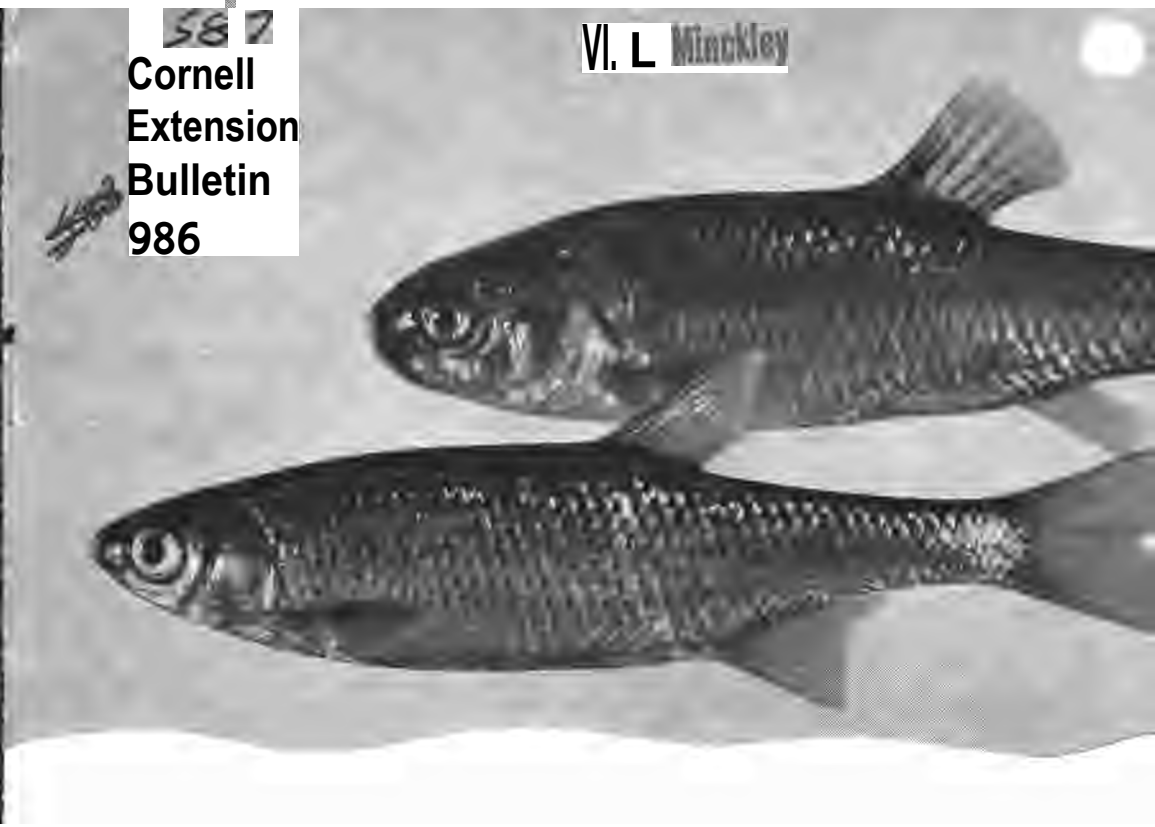

RAISING BAIT FISH AND CRAYFISH IN NEW YORK PONDS

by J. L. Forney

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Cover picture: Top, fathead minnow; center, golden shiner; bottom, white sucker.

Raising Bait Fish and Crayfish in New York Ponds

by John Forney

A generation ago, minnows for bait were easily seined from lakes and streams. Now, however, because of a tremendous increase in the number of fishermen, these natural waters cannot supply angling needs. The demand for additional new sources of bait led the New York State Conservation Department in cooperation with Cornell University to explore the possibilities of raising bait fish in New York ponds. Tests conducted in 90 ponds demonstrated that the golden shiner, fathead minnow and white sucker can be raised successfully in New York in properly designed ponds.[1]

Planning Bait Ponds

Ponds used for the production of bait fishes may be divided into two categories: single farm ponds which are usually filled by surface runoff, and groups of ponds with a permanent water supply designed for bait production. Farm ponds are relatively inexpensive to construct and many have produced profitable bait fish crops. However, a compact group of ponds with a permanent water supply can be operated more intensively and profitably than an individual farm pond.

This section is written as a guide in the selection of pond sites and the design of bait ponds. Principles and methods of farm pond construction are described in Cornell Extension Bulletin 949, Farm Ponds in New York. Technical help in planning and surveying pond sites is available through Soil Conservation Districts and County Agricultural Agents, as well as through private engineers and contractors.

The Farm Bait Pond

The site. A suitable pond site should possess these three characteristics: (1) topography that can be converted into a pond economically; (2) subsoil that contains enough clay to hold water; (3) a water supply that is adequate but not excessive.

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[1] Dingell-Johnson (Federal Aid in Fish Restoration) funds (Project F-4-R) assisted in the research upon which this publication is based.

Broad draws or depressions with a slope of 2 to 8 feet per 100 are desirable sites. Such areas are often found at the headwaters of a drainage system. Ponds constructed on steeper slopes require a high dam to hold a relatively small area of water. On flat land, the pond basin must be created by excavation below the natural ground level. The excavated or dug-out type pond is usually more expensive to construct than a runoff type pond.

Choose a site with a small watershed. Under most New York soil and slope conditions, a drainage area of 5 to 10 acres provides enough water to supply a one acre pond. Too much water flowing into the pond from a large drainage area or constant flowing stream carries food, fertilizer and fish out of the pond. The drainage area should be vegetated to prevent erosion. Runoff water turbid with silt and clay shortens the life of the pond and reduces productivity.

A small spring or area of spring seepage is an excellent source of water. Often springs are adequate to maintain the pond level, and a diversion terrace can be built to prevent runoff water from entering the pond. If the springs provide too much water during the summer, part of the spring water should be channeled around the pond. A large flow of spring water lowers water temperature and retards growth of the fish.

The pond site must have subsoil with a high clay content to prevent excessive seepage. When moist, a soil that contains the right amount of clay feels greasy to the touch and feathers out into a flat disk when compressed between the thumb and forefinger. Samples of the subsoil can be obtained with a soil auger or post hole digger. Sink enough holes to be certain that a two-foot layer of clay covers the entire pond site. A deeper layer of impervious soil at the site of the dam is desirable.

Figure 1. Farm ponds ½ to ½ acre in area are suitable for bait propagation.

Pond design. Farm ponds ¼ to ½ acre in size are most desirable for minnow production (figure 1) . Smaller ponds are more expensive to construct and require more labor to manage. Larger ponds are difficult to seine and cannot be harvested effectively unless they are drained. The depth of water required in a bait pond depends largely on the danger of oxygen depletion during periods of ice cover. For holding minnows over winter, ponds fed by runoff or small springs should have a depth of at least 6 feet over ⅓ the area. Dugout ponds receiving little runoff seem particularly subject to oxygen depletion and maximum depth of 10 feet is advisable.

Some provisions must be made to prevent flood waters from flowing over the dam. A broad flat channel at either end of the dam and two feet below the top of the dam can be shaped to return heavy runoff to the original drainageway. The channel or spillway should be sodded and have a uniform and gradual slope to prevent erosion. The sod spillway is an emergency outlet and will deteriorate if kept under water. A standpipe or trickle tube should be placed in the dam to keep the water level six inches below the spillway.

A drain should be installed at the lowest point in the dam. It can be combined with the trickle tube as shown in figure 2. Threaded iron pipe with a diameter of four inches is suitable for ponds under ½ acre.

All trees and brush must be cleared from the pond site. The bottom should be smoothed and sloped towards the drain. This will facilitate harvesting the minnows. In shaping the pond bottom, the shore line should drop sharply to a depth of at least two feet. Shallow water encourages the growth of cattails and other undesirable aquatic plants.

The Bait Hatchery

Ponds designed for bait fish production have one important feature usually lacking in farm ponds—a permanent water supply. Enough water to maintain the ponds at a fixed level and to fill them when necessary simplifies bait culture operations. Fish production can be safely increased by feeding if fresh water is available when needed to replenish the oxygen supply. Also, a small flow of water during periods

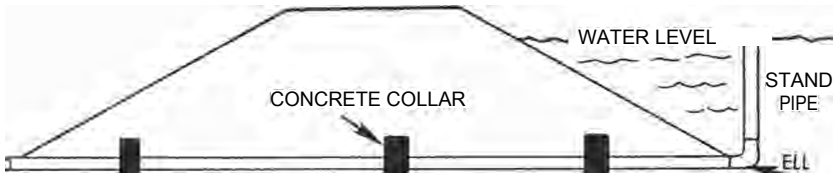

Figure 2. Cross section of a dam showing the drain pipe with concrete collars to prevent seepage, and a threaded standpipe for draining the pond.

of ice cover is good insurance against winter-kill.

The site. An ideal location for a group of ponds is a relatively flat area lying below the source of water. A gentle slope of 2 to 6 feet per 100 facilitates the flow of water to the ponds by gravity and simplifies installation of drains. The hatchery site must have subsoil with a high clay content. Ponds built on more porous soils are less productive because seepage water carries off dissolved nutrients.

A spring is a dependable source of water which can be easily controlled. However, few springs will furnish a large enough flow of water to fill ponds in a reasonable length of time. For example, a spring with a flow of 50 gallons per minute would take about one week to fill a ½ acre pond. Small springs can best be used to feed a large storage pond (figure 3), from which water can be piped to the bait ponds. Runoff water can also be collected in this manner. If runoff is the sole source of supply, the storage pond should hold twice as much water as all of the bait ponds.

Water is often diverted from permanent streams to supply the hatchery. The intake to the hatchery water system is installed upstream from the hatchery site so that all ponds are filled by gravity flow. Often a low masonry dam must be constructed on the stream to provide sufficient "head" or pressure to fill the ponds. Undesirable fish entering the ponds from the stream can seriously reduce minnow production. Coarse mesh screening across the intake pipe will exclude large fish, but screening fine enough to exclude newly hatched fry is soon clogged with debris. This difficulty can be overcome by dropping the inflowing water from a height of 12 to 18 inches on to a 24 to 30 mesh bronze screen. The screen should be set with a slope of about five percent so some water will flow along the screen and carry away fish and debris. A sloping screen is self-cleaning and will handle a large flow of water.

Hatchery design.[2] A complete survey of the hatchery site is necessary before starting construction. Plans should be drawn showing the size and location of all ponds, the water supply system and individual pond drains. The desired water level in each pond must be lower than the water supply.

Ponds between ¼ and ½ acre are ideal for bait fish management, but somewhat smaller or larger ponds are satisfactory. A maximum depth of six feet is adequate in hatchery ponds if a small flow of water through the ponds can be maintained during periods of prolonged ice cover. Pond bottoms should be sloped evenly toward the outlet so

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[2] Detailed information in "Production of Bait Minnows in the Southeast" by Prather, Fielding, Johnson and Swingle. Circular 112, Agricultural Experiment Station, Alabama Polytechnic Institute, Auburn, Alabama.

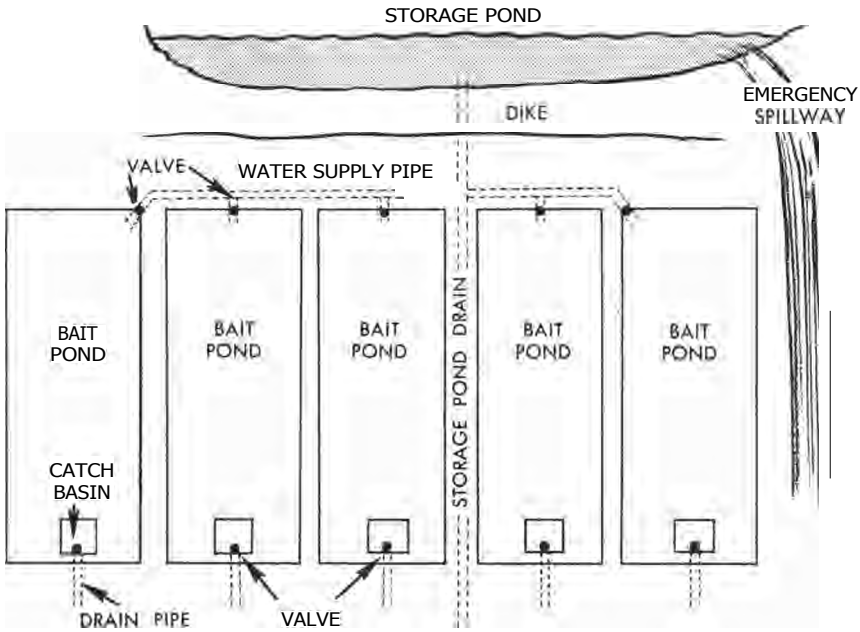

Figure 3. A storage pond can supply water for a series of bait ponds.

fish will not be stranded in pockets of water when ponds are drained.

Pond dikes are usually constructed with a steep 1½ to 1 or 2 to 1 slope to reduce the amount of shallow water next to the bank. The dam at the deep end of the pond should be 10 to 12 feet wide for use as a roadway. Dikes between adjacent ponds are often constructed with a top width of 6 to 8 feet. The top of the dam should be a foot above the water level. Higher dams will encourage burrowing of muskrats while lower dams may be overtopped during periods of heavy rainfall.

The water supply for the hatchery is usually piped from the source to the hatchery area. Asbestos cement or cast iron soil pipe is usually used for the main supply line. From the supply pipe, smaller pipes carry the water to each pond. For ponds up to ½ acre, 4-inch threaded steel pipe makes a suitable inlet. The inlet pipe can be fitted with a bushing and a small gate valve to control the water supply.

A drain that will completely empty the pond simplifies the harvest of bait fish. The most economical drain for ponds under ½ acre is the corn-

bination standpipe and drain shown in figure 1. The pipe, when vertical, should extend to within a foot of the top of the dam. In this position it removes the excess water entering the pond and maintains the desired water level. The pond can be drained by tilting the pipe to a horizontal position. A catch basin is usually constructed around the base of the drain pipe to hold the minnows when the pond is drained (figure 4). A basin 15 feet square and 1 foot deep is suitable for a ½-acre pond.

Raising Bait Fish

Success in minnow propagation requires choice of the right species of fish. Over most of New York the golden shiner, fathead minnow and common sucker are the most practical to raise. Local demand, prices and bait rearing facilities usually determine which of these to raise. A combination in a single pond is not desirable. Game fish in a bait pond greatly reduce the yield of minnows.

It is not possible to recommend stocking rates and other management practices which apply to all ponds. Ponds vary in their ability to produce bait fish. Some New York bait ponds will support 600 pounds of fish per acre, others will support less than 200 pounds. Consequently, figures on stocking, fertilization and feeding must be adjusted to the productivity of the pond after experience is gained in managing it.

Figure 4. A catch basin 12 inches deep and 10 to 15 feet square holds the minnows when the pond is drained.

Golden Shiner

The golden shiner is popular with both fishermen and bait dealers. It spawns readily in ponds and reaches bass size in 6 to 12 months. For these reasons it is one of the best species of minnows to raise for bait. Golden shiners over 2¼ inches in length can be seined, transported and sold even in warm weather if treated with care. Smaller shiners tend to lose scales, become infected with fungus and soon die when handled during the summer. Consequently, golden shiner ponds will generally prove most profitable if managed for the production of bass-size (2¼-3¼ inches) bait.

Selection of Brood Stock

Golden shiners 4 to 6 inches long are suitable for brood stock. The original stock may be purchased from bait dealers or seined from natural waters. These fish should be inspected for evidence of sores, inflamed areas and parasites on the skin. If any of the fish appear parasitized or diseased, brood stock should be obtained from a different source. After the first year, brood stock should be selected from the preceding year's production.

Stocking

Golden shiner brood stock should be placed in ponds by May 1. Stocked at rates of 200 to 400 adults per acre, golden shiners will produce as many young as can be reared to bass-size. Pond fertility has an important effect on the number of young produced. The same number of adults will produce 2 to 4 times more young in a fertilized pond than in an unfertilized one.

Spawning habits

In New York spawning usually begins in May, when water temperature reaches 68° to 70°F., and continues into late August. The slightly adhesive eggs are attached to filamentous algae (pond scum) or pond weeds. Golden shiners have occasionally failed to spawn successfully in ponds lacking aquatic vegetation. Mats of straw submerged along the shore provide a suitable spawning site in new ponds or ponds where dense plankton blooms prevent the growth of filamentous algae.

Rearing methods

Ponds stocked with adults in the spring will contain shiners ranging in length from one to 3½ inches by September. In a typical fertilized pond, 10 per cent of the young are bass-size (2¾ – 3¼ inches), 40 per cent are perch size (2 - 2¾ inches) and the remaining minnows are too small to market. Consequently, a large proportion of the year's hatch must be held for further growth. The bait producer can manage his ponds by (1) holding the entire first year hatch for a second year;

Table 1. Average number and weight of golden shiners at the end of the first and second growing seasons in eight fertilized New York ponds stocked with adult shiners.

Number of growing seasons	Pounds per acre	Number per acre	
		2 in.–2½ in.	3 in.–3½ in.
1	190	25,900	3,600
2	420	23,300	25,100

(2) removing the larger shiners as they reach bass-size; or (3) removing the small shiners and restocking them in rearing ponds. These methods are described in more detail below.

Biennial drain and restock. In this method the entire first year's hatch of golden shiners is held in the pond over winter. The pond is drained in August or September of the second year and the shiners are sold. After the pond refills it is stocked in preparation for another two-year period.

In New York ponds there is usually a 7-fold increase in the number of bass-size shiners between the end of the first and second years (table 1). Since bass-size minnows can be sold for twice as much as perch-size minnows, the value of the crop will generally double between the first and second year.

Draining and restocking ponds at two year intervals is a profitable method for managing large farm ponds which cannot be seined. But a larger number of bass-size shiners can be produced by seining the ponds and removing the larger minnows at frequent intervals, as described below.

Selective harvest. Under this system golden shiners are removed as they reach bass-size. Ponds are seined one or more times each year. The catch is placed in a fish grader (p. 21) which will retain the bass-size fish but allow small shiners to escape to the pond.

The harvest of bass-size golden shiners should begin in May or June of the second growing season. These larger shiners feed on newly hatched fry and compete with them for food. Unless bass-size shiners are removed in the spring or early summer, few young shiners will be produced and a poor hatch of young will reduce the yield of bass bait the following year. By late summer more shiners will have grown to bass-size and these can be harvested.

During the second summer after stocking and in each succeeding year, 20,000 to 30,000 bass-size shiners per acre can be harvested from fertilized ponds. After the pond has been in production for three to five years, the bottom often becomes covered with a deep layer of par-

tially decayed plant material. This muck is picked up by seines making them difficult to haul through the water. Much of the organic material will decompose if the pond is drained and the bottom thoroughly dried for two or three months. Drying the bottom also releases valuable plant nutrients stored in the mud and helps to control aquatic weeds.

Restocking young. If several hatchery ponds are available, ponds stocked with adults in the spring can be drained in the following fall or spring. The first year's hatch is graded and the large minnows are sold. Small shiners are restocked in fertilized ponds at a rate of 45,000 per acre in the fall or 35,000 per acre in the spring. A 15 per cent loss usually occurs between fall and spring, and another 15 per cent of the minnows will die of natural causes during the summer. Ponds stocked at the recommended rates will contain about 30,000 bass-size golden shiners in late summer.

Use young shiners over 1½ inches in length for stocking rearing ponds. Smaller shiners may not reach bass-size by late summer unless they are fed or stocked at a lower rate.

If the minnows are to be fed daily (p. 12) the stocking rates recommended for fertilized ponds should be doubled. Periodic checks on the size of the minnows will assist in estimating amounts to feed. The size at the time of these checks indicates whether feeding should be increased or decreased to produce the size minnow desired. Ponds fed with soybean meal have produced up to 60,000 bass-size shiners per acre (800 pounds).

Fertilization

Fertilized ponds consistently produced greater weights and numbers of golden shiners than unfertilized ponds. In a two year period, the wholesale value of golden shiners produced in ten fertilized ponds was $648 per acre compared to $173 per acre in three unfertilized ponds. The cost of the fertilizer applied was approximately $60 per acre, a small expense in comparison to increased production.

Fertilizers increase the production of microscopic plants, which in turn, increase production of animals utilized as food by minnows. Fertilizers will not produce a good growth of microscopic plants and animals (plankton) in ponds choked with aquatic weeds and filamentous algae. Dense growths of these undesirable weeds must first be treated with chemicals. For information on the use of weed killers see Cornell Extension Bulletin 910, Controlling Weeds and Algae in Farm Ponds.

Commercial fertilizers containing 6 per cent nitrogen, 12 per cent phosphorus and 6 per cent potash (6-12-6) have given satisfactory results in most New York ponds. Fertilizers with a higher percentage of nitrogen sometimes produce a better plankton crop in new ponds and ponds on lime-poor soils. Old ponds

with mucky bottoms will usually produce a plankton bloom with phosphorus alone.

Commercial fertilizers are broadcast into shallow water on one side of the pond. Wind and wave action distribute the nutrients throughout the pond. Application of 200 pounds per acre should start in late April and be repeated at two week intervals until the water becomes a murky green or brown due to the growth of microscopic plants. Subsequent applications should be made whenever the water begins to clear enough that the bottom can be seen at depths of 12 to 18 inches. Fertilizers sometimes fail to produce the desired bloom of microscopic plants, but even so have increased the production of shiners. In most ponds, fertilization should be continued until mid-September. Fertilization should be stopped a month earlier in farm ponds with a maximum depth of less than six feet; shallow ponds are more subject to oxygen depletion under an ice cover.

Commercial fertilizers are not effective in ponds that remain continuously turbid with suspended clay. Clay particles reduce the amount of light available to plants and prevent plants from fully utilizing fertilizer materials. Turbid ponds can be cleared by adding manure. Apply one ton of manure per acre every two weeks until the water becomes green or brown with plankton. Additional applications of manure or commercial fertilizer can be used to maintain the proper plankton growth. If manure is not available, cut hay, either fresh or dried, or straw can be substituted.

Feeding

The natural food supply may be supplemented by feeding. Finely ground soybean meal floats on the surface and is readily eaten by golden shiners. The dry meal should be scattered on the surface along one side of the pond. In ponds with a dependable water supply, golden shiners can be fed at a rate of 10 to 20 pounds per acre per day. Probably not more than 5 pounds of feed per acre per day can be safely used in a farm pond which is not fed by a spring or other permanent water supply.

In farm ponds feeding must be stopped before critical oxygen conditions develop. The decomposition of uneaten food, feces and dead plankton organisms may deplete the oxygen supply, particularly during periods of cloudy weather when little oxygen is produced by plants. In hatchery ponds fish kills can be avoided by flushing the pond with fresh water when the transparency of the water (visibility to the bottom) becomes less than 8 to 10 inches.

In ponds stocked with adult shiners it is advisable to delay feeding until the second year. Feeding in the first year may result in the production of more young shiners than can be reared to bass size.

The white sucker has been reared in northern states to meet the demand for 4 to 6 inch bait fish used in angling for pike and muskellunge. Suckers three to four inches long are a hardy summer bass-size bait. Small suckers under three inches long are not generally marketed by New York bait dealers. Properly managed ponds stocked with eggs or fry in the spring will produce bass-size suckers by late summer and pike-size suckers for spring angling.

Production of Eyed Eggs and Fry for Stocking

Suckers rarely spawn in ponds and must be stocked as eggs or fry. Sucker eggs can be obtained by stripping ripe fish during the spring spawning runs which occur in most streams between mid-April and mid-June. Spawning fish are most easily captured at night in small shallow streams. Before taking suckers from streams, consult your local Game Protector or District Fisheries Manager regarding laws and regulations governing the taking of suckers in your particular area.

Stripping eggs and milt from suckers is fairly simple. Express the eggs from a sucker into a dampened pan (figure 5) and immediately strip milt from a male over the eggs. Eggs and milt flow freely from ripe fish when light pressure is applied by moving the thumb and forefinger over the abdomen towards the vent. Several female and male fish may be stripped into one pan.

Gently stir the eggs and milt so that the sperm will reach all the eggs. After thoroughly mixing the eggs and milt, add a small amount of water and continue stirring the mass of eggs and sperm for about five minutes. Milt is then washed out of the eggs by changing the water in the pan several times. The washed eggs should be transferred to a large container filled with water for transportation to hatching facilities. The eggs remain slightly adhesive for a period of three to four hours and they must be stirred occasionally to prevent clumping.

Eggs are incubated in jars receiving a flow of water that gently agitates the eggs. When the water flow

Figure 5. Eggs flow freely from ripe female suckers.

Additional information in "Raising Bait Fishes." U. S. Fish and Wildlife Service, Circular No. 35. Order from Superintendent of Documents, U. S. Gov. Printing Office, Washington 25, D. C.

is properly regulated, dead eggs will float to the surface and be carried out of the jar while the live eggs remain in the lower portion of the jar. The entire mass of eggs is kept in motion by a slow, gentle 'rolling' action produced by the water coming in at the bottom of the jar. Ponds provide an excellent source of water which can be piped to the hatching unit. Pond water at a depth of about two feet below the surface is usually a suitable temperature for incubating sucker eggs (50° to 70°F.) . A simple arrangement for incubating eggs is shown in figure 6.

At the eyed stage (dark eye of embryo visible within the shell) eggs should be removed from the jars and placed one to three layers deep on screen trays located either in a trough containing running water or a pond scheduled for stocking. Measure the eggs into lots of the desired number for stocking the pond. Eggs run 30,000 to 35,000 per quart. Trays made of 14- by 18-mesh bronze screen will retain the eggs while allowing the newly hatched fry to escape into the trough or pond. Fry are cream-colored and unable to swim when hatched. They become dark in color and will be seen swimming near the surface in 4 to 8 days. Fry incubated in troughs should be stocked at the swimming stage.

Eyed eggs stocked in ponds are placed in a special hatching box (fig-

Figure 6. Hatching jars for incubating sucker eggs to the eyed stage.

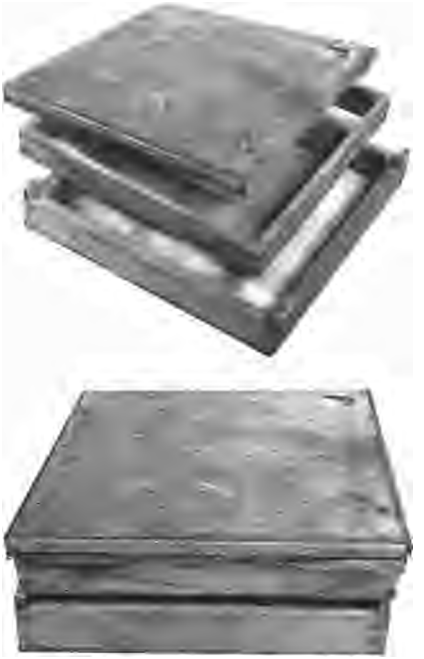

Figure 7. A hatching box is used in incubating eyed sucker eggs in ponds.

ure 7) . The principal features of a hatching unit are a cover to shade the incubating eggs, a 14- by 18-mesh screen tray to hold the eggs, and a bottom tray of fine woven nylon to support the newly hatched fry. A half inch opening between the trays allows the fry to escape into the pond as they reach the swimming stage. A hatching unit two feet square will accommodate two quarts of eggs (60,000 to 70,000 eggs) .

Dead eggs on the trays often become infected with fungus (Saprolegnia) which attacks and kills adjacent living eggs. Fungus can be controlled by exposing the eggs to a 1:20,000 solution of malachite green for one minute. Eggs on trays in a trough can be treated by stopping the flow of water and adding sufficient malachite green to attain the correct concentration. Eggs on hatching units in ponds are treated by pouring a concentrated solution (1/10 ounce in 1 quart of water) over the eggs while the tray is submerged about three inches below the water surface.

Stocking Ponds

Ponds should be drained and refilled one week before stocking, or sprayed with a mixture of kerosene and diesel oil at a rate of 10 gallons per acre immediately before stocking. This is to reduce aquatic insects that kill fish fry.

Stock fertilized ponds with 50,000 to 100,000 fry per acre. About 30 per cent of the fry will survive, so ponds will generally contain 15,000 to 30,000 suckers in late summer. This is the maximum number which can be reared to a length of 3 to 4 inches in a fertilized pond. If supplemental feed is provided during the summer, stock 100,000 and 200,000 fry per acre.

When suckers are stocked as eyed eggs, approximately 35 per cent will not hatch. Therefore, ponds should be stocked with about 1½ times as many eyed eggs as fry.

Rearing methods

Ponds stocked in the spring with eggs or fry will yield bass-size bait by

Table 2. Production per acre of white suckers in five typical fertilized ponds.

Locality	Production					Fertilizer	
	Number stocked	Pounds	Numbers 2 in.–3 in.	3 in.–4 in.	4 in.–6 in.	Pounds	Type
Geneva	67,000	307		2,300	8,200	1,200	5-10-5
Geneva	70,000	388			11,000	1,100	12-12-5
Ithaca	80,000	310	15,400	11,600	800	1,200	6-12-6
Ithaca	110,000	226	6,450	13,560	0	1,500	6-12-6
Syracuse	160,000	392	65,200	2,200	600	900	6–12–6

late summer. Usually, only the more rapidly growing fish are over three inches long in August. Large suckers should be removed periodically in late summer by seining the pond and grading the catch.

Fertilized ponds will yield 200 to 500 pounds of suckers in the first summer. The suckers may average 2½ to 6 inches long depending on the number per acre (table 2) . About 90 per cent of the suckers will reach a length of three inches by September in ponds containing 15,000 suckers per acre ; 50 per cent will grow to 3 inches in ponds containing 30,000 suckers per acre and 10 per cent will reach 3 inches in ponds with 50,000 suckers per acre.

Production of suckers can be increased by feeding soybean meal. Ponds receiving 10 to 20 pounds of meal per acre per day during the summer will yield 500 to 900 pounds of suckers per acre. The size of the fish will depend on the number in the pond (table 3) .

Suckers that do not reach bass-size by fall can be held over winter and sold in the spring. These small suckers should be restocked for overwintering at a rate of 10,000 to 15,000 per acre in fertilized ponds. If soybean meal is fed during the fall

Table 3. Production per acre of white suckers attained in one growing season by the use of supplemental feeds in two ponds.

Pond	Pounds	Production Numbers 2 in.–3 in.	3 in.–4 in.	4 in.–5 in.	Fertilizer and feed Pounds	Type
A	880	104,700	13,100	0	600	6-12-6
					1,200	soybean meal
	553	4,000	20,600	8,700	2,000	manure
					1,200	soybean meal

and spring, the young suckers can be stocked at a rate of 15,000 to 25,000 per acre. Stocked at these rates, suckers will increase about 1/4 inch in length over winter. Although a 20 per cent overwinter mortality can be expected, the growth between spring and fall will generally increase the value of the crop. The ponds should be drained in May and restocked with fry.

Fertilization

Fertilization recommendations for golden shiner ponds (page 11) are applicable to ponds stocked with suckers. Often a new pond with an exposed clay bottom becomes turbid with suspended clay as a result of the feeding activities of suckers. In new ponds, manure should be used as a fertilizer to clear the clay from the water. In one to two years, a layer of organic muck will cover the clay bottom and a commercial fertilizer can be substituted for manure.

Feeding

Daily supplemental feeding in addition to fertilization has produced the highest poundage of suckers. Dry soybean meal is broadcast into shallow water along one side of the pond as recommended for golden shiners. Unlike golden shiners, suckers feed on the meal after it sinks to the bottom.

Supplemental feeding should begin in June, three or four weeks after the fry are stocked. In the hatchery type pond (page 5) a feeding rate of 10 pounds per acre per day in June and July and 20 pounds in August and September is usually satisfactory. Although higher rates of feeding can be used, there is danger of depleting the oxygen supply. In hot weather, ponds should be inspected early in the morning. When fish are observed swimming at the surface, flush the pond with fresh water and stop feeding until the fish show normal behavior. Feeding five pounds per acre per day is probably the maximum rate that is safe to use in a conventional farm pond.

Suckers that are to be overwintered in ponds, should not be fed between late October and late March. Winter feeding is not beneficial since growth is restricted by low water temperatures.

Fathead Minnow

The fathead minnow is a tough, hardy species that can be seined and transported in hot weather. Where a market exists for a summer perch bait, the fathead is the logical species to raise. In many areas the larger fatheads will be readily accepted as a small bass-size minnow.

Selection of Brood Stock

Fathead minnows over two inches in length are usually mature and will spawn soon after they are stocked. Brood stock can be purchased from established bait raisers. This minnow is not common in New York lakes and streams, and wild

Figure 8. Spawning boards for fathead minnows are staked along the edge of the pond about six inches above the pond bottom.

stock is difficult to obtain. After the first year, brood stock should be selected from the preceding year's production. Males can be distinguished from females during the breeding season by their darker color and the presence of tubercles (small spines) on the nose. Males grow more rapidly and reach a larger size than females.

Stocking

Ponds should be stocked in April or May with 500 to 700 adults per acre. Males and females should be stocked in approximately equal numbers.

Spawning Habits

Spawning in New York ponds begins in May and continues throughout the summer. The eggs are attached to the underside of rocks, boards and plant leaves where they are zealously guarded by a male. Several females may use the same nest site forming a layer of eggs that covers 20 square inches. The eggs hatch in 4 to 6 days.

Management

The pond should be prepared for fatheads by placing flat rocks or spawning boards (figure 8) in water one to two feet deep. Spawning boards, made of 1 by 4-inch lumber, are staked about six inches above the pond bottom.

Fathead minnows hatched in the spring will reach saleable size (1.8 inches) by August or September. The larger minnows can be removed and marketed during the summer. Most ponds will produce 10,000 to 20,000 perch-size fatheads in the first year. Many young will be less than 1.8 inches long in the fall and must be held over winter and reared to saleable size the following year.

Farm ponds can be managed for several consecutive years without draining or restocking. Ponds should be seined two or more times each year and saleable size minnows removed. Fatheads have a short life span and few reach an age of two years; the harvest of yearlings therefore should be as complete as possible to prevent losses. Removing yearlings also increases the growth of the remaining small minnows of the current year's hatch. Fertilized ponds will produce 40,000 to 60,000 perch-size fatheads per acre in the second and each succeeding year.

Adult fathead minnows, even when stocked at recommended rates, may produce more young than can be reared to saleable size. This frequently occurs when the minnows are fed regularly during the first growing season following stocking. If none of the young reach a length of 1.8 inches by fall, part of the fish can be removed and transferred to new ponds, or the fatheads can be fed during the second summer. Feeding during the second year does not appear to greatly increase reproduction. Apparently the presence of many one-year-old fish reduces spawning or survival of young.

Fatheads which are below saleable size can be restocked in the spring at rates of 50,000 to 75,000 per acre in fertilized rearing ponds where they will reach perch-size by July or August. Higher stocking rates can be used if the minnows are fed daily. When fatheads over one inch in length are transferred, 70 to 80 per cent will survive and grow to saleable size.

Fertilization

Fertilization recommendations for golden shiner ponds apply to ponds stocked with fatheads. However, fathead minnow ponds can be fertilized at a higher rate than golden shiner or sucker ponds. Plankton blooms dense enough to obscure the pond bottom at a depth of six inches have been maintained without killing fathead minnows.

Feeding

The yield of fathead minnows can be increased by feeding soybean meal. Where feeding is started in the first summer, reproduction is often so heavy that young fatheads will not reach marketable size. Consequently, feeding should be delayed until the second growing season.

Fathead minnows in hatchery ponds can be fed at a rate of 10 to 20 pounds per acre per day. Samples of minnows should be collected with a seine to determine if growth is satisfactory. The rate of feeding should be increased if growth is slow, or reduced if all the food is not being used. Fatheads in farm ponds have been fed up to 10 pounds of meal per acre per day without lowering the oxygen supply to a level dangerous to this species.

Harvesting Bait Fish

The only satisfactory method of harvesting the entire crop of bait fish is to drain the pond. The water level is lowered until the fish are concentrated in the catch basin. A flow of fresh water through the catch basin should be maintained if the pond is drained in hot weather. The minnows are then removed with a small seine and transferred to tanks for transportation.

Proper management of ponds often requires the harvest of saleable size fish without lowering the water level. A large proportion of the crop can be removed by seining. A seine 75 feet long and 8 feet deep is suitable for ponds up to ½ acre. A bag or pocket in the center of the seine will increase the catch and simplify handling the fish. The seine is less cumbersome if the bottom edge is cut to taper from a depth of eight feet in the center to four feet on the ends. Seines of this type with ¼ inch mesh netting are made by companies specializing in commercial fishing gear.

A 75-foot bag seine will usually catch 70 to 95 per cent of saleable-size minnows in four hauls in ponds under ½ acre. The proportion of the fish caught depends on the shape of pond, the contour of the bottom and the species of bait fish. Seines are more effective in capturing golden shiners and fathead minnows than suckers. Suckers escape under the net unless the seine is pulled very slowly through the pond.

Dense weed beds and filamentous algae interfere with or even prevent seining of ponds. Minnows become entangled in masses of vegetation picked up by the seine and many are injured. Filamentous algae can be controlled with copper sulphate and rooted aquatic plants killed with sodium arsenite (see Extension Bulletin 910) . Ponds should be treated at least two weeks before they are seined. This will allow time for the plants to die and decompose.

A soft mucky bottom also makes seining difficult. The tendency for the seine to dig into a soft bottom can be reduced by removing weights from the lead line or placing skids along the bottom of the net. Skids made by bolting two wash basins together rim to rim are effective in lifting the lead line above muck.

Bait fish must be handled carefully during the summer. Fish injured by rough handling are more susceptible to disease when held in bait tanks. When a seine is landed, it should be bagged loosely so that the fish are not crowded. Under no circumstances should the fish be lifted from the water while in the seine. Golden shiners should be dipped from the seine using a shallow dip net lined with fine mesh nylon netting or bobbinet cloth. Do not handle golden shiners when the water temperature is over 75° F. Suckers and fathead minnows can be seined and transported throughout the summer in New York.

Figure 9. Fish graders are used to separate various sizes of minnows.

When only a small portion of the minnows are to be sold immediately, lift nets, push nets and traps can be used. Lift nets are square or round sections of netting attached to a metal rim, which may be set on the bottom of the pond and lifted vertically. The net is baited with moistened bread or cracker crumbs.

The push net consists of an 8-foot length of 2 x 4 to which is attached an 8 by 12 foot piece of netting. The 2 x 4 is pushed 10 to 15 feet out from shore with a pole, and the attached netting is allowed to sink below the surface. After the minnows are baited over the net, the edges of the net are lifted by lines attached to the free corners and pulled toward shore forming a pocket next to the 2 x 4 in which the minnows are concentrated. Push nets have taken 100 to 300 fathead minnows and golden shiners in a five minute set.

Glass minnow traps have been used successfully to harvest bait fish in farm ponds. Traps are set in shallow water near the shore and baited with pieces of cracker. Short sets of 15 minutes are effective in trapping fathead minnows and golden shiners but longer sets of an hour or more are required to trap suckers.

Grading and Weighing

Mechanical fish graders are useful in separating bait fish into several size classes with minimum injury. The grader is constructed with aluminum or iron rods spaced at regular intervals along two sides of a wooden box about 20 x 20 x 12 inches (figure 9) . The spacing of the bars determines the size (width) fish retained.

Several sizes of grader are required. A grader with 10/32-inch space between bars will usually separate perch- and bass-size golden shiners. A 9/32-inch spacing will sort out saleable-size fatheads while a 15/32-inch grader usually separates perch-and bass-size white suckers. The size grader for any given size group will vary slightly from pond to pond depending on the plumpness of the fish.

When ponds are harvested by seining, minnows are transferred from the seine to a grader floating in the pond (figure 10) . Gentle

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Detailed information in "Production and Harvest of Bait Fishes in Michigan," by S. B. Hedges and R. C. Ball. Misc. Publication No. 6, Institute for Fisheries Research, Ann Arbor, Michigan.

shaking of the grader box in the water speeds the escape of small fish. If the fish must be separated into several size classes, the grader is placed in a holding can or tub to retain the small bait fish. These small fish can be run through a second grader if necessary.

Bait fish are generally wholesaled by the gallon or pail in New York State. This practice of measuring fish in a nearly dry condition is likely to cause injuries which increase the loss of minnows in holding tanks. Less damage results when minnows are weighed in a metal bucket half filled with water. Weight of bucket and water subtracted from weight of bucket, water and minnows gives the weight of minnows. Approximately six pounds of minnows are equivalent to one gallon of bait, or 15 pounds equals a 10 quart pail of bait fish. The number of fish sold can be estimated by counting the minnows in a two to four pound sample.

Transportation

Minnows can be transported in milk cans, drums or specially constructed tanks. Water in the tanks is usually aerated by a water spray system or by bubbling oxygen through the water. Compressed oxygen can be purchased in large cylinders from welding supply companies. The flow of .oxygen from the cylinder is regulated by a valve similar to the one shown in figure 11. Oxygen should be released into the water through a loop of perforated tubing lying on the bottom of the tank. The perforated tubing breaks the stream of oxygen into very fine bubbles so that more of it is dissolved in the water.

Figure 10. Fish are transferred from the seine to the grader box for sorting.

Figure 11. An oxygen cylinder with regulator valve is connected by rubber tubing to a loop of perforated tubing lying on the bottom of the tank.

Small, uniform-size holes can be punched in rubber tubing with a sewing machine. With oxygen, minnows can be carried for several hours at a rate of ½ to 1½ pounds per gallon of water.

Minnows withstand transportation best when the water temperature is 65°F. or less. When fish are seined from ponds in the summer the water should be gradually cooled to 65°F. Sudden changes in water temperature may be fatal. Minnows transported over long distances should be held in cool water without food for one or two days.

Raising Crayfish

Crayfish, crawfish, crawdads or crabs—as they are variously known—are widely distributed in New York's streams, lakes and marshes. They are a very desirable bait for summer fishing, and each year more fishermen are using more crayfish, with the result that bait dealers are finding the supply in local lakes and marshes will not meet the demand.

Some bait dealers have solved the problem of short supply by raising crayfish in artificial ponds, and additional pond owners and bait dealers may find it profitable to follow their lead.

Figure 12. The eggs, laid in late October, are carried attached to the abdomen.

Species to Raise

A recent study of crayfish disclosed that at least eight species inhabit New York's waters. Although these eight are quite similar in appearance, each species seems to have its own particular habitat preferences or requirements. Certain species are most abundant in swift streams, others in sluggish rivers, and some are abundant only in lakes and ponds. In New York, the most common (and frequently the only kind of crayfish in ponds and marshes with a mud bottom) has the scientific name Orconectes immunis, and is often called a "grass-crab" or "paper-shell crab" by bait dealers because the shell is relatively thin. This crayfish is the only New York species recommended for pond culture.

Since it is difficult to identify the different species of crayfish, breeding stock for new ponds should be obtained from bait producers who have crayfish ponds in production. If reliance must be placed upon a supply from natural waters, the breeders should be collected from a marsh or pond with a mud bottom.

Paper-shell crayfish mate during late summer. The male transfers sperm to a receptacle in the abdomen of the female, using a specially modified pair of abdominal legs (figure 13). By mid-October most of the females have burrowed into the pond bottom. Here the eggs are released from the ovaries and become securely cemented to the abdominal legs. The female is then said to be "in berry" (figure 12).

The female crayfish, depending on her size, will carry from 60 to 300 eggs through the winter. The eggs usually hatch in May. Newly hatched crayfish cling to the female for one or two weeks before wandering off to assume an independent life.

There is considerable individual variation in growth rate. Some crayfish hatched in May will reach bait size by July 1st. Others in the same pond may not attain saleable size until September. Young crayfish which reach a length of two inches by fall may become sexually mature at this time. Thus a few females

Figure 13. Male crayfish (right) can be identified by the modified first pair of abdominal legs used to transfer sperm to seminal receptacle of female (left), situated between fourth and fifth pair of walking legs.

usually lay eggs five months after hatching, although the majority of the young will not reach sexual maturity until their second summer.

The crayfish grows by periodically discarding its hard, rigid shell and forming a new one. This process (called molting) may occur eight or more times in the first year of life. For a short period after the old shell has been discarded, the new shell is very soft and pliable, and during this period an increase in size occurs. While in the "soft" stage following molting, crayfish bring a premium price as bait.

Crayfish have a short life span. Most males die at the end of their second summer of life and females at the beginning of their third summer. Dead and dying male crayfish will frequently be noticed in August and September and some dead females are usually seen in May. Old age, rather than disease, is usually the cause of death.

Management

Crayfish have been raised in farm ponds and similar impoundments with surface areas ranging from 1/ 30th to 5 acres. Ponds under ½ acre in area are easiest to seine and manage. Farm ponds are generally constructed with a maximum depth of 6 to 10 feet, but while this

depth of water is required to assure fish an adequate supply of oxygen during periods of ice cover, shallower ponds can be used for crayfish production; in fact, ponds with a depth of only two feet have produced an excellent crop. A dependable water supply, however, is necessary to maintain the water level in shallow ponds.

Stocking

The bait pond should be stocked in the fall with 600 to 1,000 mature crayfish per acre. Crayfish with a body length of 2½ inches are sexually mature, and females will lay their eggs soon after they are stocked. If stocking is delayed until spring, female crayfish "in berry" should be stocked at a rate of 300 to 500 per acre.

Yield

Young crayfish hatched in the spring may reach bait size by July (figure 14). The yield of crayfish from several fertilized New York bait ponds is shown in table 4. Most of the crayfish removed from these ponds were young of the current year. The yearlings remain in their burrows during the day and are seldom captured when ponds are seined; thus there is no danger of depleting the breeding stock once a good population has been established.

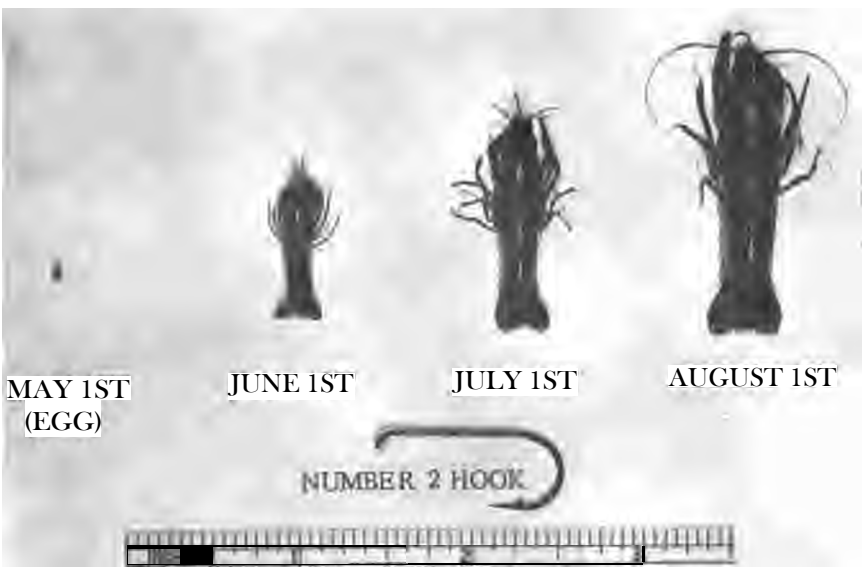

Figure 14. Young crayfish hatched in May often grow to bait size by July.

Minnows are frequently stocked with crayfish for a double bait dividend, and excellent crops of golden shiners, suckers and fathead minnows have been raised with crayfish. However, such a combination has certain disadvantages. Each time the pond is seined, crayfish and fish must be separated by hand and many minnows are injured or killed in the process. The bait producer who is primarily interested in raising minnows may find that crayfish in his ponds are more of a nuisance than an asset. While crayfish can be raised in combination with minnows, the presence of game or pan fish in a bait pond seriously lowers the yield of crayfish.

Fertilization and Feeding

Contrary to popular belief, it is not necessary to have luxuriant growth of submerged vegetation in the ponds. Although crayfish feed on rooted aquatic plants when they are available, they appear to survive and grow equally well on a diet of microscopic plants and animals. Fertilization of the pond will greatly increase the abundance of such microscopic plants and may also stimulate the growth of rooted plants. Commercial fertilizer mixtures such as 6-12-6 and 10-10-5 can be applied by broadcasting from shore over the pond surface. Application of 200 pounds per acre at three-week intervals during the spring and summer are recommended. Or 20 to 30 bushels of manure per acre at three-week intervals may be substituted for commercial fertilizer.

Feeding may be used to supplement the natural food supply produced by fertilization. Soybean meal, fish meal, cracked corn and potatoes are some of the supplemental feeds which have been used. And cut hay, either fresh or dried, is a very inexpensive feed which may have considerable value. In a test at the Cornell University Fish Hatchery, 48,000 crayfish per acre, weighing 340 pounds, were produced in a pond where 1½ tons of hay were applied in combination with 400 pounds of superphosphate per acre. The same pond the following year produced 10,000 crayfish per acre, weighing 96 pounds, when only superphosphate was applied.

Table 4. Number and weight of crayfish produced per acre in New York ponds.

Pond	Number	Weight	Fertilizer (pounds and type)	
A	22,500	89	800	6-12-6
	38,600	330	3,000	manure
	63,100	352	1,200	6-12-6
	28,700	288	900	6-12-6

Eliminating Undesirable Fish

The presence of game or pan fish in a bait pond can seriously reduce the yield of minnows. Ponds which cannot be completely drained to eliminate undesirable fish should be treated with rotenone. A permit issued by a District Fisheries Management Office must be obtained before using rotenone to eliminate fish. A list of district offices may be obtained by writing to the New York State Conservation Department, Albany 1, New York.

Derris powder, with a five per cent rotenone content, can be purchased from farm supply stores. Emulsifiable rotenone is a liquid containing five per cent rotenone which has been developed especially for treating ponds and lakes. It is more effective than derris powder and easier to handle.

Three pounds of derris powder or 11/2 quarts of five per cent emulsifiable rotenone should be applied for each acre-foot of water. The surface acreage of the pond can be estimated by multiplying the average length by the average width in feet. There are 43,560 square feet in an acre. The acreage multiplied by the average depth in feet gives the number of acre-feet of water in the pond. For example, six pounds of derris powder or 2¼ quarts of emulsifiable rotenone is required to treat a ½ acre pond (21,780 square feet) with an average depth of four feet (½ x 4=2 acre-feet) .

Powdered derris should be mixed with water to form a paste, after which more water is added to make a thin soup. The emulsifiable rotenone should also be diluted with water before application. Spray the entire pond area, using a pump type garden sprayer. The pond-water temperature should be above 50°F. for best results. Rotenone causes fish to suffocate by restricting the flow of blood to the gills. Rotenone in water gradually decomposes and within two to four weeks ponds can usually be restocked. Ponds treated with rotenone at the dosages recommended above are safe for livestock watering.

Regulations

Although there are no laws which deal specifically with the commercial rearing of bait fish, a number of laws or regulations have some bearing on the propagation of bait fish.

1. Before building a pond with a capacity exceeding 1,000,000 gallons or with a watershed exceeding one square mile or with a dam over ten feet high, a permit must be secured from the Superintendent of Public Works. Farm ponds meeting certain specifications are exempt from this law. The Superintendent, New York State Department of Public

Works, should be contacted for further information on these specifications.

2. Pond owners must in all cases obtain a permit before stocking fish or fish eggs. This regulation is necessary to prevent the introduction of undesirable fish into trout waters and waters reclaimed for fish production. Application for a stocking permit should be made to the District Fisheries Manager's Office. A list of these offices may be obtained from the New York State Department of Conservation, Albany 1. There is no charge for a stocking permit.
3. A net-and-sell-bait fish license is required before minnows can be legally removed and marketed from ponds. The fee for this license is 100 per lineal foot of net to be used, with a minimum fee of $1.00. Application for the license should be made to the Bureau of Fish, New York State Conservation Department, Albany 1.
4. Under section 358 of the Conservation Law, bodies of water not over ten acres and located on lands actually occupied and cultivated may be licensed as farm fish ponds. Applications (no fee required) should be made to District Fisheries Managers. This law permits considerable flexibility as to permission to control undesirable fish, manner of taking, etc. and provides a method for permitting much special management otherwise restricted by other sections of the Conservation Law.

Financial Considerations

Some New York pond owners have found the rearing of bait fish a profitable business. However, much capital, labor and technical knowledge are required to assure success. One acre of minnow ponds can be installed at a cost of $1,000 to $1,500. Construction costs will be lower if the owner does part of the work. Nets and transporting equipment will cost $20 to several hundred dollars depending on the size of the operation. The bait producer will also have to expend 20 to 100 hours each year managing an acre of ponds.

In New York, pond-reared bait must be sold in a market where the prices paid are governed by the availability of wild minnows. Careful choice of species and management procedures will enable the pond owner to have minnows for sale when wild minnows are least available. The higher prices are offered during the summer months when bait from natural waters is scarce, and at this season the more hardy species are particularly in demand. At present, wholesale prices per 1,000 for perch-size minnows vary from $5 to $20 and for bait

of bass-size from $15 to $35. Minnows four to six inches in length wholesale at $25 to $50 per 1,000. Wholesale prices are paid for minnows delivered to the retailer. If minnows are sold in the pond, the bait producer will receive about half the wholesale price.

On the basis of price alone it would appear logical to devote all ponds to the production of pike-size minnows. In practice, however, the returns from rearing "pike minnows" will frequently be less than the returns from the rearing of smaller sizes. A pond will produce only a limited quantity of food, and this food supply can be used to produce a large number of small minnows or fewer large ones. As a general rule, the price obtained for pike minnows must be three times the price for bass minnows to justify raising bait to the pike length of four to six inches.

Although in New York State the supply of wild minnows is limited during the summer months, the shortage of bait here is not yet as severe as in other regions of the country, where bait raising has been most financially successful to date. Under present market conditions, the established retail bait dealer in New York State is likely to find bait raising profitable as a method of supplementing his supply of wild minnows. Farmers with ponds already constructed can realize a return on their investment by stocking bait minnows or leasing ponds to dealers for bait production. Most farm ponds will produce a modest crop of saleable minnows with only small investments in fertilizer and labor. The large-scale rearing of minnows for sale through wholesale channels should be considered only after the likelihood if its success can be judged from experience gained in operating a small group of ponds.

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