealers frequently use glass or screen traps to capture small numbers of minnows. The traps are similar in design and function, differing only in construction materials. Glass traps are usually round while wire traps may be made in various shapes. Either may have one or more funnel openings through which minnows may enter the trap.

A small amount of food is placed in the trap and the trap lowered into the water. Traps should be checked frequently because minnows, if allowed to remain long in the traps, may injure themselves on the wire or may die from lack of oxygen in the glass traps.

Trapnets (lift nets) constructed of a soft material such as bobbinet cloth are generally effective for collecting minnows and do so with minimum injury. The trapnet shown in Figure 8 (constructed with a rigid framework of 1/4 inch re-enforcing steel) is 42 inches wide and 60 inches long. The netting, cut 48 inches by 66 inches, forms a pocket when the trap is lifted. A tripod is used for a fulcrum to raise the trap, which is attached to a long pipe or pole. The tripod (Fig. 8) is 72 inches tall, 18 inches wide at the top, and the legs spread to 36 inches at the bottom. The center leg is movable in order to adjust the height of the tripod.

A trapnet is usually set in a pond near the area where fish are fed. Food material moistened and rolled into the shape of a ball is placed in the net which is then lowered into the pond. The net should not be lifted entirely from the water but only high enough to permit the operator to collect the minnows with a dip net. Trapnets should be checked periodically and rebaited when necessary. It may be necessary to omit feeding for a time before trapping in order that they be attracted to the baited net.

Draining the Pond

Ponds equipped with individual drains can be completely harvested by draining only. Part of the water may be drained from a pond and most of the fish harvested with a seine. The water level can then be dropped and the remaining fish removed with a dip net or if the drain outlet of a pond is accessible, the remaining fish may be collected where the water leaves the pond.

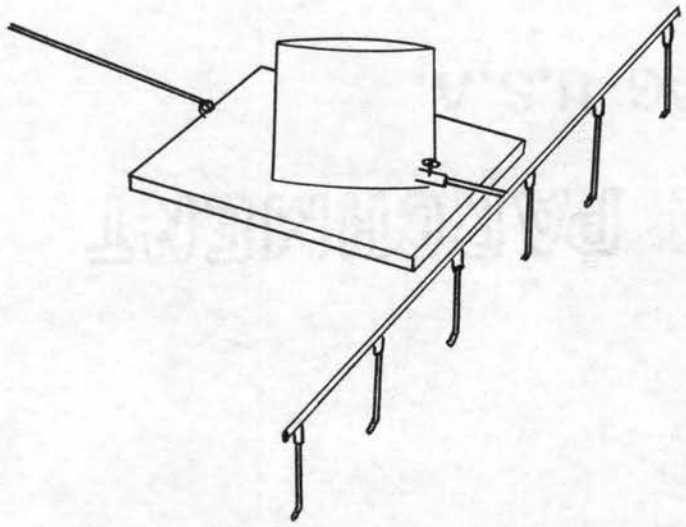

Figure 7. Dispenser raft

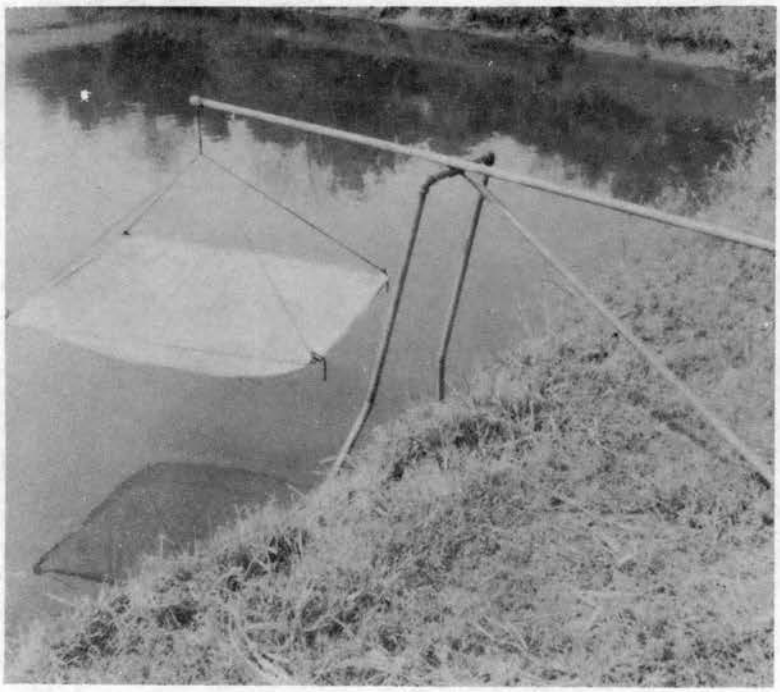

Figure 8. Trapnet

PREPARING THE MINNOWS FOR SALE

The selling price of minnows varies with the size and the uniformity of size. Therefore, grading or sorting will eventually be necessary in hatchery operations.

All minnows harvested from the same pond will not of necessity be of uniform size and will require sorting or grading before they can be marketed to advantage. Sorting involves the separation of kinds of fish and the separation of sizes into desired groups. By sorting and grading the marketable sizes can be separated for sale, a pond crop divided into uniform sizes, or rapidly-growing individuals selected for breeding stock.

Mechanical Graders

Many types and sizes of mechanical graders (self-graders) are in present use but most of them grade minnows only on the basis of body width. Mechanical graders speed the process of minnow grading and if properly constructed will hold injury to a minimum.

Basically a mechanical minnow grader consists of a box which has one or more of its sides, and/or bottom, fitted with a grillwork of round metal rods. The rod grillwork will retain in the box minnows having a body width greater than the distance between rods and will allow smaller minnows to pass through and into the water outside the box.

The grader box should float or be suspended at or near the surface of the water. Minnows are poured into the suspended grader and the

smaller ones permitted to escape through the grillwork. At times it may become necessary to shake or jar the grader box to speed the grading process.

Since there is a rather definite relationship between minnow length and body width for a given species, the use of a minnow grader provides minnows of nearly uniform length size.

Several sizes of graders will be needed in order to grade minnows according to the sizes preferred by customers. The rods in the grader sides must be accurately and uniformly spaced. Units of 1/16, 1/32, or 1/64 of an inch are usually used to measure the space between rods. For example, a number 15 grader will have the space between rods 15/64 of an inch and a number 23 grader will have spaces 23/64 of an inch between rods when graders built are based upon 1/64 of an inch unit measurement.

The mechanical grader (Fig. 9) 30 inches long, 18 inches wide, and 16 inches deep, with two grading ends, is one type which may be used. Modifications of the type shown with one or more grading sides may also prove effective in the grading process. The over-all size of a grader may vary according to the sizes of the troughs in which it is used.

Cylindrical rods, 1/4 inch in diameter, of aluminum, stainless steel, brass, or other materials which will not rust should be used to make the grading sides of a grader. Spacings between the rods will determine the size of the minnow that will be retained in the grader and must be uniform between all rods. Some sort of jig or guide will be necessary for accurately spacing the rods. A piece of 1/8 inch strap iron, long enough for a grader side, with 1/4 inch holes drilled at uniform distances, can be used as a guide for spacing the rods. One such pattern should be provided for each grader size desired.

Plaster molds can be used that will hold the rods in the desired position while liquid plastic is poured over the ends to form a plastic block. When hardened the plastic will hold the rods in the proper place. The grill thus formed may be fitted into the sides of a grader box.

Sorting Table

The sorting table pictured in Figure 10 is useful when separating kinds of fishes or when small quantities of minnows are to be graded or counted.

This sorting table has a rectangular working surface of plate glass, 40 inches long by 24 inches wide, with sheet metal sides which project above the table top. Corner openings in the metal, 4 inches in width, provide places through which the desired minnows may be pushed from the glass into a bucket partially filled with water. Metal plates large enough to support the buckets can be welded to the table legs under each slot. Thirty-six inches seems to be a practical height for the table top. The table shown has a fitting through which running water may be delivered while sorting or counting minnows.

Minnows are placed on the wet table top and counted or graded. For convenience in counting, minnows in groups of five are usually handled and counted as one, which means that when a count of 100 is reached, 500 minnows have been counted.

When a sorting table is used for counting minnows, increased handling is necessary and more opportunities are afforded for minnow injury. Because of this fact, a combination weight-count method is often employed when large numbers of minnows are to be counted.

The usual method for rapid determination of numbers of minnows for a large shipment is as follows: count the number of minnows that weigh

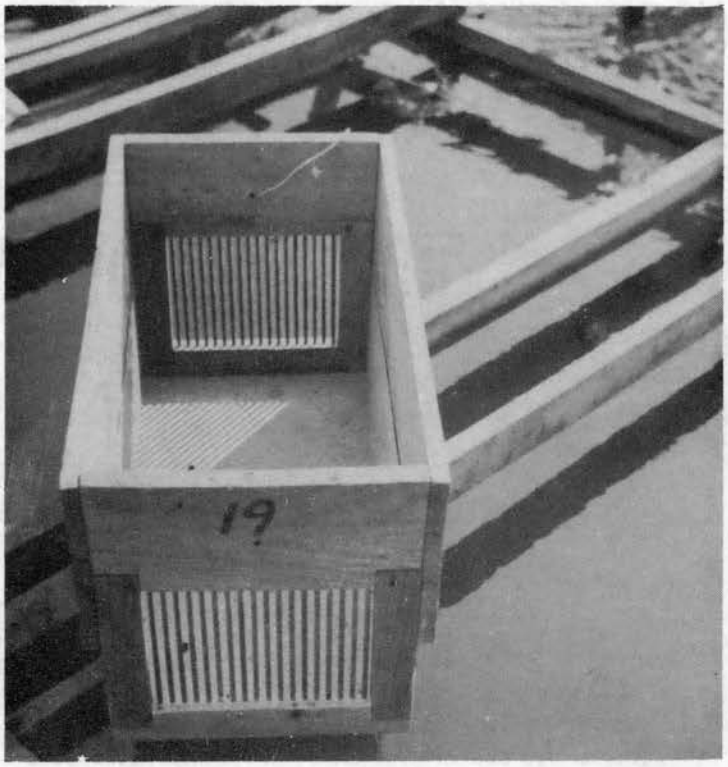

Figure 9. Mechanical Grader

Figure 10. Sorting Table

1 pound (or a fraction of 1 pound), calculate the number of pounds needed to fill the order, then weigh the amount needed. For this method the minnows should be graded to insure uniform size. Minnows should always be weighed in water.

TRANSPORTATION OF MINNOWS

The location of the bait farm with respect to bait dealers and other outlets will largely determine the transportation facilities that will be needed to market the minnow crop.

If the beginner in the bait farming business can arrange to sell the minnow crop at the bait farm site, he will have invested less capital and avoided many problems connected with the transportation of minnows. When the crop volume exceeds the local demand deliveries may be necessary.

Transportation should be conducted on cool days or at night, but this is not always possible. Hot weather is common in the Southwest, therefore specialized equipment for safe transportation of minnows must be provided. Short trips of not more than 3 hours duration can be accomplished by the use of simple equipment, while trips of two to three hundred miles or more will require more specialized equipment.

Containers for Short Hauls

There are many types of containers that suffice for transporting minnows over short distances. It would be advisable for the beginner in the minnow business to observe some of the containers in use at other hatcheries before choosing one. Several of the types in use will be mentioned here but the list is by no means complete.

1. Large canvas bags based on the principle of drinking water containers as used by our armed forces will suffice for short hauls. Nine to twelve heavy canvas bags about 36 inches deep by 18 inches in diameter

can be suspended by the top, open to the air and carried in a pickup truck. Their advantages include simplicity, low cost, little injury to the minnows, little splashing, and the elimination of supplemental aeration. The water in the bags is cooled by constant evaporation and the water is oxygenated by absorption through the canvas.

2. Some dealers use barrels or drums as containers. In most cases oxygen is supplied to the water by means of a compressor or by oxygen cylinders. Wooden barrels are preferable in that they tend to stay cooler than metal barrels.

3. Tanks of various sizes, shapes, and materials are also used extensively in the transportation of minnows. Usually tanks are constructed to make use of agitators, circulating pumps, oxygen cylinders, ice, or a combination of these.

Pictures of two types of tanks that can be used for transporting minnows are shown in Figures 11 and 12. The tanks were made of galvanized iron. Similar ones can be constructed by any competent tinsmith.

4. Cylindrical strainer type containers are useful for carrying assorted sizes of minnows when only a small number is to be transported. Eight of these containers, shown in Figure 11, can be carried in the larger agitator-equipped tank pictured in Figure 12.

Long Distance Transportation

A bait farm dealer who plans to transport minnows over long distances should visit several large bait or fish hatcheries and observe the methods and equipment being used before investing money or planning equipment.

Many kinds or types of tanks are being used to transport bait for long distances. Nearly all methods involve the use of some device for

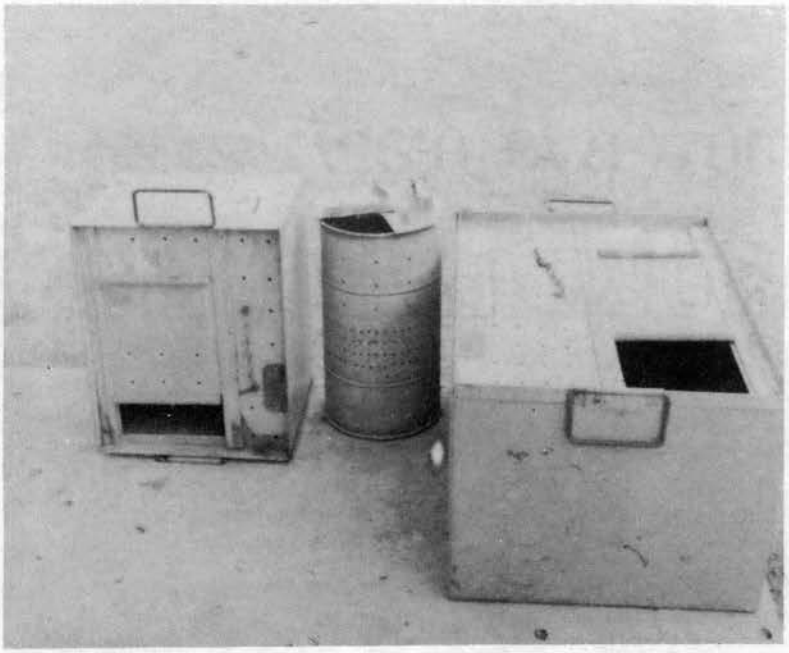

Figure 11. Tanks For Transportation

Figure 12. Agitator Equipped Tank

aeration or agitation to insure an adequate oxygen supply for the fish and the use of some form of cooling device. Also some successful shippers use chemicals to partly anesthetize the fish which lowers their activity and oxygen demand and use additional devices to remove the carbon dioxide and other organic wastes. No special tank for long distance transportation will be discussed. However, plans for tanks to be carried on trucks might be obtained by contacting your State Game & Fish Department. It is felt that one can get a better idea of what is needed by visiting several of the larger fish or bait farms.

The safe transportation of minnows involves the following factors:

1. Minnow size and container size
2. Care of minnows
3. Distance to be transported
4. Season of the year
5. Temperature of the water
6. Oxygen supply
7. Waste products
8. Fatigue from continued splashings

All these factors are more or less integrated and one should take all of them into consideration when planning the transportation of minnows.

Kinds and Sizes of Minnows

The kinds and sizes of minnows to be transported must be considered in determining the number of minnows to be carried in a certain sized container. Fathead minnows and bluntnose minnows will withstand more crowding than will the golden shiners. Generally speaking, the smaller the fish the less weight in pounds can be carried per gallon of water. (Schaeperclaus, 1933.)

Kinds and Sizes of Containers

The kind and size of container being used will also be a determining

factor in the number of minnows to be safely carried. Generally, by cooling with ice and aeration by pumps, one can safely carry 1,000 2-1/2 inch minnows to each 10 gallons of water. Experience will indicate the number which can be transported safely.

Care of Minnows

Harvesting and handling methods prior to and during the journey will have an effect on the condition of the minnows on arrival at their destination. (See Harvesting.)

A hardening or tempering process will be of value in conditioning the minnows for a journey. This process of hardening or tempering consists of gradually raising or lowering the temperature of the water in which the minnows are held until a suitable temperature is reached.

> Water in non-aerated tanks should be kept at 65° F. or lower...A minnow should not be subjected to more than a 10° change of temperature unless the change is very gradual. Proper tempering requires twenty minutes for every 10° change. (Dobie, et al., 1948.)

The sudden shock encountered when minnows are changed from one water temperature to another is often fatal. The shock is greater or has more lethal effect on the minnows when the change is from a colder to a warmer water. This factor should be kept in mind when unloading the minnows at their destination and the tempering process should again be used to condition the minnows to the temperature of the water in which they are to be placed.

Most dealers stop feeding the minnows a few days prior to shipping. This procedure reduces the amount of waste material that will be passed into the water during transportation and usually reduces the oxygen demand.

The risk of loss will increase as the distance to be traveled or the time spent en route increases. Therefore, long trips call for more

specialized equipment and greater precautions en route.

Season

The season of the year has a decided effect on the number of minnows per container that may be safely transported. Fall, winter, and early spring months are generally considered the best months for safe transportation of minnows. However, bait farm dealers cannot always dispose of their crops during these months and must transport some minnows during the hotter months. The number of minnows per container must then be reduced to insure maximum safety during the trip.

> In Alabama the transportation of fatheads is confined to the winter and spring since they may not be handled safely in summer...The transportation of golden shiners is limited to the cooler months of the year. They are never shipped via railway express. (Prather, et al., 1953.)

Temperature

Most experienced bait haulers agree that keeping the temperature of the water at 65° F. or below prevents the occurrence of excessive losses of minnows during transportation. The minnows are less active and use less oxygen.

The most common method of lowering the temperature of the water in the hardening or tempering process and holding it at the desired temperature is that of adding ice to the water. Make certain that the temperature of the water is not lowered faster than 10° F. in 20 minutes because the sudden shock will cause a high mortality of minnows.

Oxygen

An adequate supply of oxygen for the minnows must be maintained at all times. The supply of oxygen during transportation is maintained by

several methods or combinations of methods.

1. Agitation. Agitation of the water by means of an electrically driven impeller, which is connected to the power supply of the vehicle, is one means of mixing or stirring the water and increasing the oxygen supply. This method is suitable for short trips with a small number of minnows. Several types of agitators are on the market, or a suitable one may be constructed by the dealer.

2. Circulation. Another method of aeration is by means of a circulating pump that takes water from the bottom of the tank and sprays it into the top of the tank, thus absorbing oxygen as the spray passes through the air.

When transporting golden shiners the spray should not fall directly on the water but should be baffled because shiners have a tendency to jump, causing many injuries. (Prather, et al., 1953.)

When tanks are aerated with running water a continuous flow of not less than 1 gallon per minute for each 25 gallons of water in the tanks should be maintained. The water should reach the tank from pressure jets placed well above the water level. Each tank should have a minimum of two pressure jets and at least one jet for every 25 gallons of water in the tank. (Dobie, et al., 1948.)

Many modifications of the water circulating type system are used in the transportation of minnows. Some haulers state that by the addition of a venturi (a particular type of pressure nozzle) in the discharge pipe of the water circulating pump the hauling capacity of a tank has been increased tenfold. (Feast and Hagie, 1948.)

Oxygen in either pure or atmospheric form is used where circulation of water is not employed and sometimes in combination with the water circulation process. The water can be oxygenated from air compressors or from metal cylinders of pure oxygen. When oxygen is supplied by a compressor or a cylinder, it is necessary to have tubes fitted with valves

and an atomizing device to carry, control, and disperse the oxygen. Carborundum aerator stones or a perforated oxygen release tube which produce small bubbles of oxygen as it enters the water are commonly used as atomizing devices. When using oxygen under pressure, an oxygen regulator valve and gauge of the type used by welders is necessary to control the pressure and to determine the amount being used.

Only a small amount of oxygen entering the tank is necessary since somewhere around three parts per million is the minimum quantity. Amounts greater than 10 parts per million are a waste and can be dangerous.

In the transportation of golden shiners in Alabama, oxygen alone (without water circulation) was recommended as the best method for trips lasting twelve hours or less. "With this method, up to 7,500 shiners 4 to 5 inches in length can be hauled per 100 gallons of water without injury if the temperature is 65° F. or lower." (Prather, et al., 1953.)

Transportation Methods Employing Chemicals

Experiments with and recent developments in the use of hypnotic drugs have shown that possibilities exist for their application to fishery practices, especially during transportation and handling.

Most of the drugs, when dissolved in the water, reduce the respiration rate and the activity of minnows, thus permitting an increased number of fish per volume of water.

Several drugs that have been tried are mentioned but no specific recommendations for their use are given.

Thiouracil when used on stonerollers and on bigmouth shiners at the rate of nine grains per 15,000 cubic centimeters of water (388 parts per million) reduced the oxygen consumption about 20 percent and seemed to

increase the fishes ability to withstand lower concentrations of dissolved oxygen. (Osborn, 1951.)

Urethane (Ethyl carbamate) decreases the oxygen consumption of fish under its influence and has been used in transporting fish during hot weather. In a 0.5 percent solution redfin shiners, small common suckers, and rainbow darters could be left for 18 minutes without injury, (0.5 percent solution equals 19 grams, 2/3 ounce, dissolved in 1 gallon of water). The cost of 19 grams is approximately $0.16. (Gerking, 1949.) A weaker solution which would cause decreased activity and decreased respiration but not completely anesthetize the fish would be convenient for transportation.

Sodium Amytal and Sodium Seconal have been recently tested by employees of the California Department of Fish and Game in experiments conducted in the transportation of trout and some other fish. In general, the results of the tests indicate that the carrying capacity of containers can be approximately tripled by the use of the drugs.

> In the case of warm water fish the use of drugs showed excellent results. Recently, 12 pounds of golden shiners were carried in 4 gallons of water in a solution of 0.5 grain Sodium Seconal per gallon. These fish were carried from Sacramento to Bishop, held there for 2 hours, then flown to Oxnard, and from there by truck to the Fillmore Hatchery. No loss occurred during the entire trip and the fish arrived in excellent shape...On a recent trip a load of smallmouth bass were flown from Sacramento to Blythe, California, a distance of 550 miles; total time 3 hours. Normally carried 50 ounces in 8 gallons of water; Sodium Amytal at 0.5 per gallon of water was used, and 50 ounces in 2 gallons of water were carried. These fish arrived in perfect condition and were planted in the Colorado River later by truck...Solutions of 0.5 to 2 grains of Sodium Seconal were found to give the best results. Concentrations of 5 to 15 grains per gallon indicated toxic effects, but did not kill the fish. (Reese, 1953.)

These two drugs tend to lose their strength in water over 50° F., therefore, when using the drugs the water should be kept at 50° F. or lower. In most cases a pressurized aerating system was utilized while the fish

were en route. The combined method of drugs and aeration increased the number and weight of the fish that could be handled per gallon of water. The cost of the drugs is approximately one-half cent per grain and would probably be cheaper in bulk packages. (Reese, 1953.)

Further experiments in the use of drugs will probably disclose a formula which will be acceptable for general use in concentrating fishes or minnows for transportation.

RETAILING MINNOWS

The retail minnow business is generally separated from hatchery operations and is commonly executed at sporting goods shops, service stations, grocery stores, or bait shops. However, some hatcheries sell minnows both at wholesale and retail prices. If the latter be the case, regular wholesale customers of the hatchery should receive consideration before minnows are sold direct to consumers, else the good will and the business of the dealers may be lost.

Persons considering the retail minnow business as an investment would be wise to visit as many bait shops as possible, noting the equipment used and the manner in which the business is conducted. A good location, plenty of suitable water, and the proper equipment are essential items to the success of the business venture.

Minnows on the Market

Retail establishments may buy minnows from commercial minnow farms or from dealers who seine them from the streams or ponds. In some instances minnows of assorted sizes are sold to retail dealers by the gallon. This necessitates grading or sorting by the dealer. Most minnow farms sort and grade minnows into small, medium, and large sizes which are then sold to dealers at a price based on minnow size.

Fathead and bluntnose minnows 1-1/2 to 2 inches long are classed as small and cost the retail dealer about $10 per thousand. Retail price on this group averages about 35 cents per dozen or 3 dozen for $1. Medium

graded fathead and bluntnose minnows run 2 to 2-1/2 inches in length. This size costs the retailer about $12.50 per thousand and will retail for about 45 cents per dozen. Minnows of these two species 2-1/2 inches or longer are graded large, cost the dealer $15 per thousand and will retail for 55 cents per dozen. Golden shiners when graded into the three groups will run somewhat larger and the prices may be a little higher. Minnow sizes and prices may vary with conditions and localities. Minnows which in one week may be sold as grade medium may in the next week be sold as large or as small size depending on the customer wants and the sizes of minnows on hand.

Minnows must be in good condition (free of diseases and parasites) in order to live long enough to satisfy the customer. The minnow dealer should caution the customer against crowding the minnows in a container and against changing the temperature of the water in the containers rapidly.

Holding and dispensing pens vary in size, shape and material. Some dealers prefer wood, others metal and still others cement as building materials. Pens or tanks 4 feet wide, 6 feet long, and 4 feet deep will serve satisfactorily for minnow retainers in a retail store. The pens or tanks, provided with running water, should be in a shaded or protected area.

Equipment needed in a retail establishment includes water pumps, agitators, or some means by which water is circulated and aerated, sorting trays or tables, scales for weighing, and dip nets for handling minnows.

The retail minnow business is not a guaranteed money-making venture. Operating expenses, equipment repairs and replacements, disease among minnows, over-crowding and rough handling of minnows, hot weather, polluted water, and a lack of demand for bait are some of the items which can shrink the income from the sale of minnows.

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