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DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES
HUGH M. SMITH, Commissioner

# FISH PONDS ON FARMS

By ROBERT S. JOHNSON and M. F. STAPLETON

APPENDIX II TO THE REPORT OF THE U. S. COMMISSIONER
OF FISHERIES FOR 1915

Bureau of Fisheries Document No. 826

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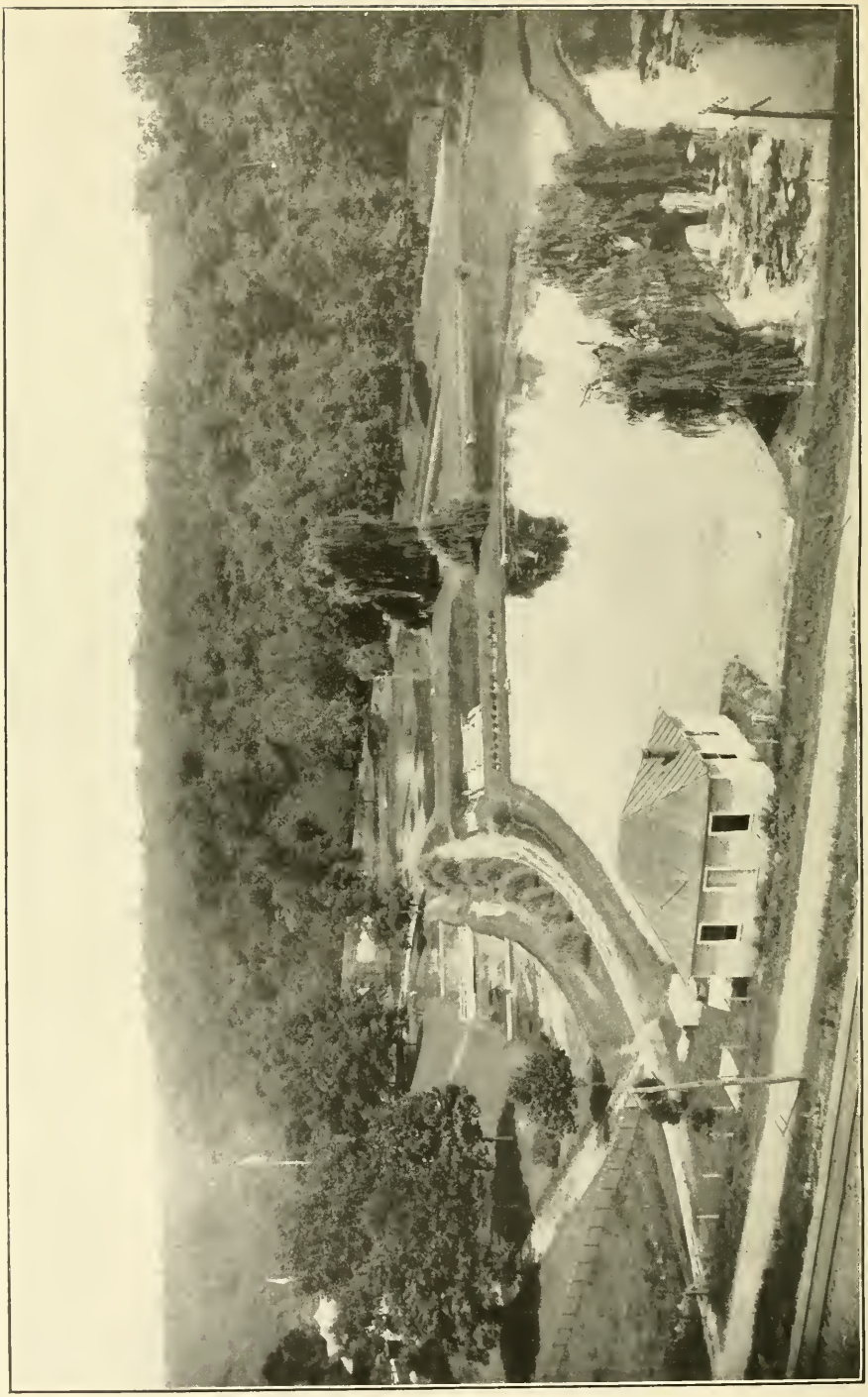

POND FISH-CULTURAL STATION, MAMMOTH SPRING, ARK. (BUREAU OF FISHERIES.)

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Appendix II to the Report of the U. S. Commissioner
of Fisheries for 1915

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# FISH PONDS ON FARMS.

By Robert S. Johnson and M. F. Stapleton.

## INTRODUCTION.

The propagation of fish on farms in artificially constructed ponds or in natural ponds of limited area is perfectly feasible; and with proper management such ponds will afford a convenient and economical food supply that will justify the expense of their construction or preparation and maintenance.

It is the purpose of this report to point out briefly the essential features to be considered in the location of a site, the construction of the pond and its operation, and the care of the fish contained therein.

This information has reference exclusively to the rearing of the spiny-rayed or warm-water fishes, which are especially adapted to culture in ponds, and which can only be propagated through natural reproduction.

Data regarding the trouts and other species of the Salmonidæ which can be propagated artifically are contained in another publication of the Bureau of Fisheries, which will be furnished on request.[a]

Federal and State Government have in the past decade done much to improve the conditions of rural life by the development of public resources, the advancement of social intercourse, the dissemination of agricultural knowledge, and demonstrations of a better domestic practice. Up to the present time, however, but little attention has been given to fish culture as an adjunct to farming.

## VALUE OF FISH AS FOOD.

Mental and physical efficiency, in the last analysis, are dependent upon the character of the food supply, and fish may well constitute a needed ingredient which is usually missing from the farm dietary.

The requirement of variety in food is unquestioned, if indeterminate, and the palatability of fish to the average person, in conjunction with its value in protein content, makes it a pleasing and beneficial addition to the daily regimen.

[a] Artificial Propagation of the Atlantic Salmon, Rainbow Trout, and Brook Trout. Bureau of Fisheries, Document No. 346.

The chemically complex substance known as protein is an essential constituent of food, the most important tissues of the body, other than the skeleton, being principally composed of it. Most human beings derive their needed protein from the flesh of animals, and in practically all civilized communities the greater part of it is supplied by meat and poultry. In the United States the main dependence in the past has been on meat—beef, mutton, and pork—which, owing to the large areas available for grazing and the low price of corn, could be raised in quantities great in proportion to the population.

These conditions no longer prevail, and shortage of the meat supply, with resulting high prices, is now a general condition. As a substitute for meat fish offer many advantages. Pound for pound it contains as much protein as meat, and in some cases more. It therefore affords the same class and grade of food material as beef, mutton, and pork.

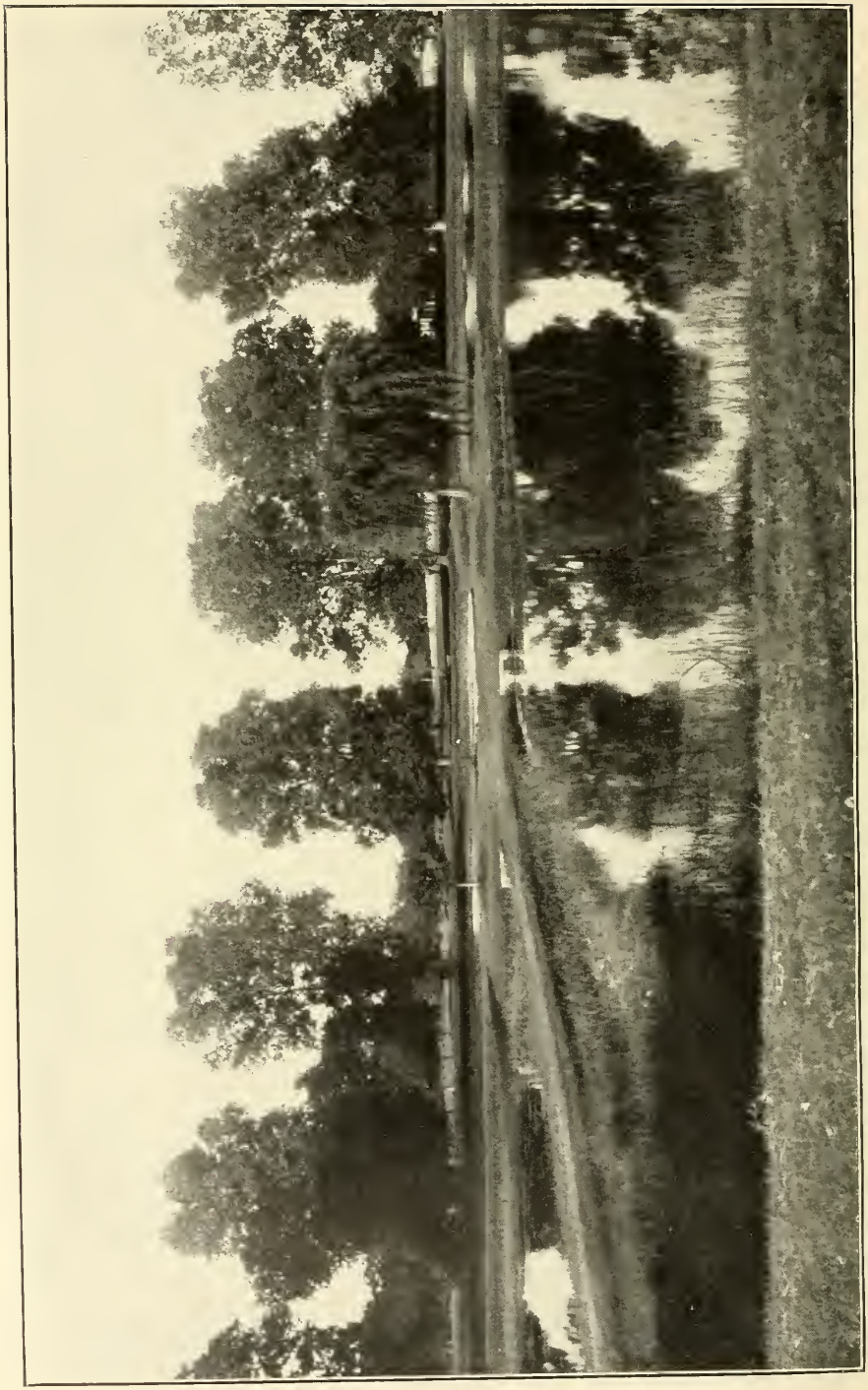
Unfortunately, those actively engaged in farm work rarely have the opportunity to fish in neighboring lakes and streams, and more distant excursions, involving several days' absence from home, are usually beyond consideration. The need is apparent, therefore, for a readily accessible supply of fresh fish that may be drawn upon when desired—a source as dependable as the smokehouse or the poultry yard.

## UTILIZATION OF WASTE LANDS.

The Bureau aims especially to influence the utilization of the natural and favorable water areas existing on countless farms which at the present time are being put to no use, many of them constituting unsightly waste spaces that detract from the value of the land. The presence of springs, lakes, flowing wells, or adjacent streams are all leading incentives to a fishery project, and suitable sites for the construction of ponds, especially if at present unremunerative, should make their use to such a purpose desirable to the thrifty husbandman after a full comprehension of their possibilities in a fish-cultural way.

Ponds intended primarily for the cultivation of fish may be conveniently located for the watering of stock, or the overflow therefrom may be utilized for the irrigation of land. In many sections of the United States artificial ponds on farms are an absolute necessity to serve one or both these latter purposes, and by a merely nominal expenditure such water areas may be advantageously utilized for the growing of fish without interfering in any way with the original uses for which they were intended.

At the outset the main object of the amateur farmer fish-culturist should be the production of a food supply for home consumption.



BASS AND CRAPPIE PONDS SHOWING DRAINS AND CROSS SECTION EMBANKMENT. SAN MARCOS, STATION, TEXAS. (BUREAU OF FISHERIES.)

There are no authentic published records as to the financial returns that may be expected from the pursuit of pond fish culture on a commercial basis. Many theories have been advanced on this point, but, as in other undertakings of importance, the efficiency necessary in order to profitably conduct such a business can only be gained by repeated efforts and actual experience. Furthermore, in order to arrive at an estimate of any value one would have to take into consideration such important factors as the topographical features of the site, the character and quantity of the water supply available, the extent of the enterprise, and the location of the plant with reference to market and transportation facilities.

Taking all these facts into consideration, one can readily see the futility of attempting to forecast in a general treatise the financial returns that may be expected from any given pond area devoted to commercial fish culture.

All this, however, detracts in no way from the argument favoring the construction of ponds with the view to providing a food supply for private use. The feasibility of pond fish culture on this basis has been fully demonstrated, and ample quantities of fish for home use are to-day being propagated in established ponds on farms, proving the value of such an undertaking for that purpose alone.

After gaining the required experience and knowledge of the subject as a result of conducting work for several years on a limited scale, the farmer will be well qualified to judge as to the practicability of extending his operations, and can then, if he so chooses, increase his facilities with the view of raising fish for the market.

Frequent inquiries are received by the Bureau of Fisheries regarding the use of natural ponds, lakes, and streams, for the raising of fish. With respect to such water areas it may be stated that if drainage is provided for, the pond bed cleared of débris, the site protected against the inflow of surface water—if, in short, complete control is effected, natural water areas will possess many advantages over artificial constructions. There is objection, however, to any body of water not under complete control.

## WATER SUPPLY—VOLUME, QUALITY, AND TEMPERATURE.

In a brood pond, a constant water level should be maintained at all times, especially during the breeding season. The required flow, which will vary with the character of the soil, must be sufficient to replace loss by evaporation and seepage. An amount just short of overflowing the pond is the ideal to be attained, as it is desirable to avoid a current. A surplus of water is preferable to a shortage, as any excess may be easily diverted through waste channels or held as an emergency reserve.

For a 1-acre pond, where the sides and bottom are of clay or rich loam, a flow of from 30 to 50 gallons per minute should be sufficient to maintain a proper water level at all times, while sandy or gravel soil untreated may require double that amount. A practical method of measuring the flow of water from any source is as follows:

Select a stretch on the stream or ditch affording as straight and uniform a course as possible. If the water at any point is carried in a flume, it will be better to measure at that point. Lay off a distance of, say from 10 to 50 feet; measure the width of flowing water at about six different places in this distance, and obtain its average width. Likewise at these same points measure the depth of water at three or four places across the stream and obtain its average depth. Then drop a float in the water and note the number of seconds it takes to traverse the given distance. The product obtained by multiplying the average width in feet by the average depth in feet by the velocity (expressed in number of feet per second) will give the flow of the stream in cubic feet per second. From the figures so obtained it is advisable to deduct about 20 per cent, as the surface velocity of water is in excess of the actual average velocity.

High temperatures in season are necessary in brood and rearing ponds. If the water is cold at the source, the fault must be corrected by reducing the inflow to the lowest quantity that will maintain a uniform level, thus allowing the maximum absorption of warmth from the sun and air. Water that does not fall below 60° F. in the brood pond during the spawning season is desirable.

## SOURCES OF WATER SUPPLY FOR PONDS.

Springs are the most dependable of all the sources of water supply, requiring the minimum expenditure in preparation and being the least subject to outside influence. The presence of injurious mineral substances can usually be detected without expert analysis, but the amateur fish-culturist may be surprised to learn that so-called pure water often carries abnormal proportions of oxygen or nitrogen gases in quantities inimical to fish life. This may be due either to subaeration or superaeration, and the results following the use of such water will be as disastrous in the one case as in the other.

This contingency and the requisite of high temperature make precarious the embodiment of springs and wells within the pond bed. In the absence of thoroughly demonstrated fitness, the more prudent course will be to provide an independent water supply reservoir, apportioning its area to the volume of the spring. While being held in this reservoir the gaseous contents of the water will be corrected and its temperature seasonably modified.

The flow from many springs is so obstructed through the trampling of stock or from other causes that they emit only a small portion of the water available near the surface. In such cases the supply may

usually be materially increased by sinking 2-foot lengths of terra-cotta pipe over the bubble and removing the incased earth. Several such pipes in a promising area will often result in an astonishing increase in flow. Where the cost is not prohibitive, however, the better course will be to excavate the site and wall it in with rock and concrete.

In profusely watered sections—notably, in the States bordering the Great Lakes—there are many tracts of marshy characteristics, some of them hundreds of acres in extent, promiscuously interlaced with tiny rivulets which combine to form streams of considerable size. Seemingly inexhaustible quantities of water lie close to the surface in many such places, and by driving pipes only a few feet into the ground flowing wells are obtained.

Where the volume of water is a matter of concern the overflow level of spring reservoirs, sunken tiling or driven pipes should be kept as low as possible, consistent with the object in view, as the flow will naturally decrease with the elevation of the head against which it works.

A brood pond contiguous to a spring reservoir may be fed through a spillway directly into the stock pond. Where a reservoir is impracticable, at least partial correction of any abnormal condition of the water may be brought about by conducting it to the pond through open ditches or raceways of wood or concrete, the choice of material being determined by adaptability of the soil and the comparative expenditure involved.

The chief objection to creek or river water as a supply for fish ponds is the great quantity of mud and débris carried during freshets, and the excessive cost of effective measures to prevent its introduction into the ponds. Streams subject to extremely high-water periods are totally impracticable as a source of supply, while those of lesser floods can be utilized only after a considerable initial expenditure, and much vigilance will be entailed in their use, as large and continuous deposits of mud in breeding ponds will ruin any eggs present, and invariably kill recently hatched fry. Furthermore, protracted roily water will retard and sometimes prevent growth of the aquatic vegetation so essential to pond fish-cultural operations. It is also imperative that undesirable and predaceous fishes be rigorously excluded from the ponds, and it will be impossible to accomplish this if the water supply is beyond control during certain periods.

From the foregoing it can readily be seen that if a stream is subject to appreciable changes, as a result of storms or drainage from local watersheds, it will be unwise to establish a pond therein by the construction of dams, as is often contemplated. It will be entirely feasible, however, to conduct water from such a stream to ponds ad-

jacently located, provided the intake is adequately screened, the supply arranged so that it can be cut off during times of excessive turbidity, and measures are taken to prevent the inundation of the pond site in high-water periods.

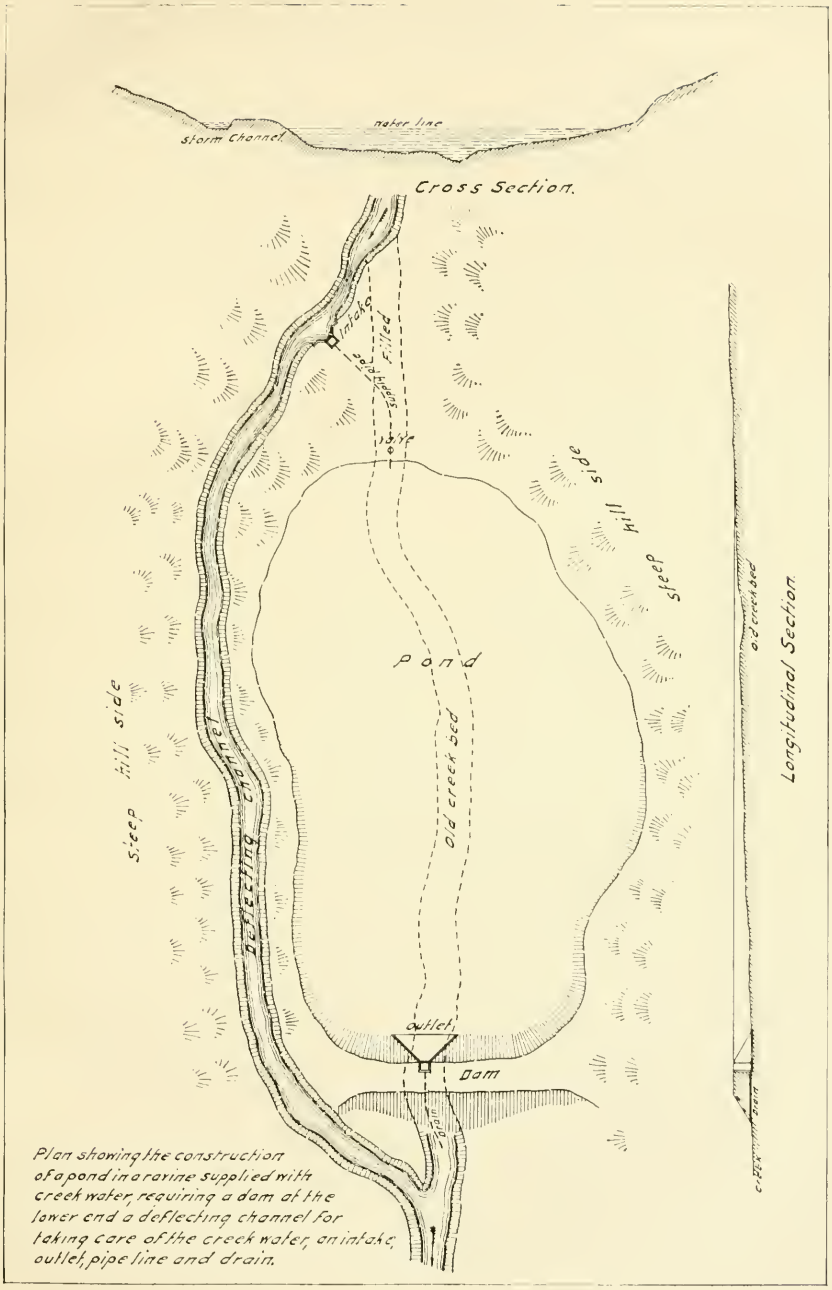
It may be necessary to erect a dam in the channel of the stream, to provide the required head of water for a gravity flow to the pond, in which case it may be of a simple type, designed merely to accomplish the end in view. The intake from the stream should be wide and deep, thus presenting a large screen surface to obviate the complete stoppage of the water supply in the absence of the caretaker. It should be covered by a series of screens graduated in size, the first to consist of coarse hog wire, or wooden racks with like openings, to catch the largest objects. The intermediate screen (of 2-inch mesh) will intercept vegetation, while the inner one must be fine enough to exclude smaller débris and the fry of undesirable fishes. Immediately below the screens, gates should be provided so that the water may be shut off at will and diverted into a storm channel when it becomes too roily for use.

Where the source of supply is a lake the difficulties referred to above are not encountered, lake water seldom being roily and demanding less attention to screens owing to absence of currents.

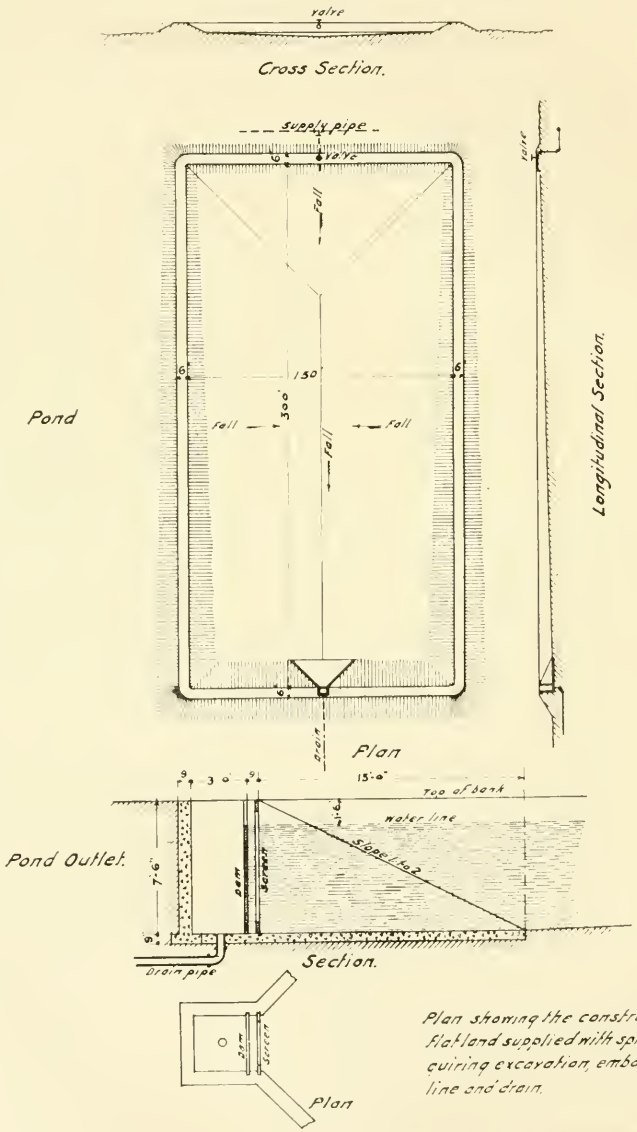
Uncontaminated open waters have many advantages. Their temperatures are seasonal; usually there are no abnormal gaseous constituents to be corrected; the plankton or pelagic animal and plant life contained therein forms a valuable addition to the natural food supply in the pond, and were it not for the difficulty of control and occasional roilyness, such waters would be preferable to springs and wells as a source of supply to fish ponds.

Wells, both flowing and power lifted, are successfully used in some sections for the cultivation of fish. Before incurring the expense of constructing ponds to be supplied from such a source, however, it will be advisable to thoroughly test the water in order to demonstrate its fitness for fish culture. This can best be done by fitting up a running-water supply in a retaining reservoir, and holding therein, for an extended period, a number of specimens of the species of fish it is desired to propagate. If they thrive, it may be assumed that the water is free from injurious gases or mineral substances and is adapted to the work it is proposed to undertake.

Rain water (surface drainage).—Another class of ponds available for the propagation of fish, known as "sky ponds," embraces those wholly or partly dependent upon local precipitation for their supply of water. Such ponds are invariably profuse in the production of fish food, and for this reason would be ideal were there an auxiliary water supply adequate to maintain constant surface levels during the critical nesting season, and a fair depth throughout the




Plan showing the construction of a pond in a ravine supplied with creek water, requiring a dam at the lower end a deflecting channel for taking care of the creek water, an intake, outlet, pipe line and drain.




Plan showing the construction of pond on flat land supplied with spring water and requiring excavation, embankments, outlet pipe line and drain.

remainder of the year. In the absence of this reserve many such ponds become practically dry during periods of drought or freeze to the bottom in the winter months. Where ponds are subjected to such conditions fish cultural operations are impracticable.

Ponds dependent entirely upon precipitation and surface drainage for their water supply must necessarily be located at a low elevation, in order that the surface drainage from surrounding lands may be taken advantage of. Land depressions, ravines protected from floods, or swamp lands, are desirable sites for such ponds.

Catfishes only can be recommended for the best of "sky ponds," strictly speaking, and the results even with them will be very uncertain.

## DESIRABLE SITES FOR THE LOCATION OF PONDS.

If a gravity flow of water is contemplated, the fish pond must, of course, be located below the level of the source of supply. Porous soils are to be avoided, if possible, not only because of the large volume of water required to replace loss from seepage but because they are usually sterile. Swamp lands, old water courses, and catch basins of years' standing are the best and most productive soils, as they possess the required fertility and contain seeds and spores for the early development of profuse vegetation and animalcula. Ponds located in such soil will maintain their water levels with a minimum inflow.

Satisfaction may be had from ponds less favorably located, however, if good sense is employed in their preparation and maintenance. Aside from the ideal lands of alluvial deposits, clay loams are a first choice, being most nearly impervious to water and quickly responsive to efforts made to establish their fertility. Sandy loam, being the most prevalent, is probably the most general soil in use for pond construction. While some difficulty may at first be experienced in making it retain water, this is overcome in time by the accumulation of decayed vegetation. Its fertility is good and, in general, it produces a sufficient supply of natural food. Even clear sand and gravel mixtures may be made to hold water and brought to fair productivity by increased expenditures in construction, and by the application of fertilizers in a manner to be explained later.

It is very desirable, and also essential for a marked degree of success, that ponds be so located and constructed that they may be entirely emptied of water at certain seasons. To this end there should be accessible a natural dry run or water course lower than the bottom of the proposed pond, to which drain pipes may be conducted.

Ponds are drained for the purpose of assorting fish, removing objectionable species, reducing the stock, killing out excessive vegetation, etc. Complete drainage can not be effected, of course, unless

there are adjacent waters to which the fish can be removed during this process. A number of small auxiliary ponds will always be found advantageous in fish-cultural work.

Where the primary purpose is other than fish culture the selection of the site must depend upon the more important object in view. Fish culture will yield very satisfactory returns as a secondary enterprise, but the site selected for the work should by all means be the best available consistent with the general scheme of farming operations.

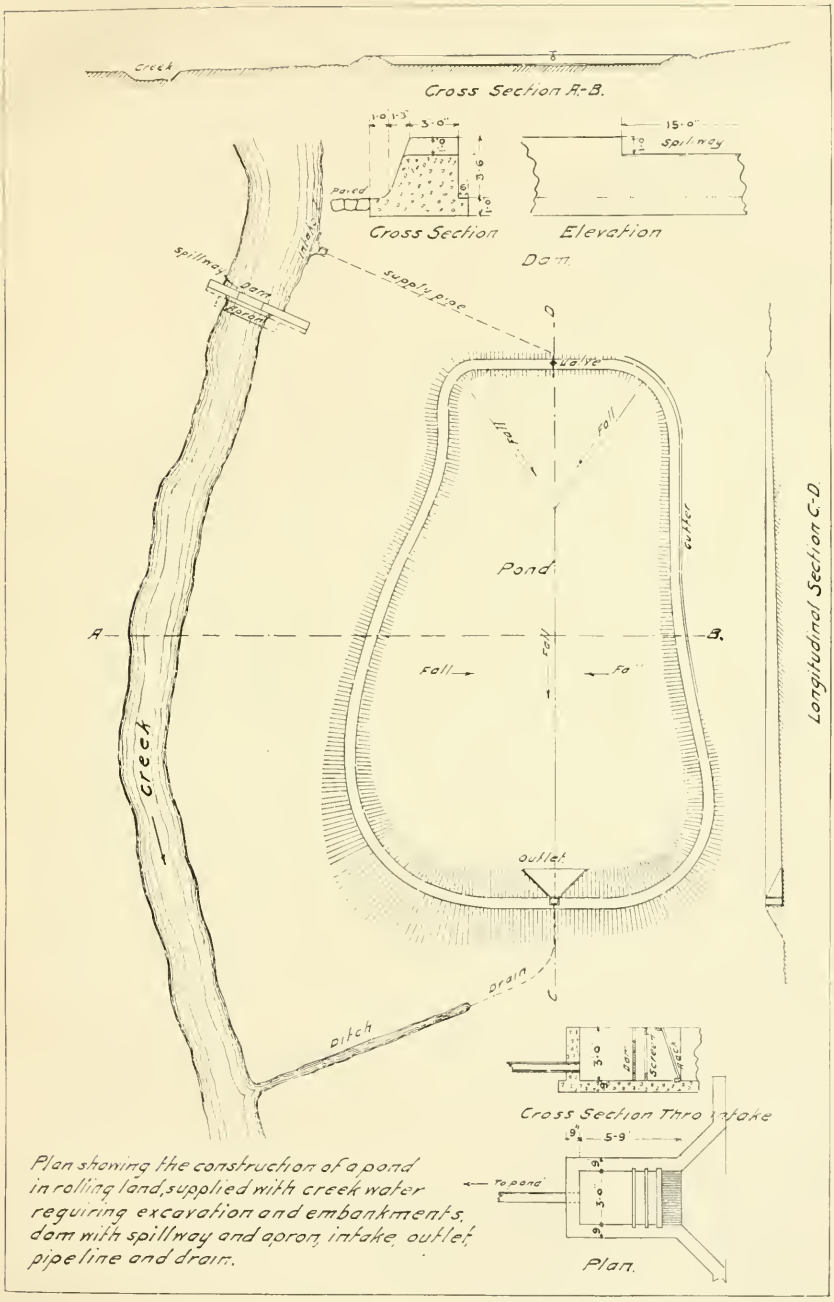
## POND CONSTRUCTION.

The exact mode of construction must depend largely upon local conditions, such as the presence or absence of favorable land contour, the nature of the soil, proximity to storm channels, and the area of the ground to be worked. Even with these features specified lesser local characteristics and the exigencies of individual circumstances will vary the application of any approved general method. Where practicable ponds should be not less than 1 acre in surface area. Those of smaller extent will produce fish and add an interesting feature to farm life, but they will not yield adult food fishes of the larger species in quantities sufficient for the requirement of the average farmer's table.

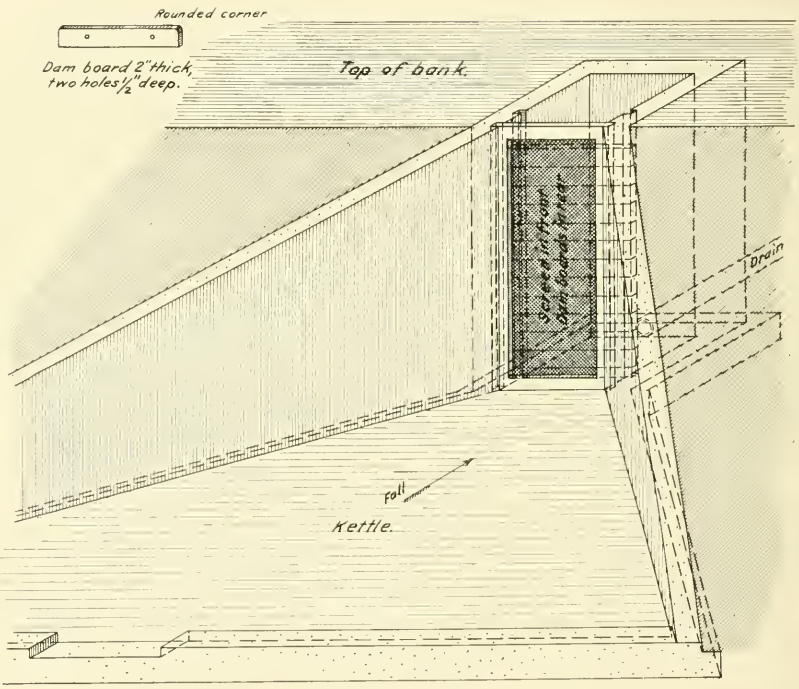
Natural draws or ravines involve the least expenditure in their adaptation to fish ponds, as two and frequently three sides are already formed, so that an earthen embankment connecting them will complete the inclosure. Such locations must be surrounded by ditches to divert surface water where that is likely to roil the pond, and effective waste channels should be provided if the site covers the natural course of flood waters.

If flat land of an elevation only slightly lower than that of the source of water supply is selected, it will be necessary to excavate the ponds in whole or in part to the required depth to insure a water level lower than the supply. Thus the excavations will form solid banks which, if impervious to water and properly sloped, will require no further attention except to bring them to uniform widths and elevation, which can be done with the material excavated in forming the pond proper. The bottom of the pond should be shaped to drain to a central point.

On swamp lands and depressions which are susceptible to drainage and are at the same time low enough to insure a gravity flow of water from the source of supply, one or more fish ponds can be constructed by the erection of longitudinal and cross-section dikes high enough to provide the required depth of water. The construction of such ponds involves only sufficient excavating to give the bottom the proper slope. In other words, the pond should be built up rather than




Plan showing the construction of a pond in rolling land, supplied with creek water requiring excavation and embankments, dam with spillway and apron, intake, outlet, pipe line and drain.




Pond Outlet of Cement.

Outlet made of wood is similar in construction to that of concrete, requiring driven posts under same to secure it and suitable cleats to hold screen and dam boards

excavated, and the water level therein will be higher than the surrounding land.

The method of constructing pond embankments is governed by the topography of the land, the character of the soil, and the volume and pressure of the water to be confined. All made embankments should be at least 6 feet wide at the top, and the sides sloped not less than 2 feet to each foot in height. For instance, a 6-foot fill should be 30 feet wide at the base and 6 feet at the top.

Prepare the foundation by plowing the site of the embankment, after first removing all trees, underbrush, rock and sod, and, as an extra precaution against seepage, dig a trench 12 inches deep along the median line. This will form a break, or set-off, between the original ground and the made construction, which is a point of natural weakness. The filling should progress by layers over the full width and length of the levee as a continuous operation rather than by sections; otherwise the completed work will later develop checks by reason of variations in material and compactness. Rocks are of use as a protecting riprap on the slopes after completion.

In case the water supply to a pond is taken from a creek, the latter must be dammed and an intake built above the construction provided with screen and dam boards, from which a water conduit must be laid to the pond. The dam should be provided with an ample spillway, which may best be constructed of concrete.

The shape or outline of the pond is immaterial. Currents of water are undesirable in the propagation of the spiny-rayed fishes. In fact, the best brood and rearing ponds are those which are supplied by backwater from other bodies, and if there is reasonable depth and a fair growth of vegetation no stagnation will result.

Success in pond fish culture is being attained with widely varying forms of construction. To a considerable extent fish will adapt themselves to existing physical conditions. In nature they seek comparatively shoal waters in which to spawn, by reason of the prevailing higher temperatures, and during certain stages of their growth the young choose similar depths, where food is plentiful and beyond the bounds of the customary range of large fish. Relatively deep waters must be accessible to the stock fish during winter months, and what this depth shall be will depend largely upon the latitude of the location; cold climates where great thickness of ice forms require the deepest pools.

Experience teaches that breeding ponds should be excavated to hold not less than 12 inches of water at or near the margins; that one-fourth of the pond area should range from 12 to 30 inches in depth; and that one-half its total area should be not over 3 feet deep, the bottom of the remainder to slope from this depth to 6 feet or more at the outlet. Avoid abrupt slopes. Provide complete drain-

age to the deepest point, where a waste pipe controlled by gates or slash boards should lead to outside natural channels.

It will be found a great convenience when draining ponds to have shallow channels 6 inches deep and 15 inches wide, at the head of the drainpipe, radiating to all parts of the pond bottom from a kettle or pit, which may be of wood or concrete. A large percentage of the fish will follow such channels as the water recedes, and may be removed from the kettle with less danger of injury than if picked up promiscuously about the pond.

Remove all projections from the pond bottom which might interfere with the operations of seines, plow the entire bed and level it with harrows before turning in the water or treating further for water-tightness.

As stated above, ponds located on swamp bottoms or in clay soils are practically impervious to seepage, and there should be no difficulty in maintaining their surface levels. Sandy loams are more uncertain; they require time to become thoroughly saturated, but will improve in this respect from year to year, through the accumulating deposits of decaying vegetation. It is an excellent practice when first filling newly-constructed ponds with water, whatever the nature of the soil, to follow the advancing water line with a drag or harrow, driving the team knee-deep into the water. The constant roiling and puddling of the ground in this manner is very effective in cementing open cracks and crevices. Very porous soils may require the addition of a layer of clay before they will hold water. From 2 to 6 inches of stiff brick clay over the entire bottom and up the sides, well above the water line, the bottom harrowed down as explained above, will hold water over the most open ground likely to be used. The only objection to the presence of clay is its general sterility, but this may be corrected by another layer of rich loam, after the clay has been worked down and proved efficacious. Where this process is to be employed, allowance must be made at the time of excavation for the refill of 12 or more inches. Coarse stable manure, and even clean straw, well trampled into the pond bottom, has been reported as a successful remedy for seepage.

A good set of native sod or sedge grass around the entire pond at the water line is the best preventive of wave washing and encroachments upon new fills. If the location is such that strong currents or eddies are present, piling, rock riprap, or other reinforcement, will be necessary at the points of greatest exposure.

Landowners desiring to undertake fish propagation may feel that the expenditure necessary to secure completed ponds, as described above, is prohibitive; or they may have waters available for fish culture which it would not be expedient to remodel along the lines indicated. The plans outlined are in accordance with the present-

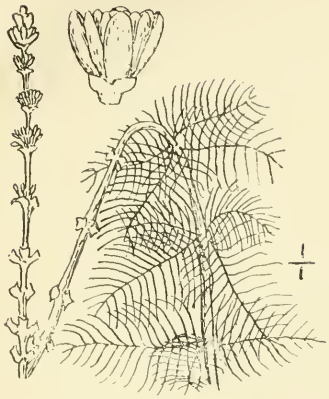



FIG. 1.—Spiked water milfoil (*Myriophyllum spicatum*). Found in deep water. Newfoundland to Manitoba and the Northwest Territory, south to Florida, Iowa, Utah, and California. Commonly known as foxtail. Suited to southern ponds of high temperature, and unlike most species will thrive in comparatively soft waters. "Parrot-feather," and introduced species of *Myriophyllum* will make better growth in sterile ground than the foxtail; otherwise the two have similar characteristics.

FIG. 3.—Fanwort (*Cabomba carolinianum*). Found in ponds and slow streams, southern Illinois to North Carolina, south to Florida and Texas. Characteristics similar to Ceratophyllum.

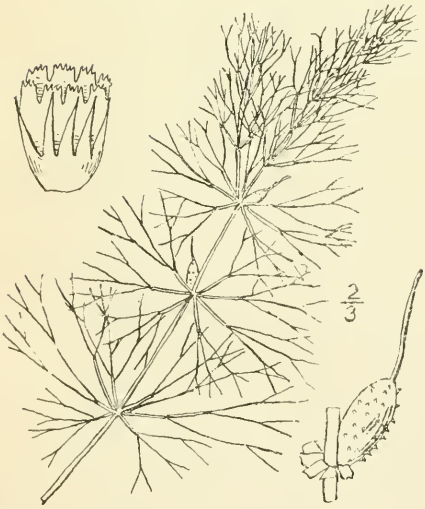
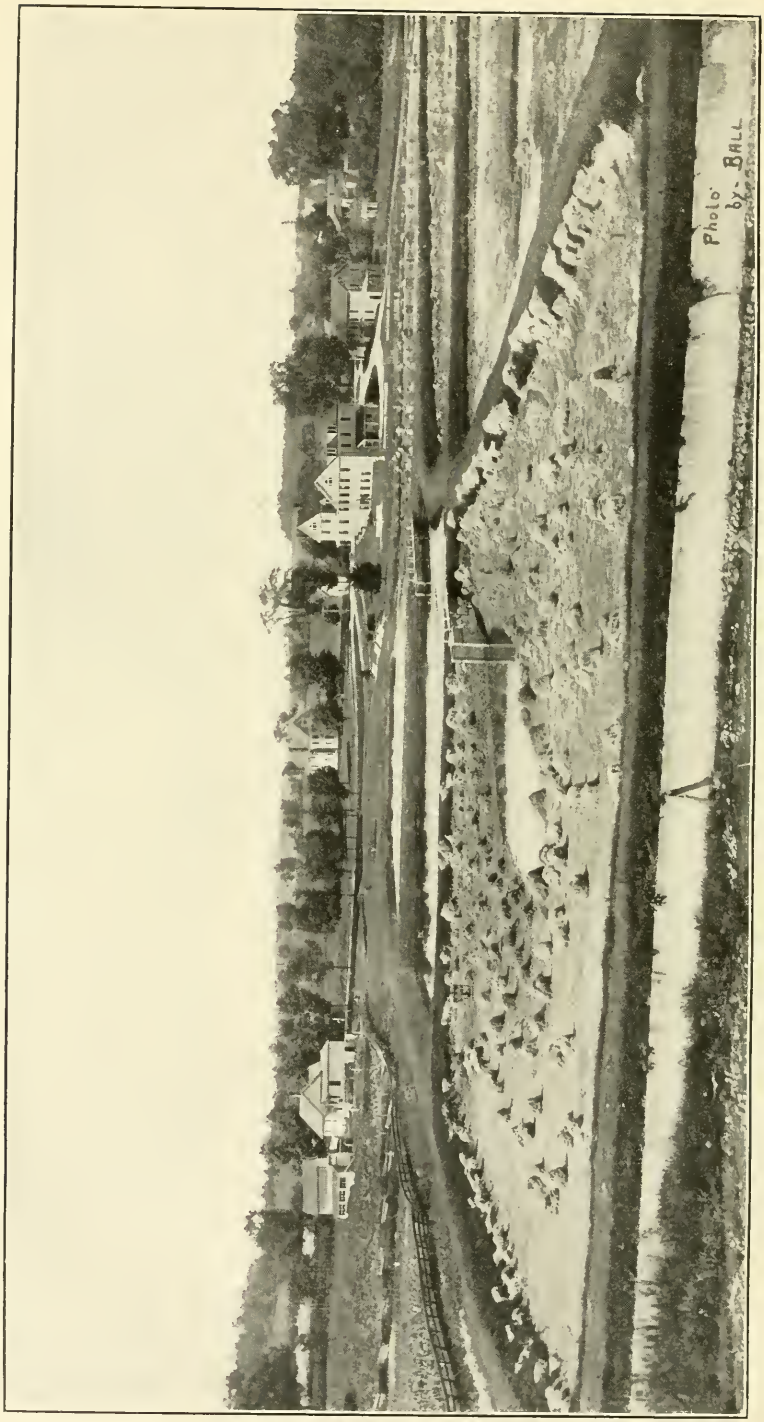



FIG. 2.—Hornwort (*Ceratophyllum demersum*). Found in ponds and slow streams throughout North America, except extreme north. This plant is shallow-rooted, deriving most of its sustenance from the water. Will thrive in cold spring water.

FIG. 4.—*Chara fragillis*. A common form of chara. There are many varieties of this species and all are classed very high as food producers and oxygenators. Grows profusely in all limestone waters throughout the United States,




PONDS AT NORTHVILLE, MICH., STATION AFTER WATER HAS BEEN DRAWN OFF AND THE CHARA RAKED INTO PILES.

day standards. Fish may and are being successfully propagated in far less ideal environments, but more native ingenuity in such cases is required. This, however, is a common attribute of the American farmer, and any one who can mix balanced feeds, practice scientific grain breeding, or master the intricacies of modern farm machinery, need not hesitate for fear of failure to add fish culture to his daily routine.

Summarizing the construction, these features should be provided for:

1. Water-tightness, so that a small inflow will be sufficient. This will result in high temperatures during the summer months.

2. A shallow area, from 18 to 30 inches deep, where the fish may nest.

3. A deeper area, of 6 feet or more, for winter quarters. This will also be occupied by the adults in the summer, after nesting is completed.

4. A fertile bottom for the growth of aquatic plants, upon which fish food depends.

If these requisites, together with a suitable water supply, are provided the fish will thrive.

The accompanying drawings explain the types of intake and drainage devices which have proved effective. These may be varied to meet the conditions encountered, and be constructed of either wood or concrete. The latter material is shown in the illustrations, and is the most durable, but wood will be equally as satisfactory while it lasts.

## AQUATIC PLANTS AND THEIR VALUE IN POND-FISH CULTURE.

Frequent reference has been made to the necessity of vegetation in fish ponds. Its advantages are many. It serves as food and a harbor for the lowest forms of minute animal life. Each advance in the scale of life constitutes a food for higher forms, and in the guise of fish the fertility of the ground contributes to the food of the human race.

Plants play an important part in the purification of water, taking up the carbonic acid gas liberated by decomposition and exhaling the oxygen essential to living creatures. They thus prevent the asphyxiation of fish life, and act as a corrective of many abnormal characteristics of individual waters.

Losses of fish through the depredations of enemies will be greatly lessened where there is an abundant aquatic growth in which they may hide. It furnishes a grateful shade on bright warm days, and the interlacing roots so bind the bottom soil as to prevent turbidity from casual disturbances.

The aquatic flora of a locality varies greatly with its latitude and is also governed by the chemical ingredients of specific waters. The most desirable species usually thrive best in waters of limestone

origin. Plants of filamentous character are preferable to the large regular-leaved kinds, as they present greater surface expanse for the exchange of gases, and, on account of their shallow rootage, are more readily controlled by the fish-culturist. Pond lilies, cat's-tail, and coarse water grasses or weeds in moderation are beneficial, as they afford shade and shelter. However, they are lower forms of oxygenators than the plants of finer growth, and they make seining operations more difficult; and it is practically impossible to eradicate them after they have obtained a foothold.

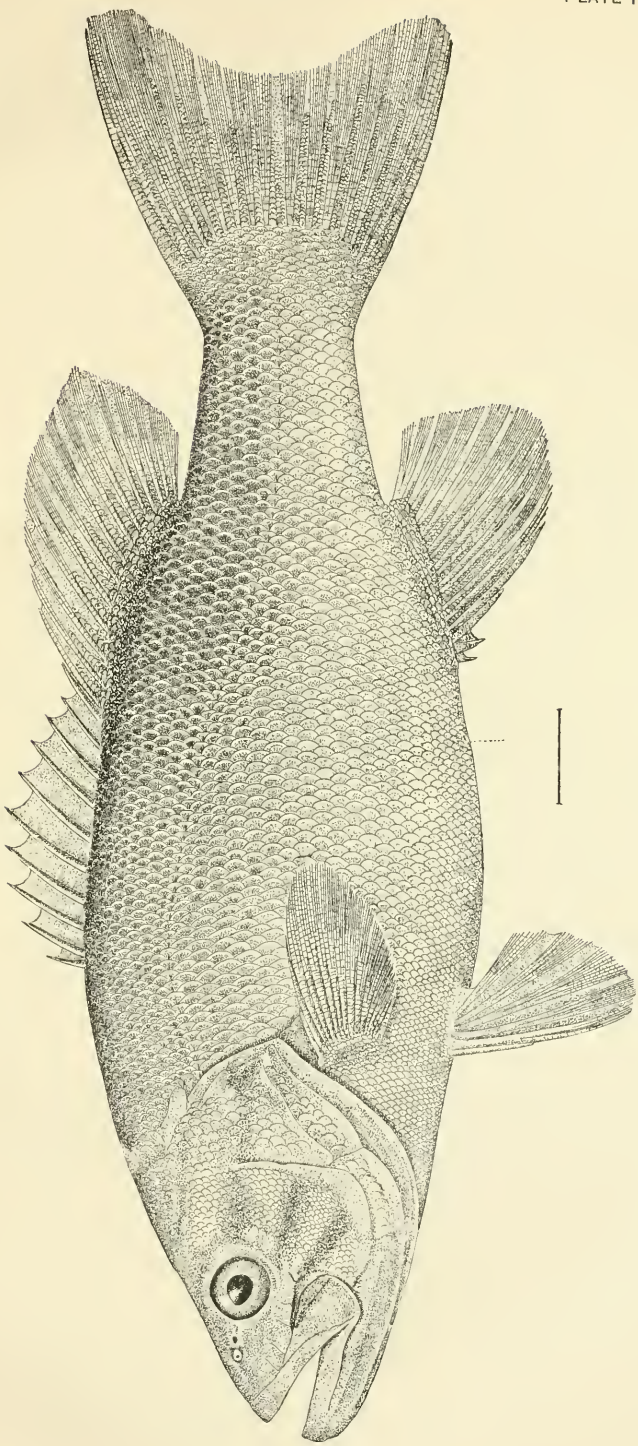
All species herein described which are indigenous to the waters of the locality in question may be advantageously utilized in pond-fish culture. Undoubtedly one or two of the introduced species will eventually drive out the others, but those remaining will be the ones best adapted to the environment. All of these will grow from cuttings, making it unnecessary to transplant the roots. The plants may simply be raked or pulled out of the open waters and pressed by handfuls into the soft earth in the shallow sections of the new pond, in spaces about 5 feet apart. The bottom must be covered with 6 to 12 inches of water during the operation, otherwise the sun and air will soon ruin the sets. In deep water the plants may be started by attaching a weight and sinking them to the bottom of the pond.

Much time and trouble are often required to bring about a profuse growth of aquatic vegetation,[a] but after a pond is thoroughly stocked even more labor is required to keep it within bounds. Ponds may become literally choked with water mosses, resulting in inconvenience to the owner and a detriment to the fish. They will roll the seines, snag the lines, and smother the fish when an attempt is made to draw down the water. It will usually be necessary to thin the moss out once or twice in the course of a summer, and all growth should be removed when draining the pond. An efficient method of removal is by raking, the worker standing on the embankment and throwing the moss out on land, or wading into the shallow water of the pond drawing it from a circle about him and building cocks of it. The deeper waters will have to be worked from a boat or raft.

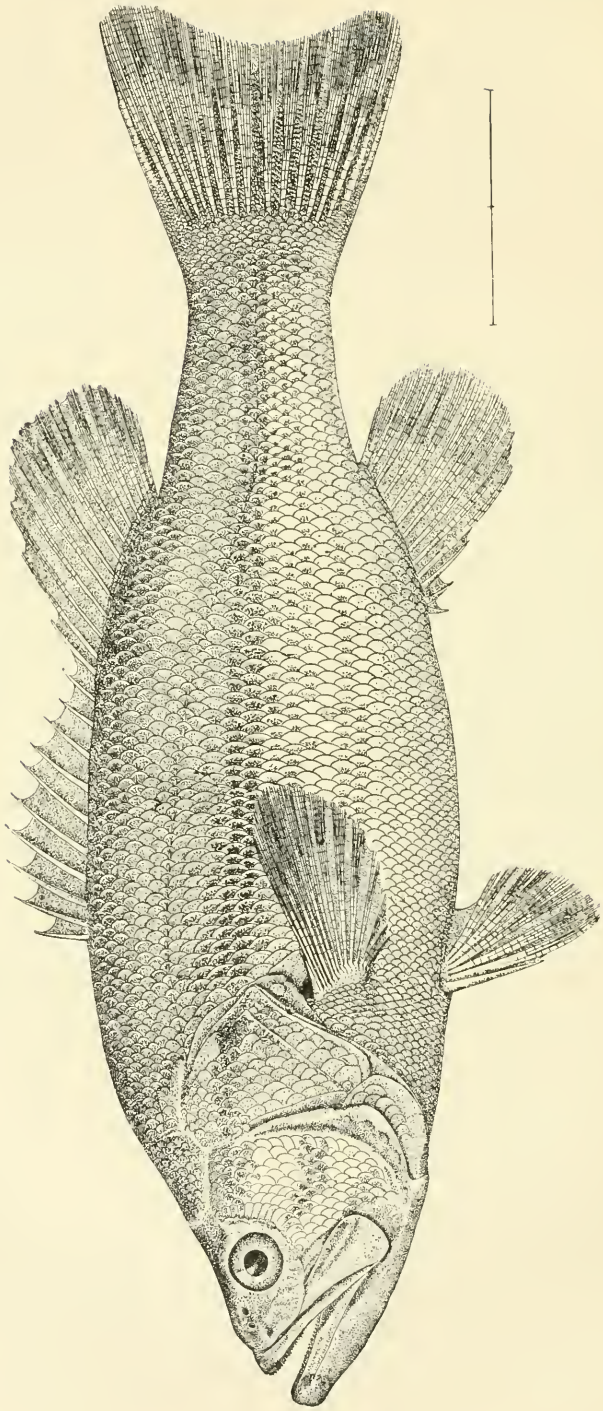
## SPECIES OF FISHES SUITABLE FOR POND CULTURE.

Smallmouth black bass (*Micropterus dolomieu*).—Indigenous to lakes, rivers, and smaller streams from Lake Champlain to Manitoba and south to North Carolina and Arkansas. It seeks by preference the clear cool waters of its range, and in the Southern States is confined to the more rapid streams. The maximum weight is about 5 pounds, and the average weight from 1 to 2 pounds. This species should be selected for cultivation only in ponds of 2 or more acres

[a] All but one of the cuts published herewith are copied from Britton & Brown's "Illustrated Flora of North America." The figure of *Chara* is taken from the "Text Book of Botany," by Strasburger, Noll, Schenk, and Schimper.



SMALLMOUTH BLACK BASS.



LARGEMOUTH BLACK BASS.

in area, where the temperatures and other physical characteristics conform to those of its natural habitat. Rock bass and sunfish will live congenially with the smallmouth black bass, and can be successfully propagated in the same ponds with them.

Largemouth black bass (*Micropterus salmoides*).—Known locally as straw bass, green bass, bayou bass, Oswego bass, trout, and chub. Its range is from Canada to the Gulf of Mexico and from the Atlantic coast to the Rocky Mountains. The species is prolific in congenial waters, but reaches its greatest size in the warmer lakes and more sluggish streams of the South. Its maximum weight is authentically stated to be from 20 to 25 pounds, though in most localities it does not exceed a weight of 6 pounds, and the average is probably less than 3 pounds.

Because of their size and cannibalistic tendencies the two species of black bass should be selected only for ponds not less than 2 acres in area. The largemouth species is equally well adapted to cultivation in northern or southern climates, but its cultivation in the former should be restricted to waters attaining maximum temperatures. Crappie, sunfish, and warmouth bass are suitable species to introduce in waters with the largemouth bass.

The two black basses are frequently confounded, but they have contrasting marks of distinction, which vary somewhat with their environment. They may be reliably classified by the number of rows of scales on the check, the largemouth possessing 10 and the smallmouth 17 rows. The mouth of the former species extends back of the eye, and that of the smallmouth even with the anterior margin of the eye.

Crappie (*Pomoxis annularis*).—Commonly called bachelor, campbellite, new light, sac-a-lait, tinmouth, crapet, and chinquapin. Its range is from New York and Vermont westward through the Great Lakes region and the Mississippi Valley to the Dakotas, and south to Texas. It inhabits sluggish muddy water and reaches a length of 1 foot in its most southerly range. The crappie is an excellent pan fish and should be generally cultivated where conditions are favorable. It is an extremely delicate fish to handle, its protruding eyes being easily injured and frequently blinded when constantly exposed to direct sunlight in clear water. In ponds devoted primarily to the propagation of crappie many fish-culturists introduce carp, suckers, or other bottom feeders, as the resulting turbid water seems to be a favorable condition for them. The natural habitat of the crappie suggests its suitability for ponds containing largemouth black bass or catfish, where the water supply is drawn from turbid streams or furnished by surface drainage.

Calico bass (*Pomoxis sparoides*).—Also known as strawberry bass, grass bass, and barfish. Is abundant in the Great Lakes region and

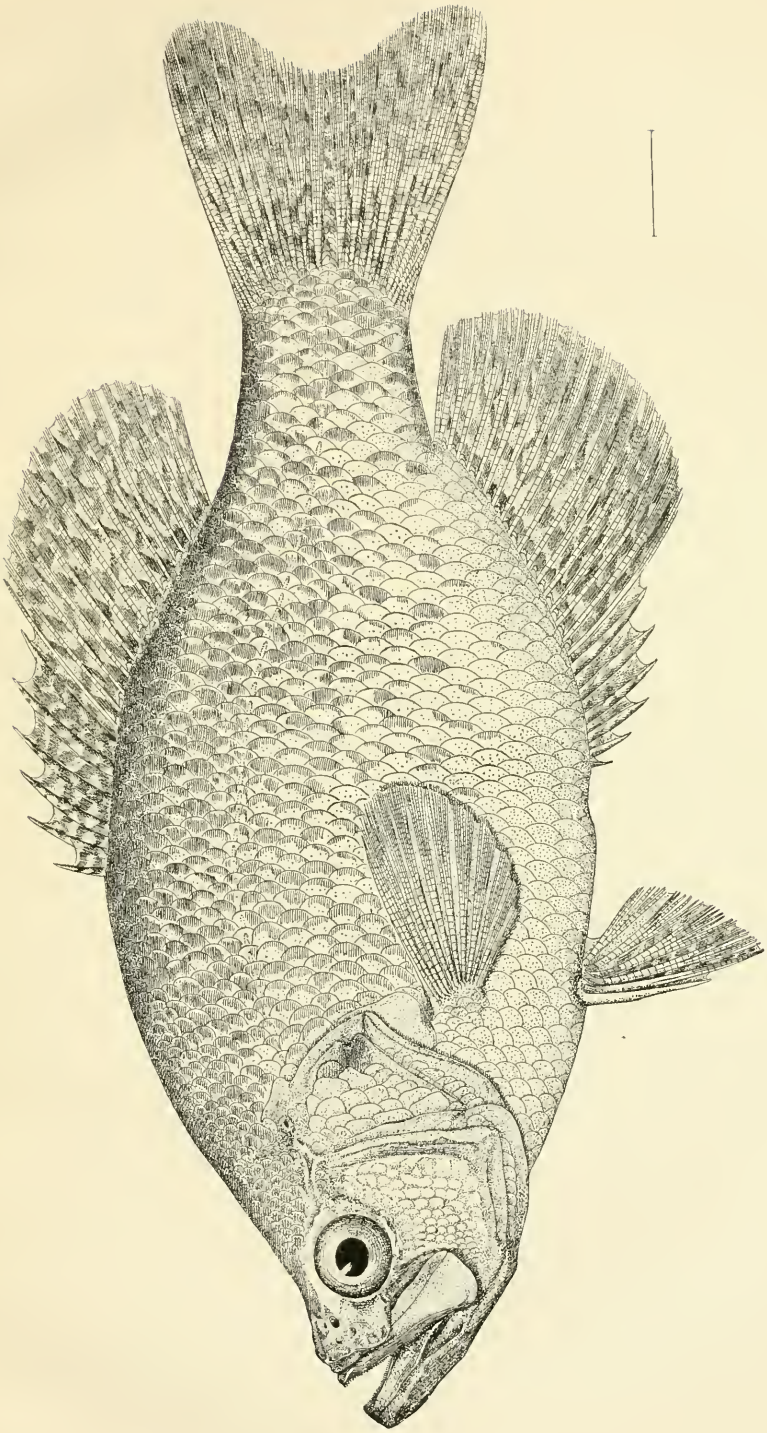
the upper Mississippi Valley, with extreme range east to New Jersey and south to Texas. It very much resembles the crappie, but is hardier in every respect and better adapted to pond culture. It may be distinguished from the crappie by the presence of 7 or 8 spines in the dorsal fin, where the crappie has but 5 or 6. It will thrive in company with any of the pond species that are suited to relatively high temperatures.

Rock bass (*Ambloplites rupestris*).—Colloquially termed red-eye and goggle-eye. This species is found in lakes and streams from New England to Manitoba and south to Louisiana and Texas, being particularly abundant in the cooler lakes and streams of the upper Mississippi Valley. It inhabits by choice only clear, cool waters, and is therefore less thrifty in its southern range. The rock bass has been known to attain a weight of 1½ pounds and a length of 12 inches, but the average specimen probably does not exceed a weight of one-half pound or a length of 7 inches. Fish of this species are well suited for introduction into spring-fed ponds with the smallmouth black bass.

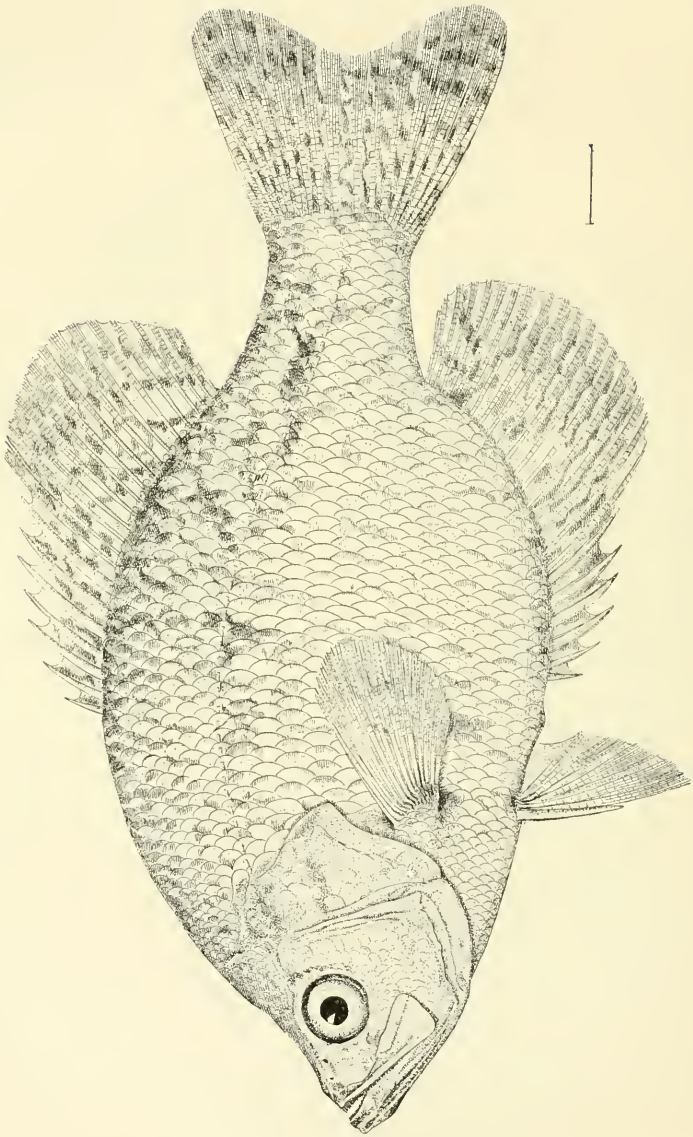
Warmouth bass (*Chænobryttus gulosus*).—Is often confused with the rock bass. It has very much the same range and similar general characteristics, but is better adapted to waters of a high temperature, and is therefore most abundant in the South. The two species may be distinguished by the three oblique dark stripes radiating backward from the eye in the warmouth bass and by the rather indistinct vertical stripes on the body of the rock bass. The warmouth bass may be propagated in conjunction with the largemouth black bass or in small ponds with the crappie and sunfish.

Sunfish (*Lepomis incisor*).—Locally termed bluegill, blue sunfish, copper-nosed bream, dollardee, and blue bream. Of the many species of sunfishes distributed throughout the United States east of the Rocky Mountains, this is the only one that can be recommended by the Bureau of Fisheries as worthy of artificial propagation, and it is believed to be the finest pond fish available for private culture. It is adapted to practically all conditions, is prolific, and of unsurpassed table qualities. The largest specimens will measure from 12 to 14 inches in length and attain a weight of nearly a pound. The bluegill may be propagated in connection with any of the other species listed above.

Catfish (*Ameiurus nebulosus*).—Locally known as bullhead, horned pout, Schuylkill cat, small yellow cat, and the subspecies *Ameiurus nebulosus marmoratus*, known in the South as marble cat. This is the only member of the catfish family that has so far been propagated in ponds. It is distinct from the genus *Ictalurus*, which embraces the larger catfishes—blue cat, channel cat, forked-tail cat, and spotted cat. Many attempts have



CRAPPIE.



CALICO BASS.

been made to propagate these latter species, but without success. They seem to require some element not found in still waters. The bullhead is abundant in all ponds, lakes, and sluggish streams of the eastern United States and the Mississippi Valley region. It adapts itself to widely varying conditions and demands less expensive preparation for its cultivation than any of the other fishes considered. The bullhead is the most easily domesticated of any of the pond fishes. Its appearance is formidable and repugnant to some, but when propagated in comparatively pure water it is very palatable. It may be cultivated in connection with any of the warm-water species referred to, and is particularly suited to the changing conditions of drainage-fed ponds.

## NATURAL AND ARTIFICIAL FISH FOODS.

As with all forms of live stock, it is essential that brood fish be kept in a thrifty condition. Good food, proper shelter, ventilation, and exercise—familiar requirements to the farmer—have their equivalents in the food, physical characteristics of the pond, composition and aeration of the water, and the amount of space allotted to a given number of fish. Common sense, based upon observation of natural laws, will carry the fish-culturist a long way toward success.

All the fishes recommended for pond culture are naturally carnivorous, choosing live food through preference. Their predatory instinct in this respect can not be catered to exclusively where their culture is undertaken on an extensive scale, but the closer it is adhered to the better will be the results. It would be detrimental to the ultimate object in view to feed them live predaceous species of minnows, for those that were not devoured would prey upon the young of the species being propagated, and eventually, the minnow offspring would monopolize the vital resources of the water. The smaller minnows, with sucker-like mouths, may be advantageously liberated in the pond as food; for this purpose many fish-culturists utilize goldfish, which are herbivorous feeders and scavengers, and which, in limited numbers, do not materially lessen the supply of natural food available for the game fishes. Large numbers of goldfish would work injury through the destruction of aquatic plants, but if held in subjection the young goldfish constitute a superior food, and any that escape this destiny have a commercial value in their ornamental colorings.

Frogs, worms, and flying insects all contribute to the food supply of the brood fish, likewise the larger aquatic insects inhabiting the water. If not overstocked, therefore, the average pond may be managed so that it will furnish all the live food necessary for the adult fish. Where this is insufficient to properly maintain the stock,

however, it may be supplemented by meat or, preferably, coarse fish, which should be cut in pieces small enough to be readily swallowed. Wild stock will refuse to accept this food until near the starvation point. Some will never do it, but the majority show such greediness for the substitute food, after having once tasted it, that they will follow the attendant about the pond whenever he appears.

Fresh livers and hearts are the materials most commonly used where a meat diet is employed, being the cheapest good materials obtainable; fresh fish is a more natural food, however. If the farmer is located within a reasonable distance of a fish market, arrangements can usually be made for regular deliveries of species having little or no commercial value, such as are incidentally taken by the fishermen in seining. If the magnitude of the operations will warrant, it is advisable to devote one pond to the propagation of carp for the sole purpose of producing food for the game fishes. Carp feed on vegetation and large numbers of them may be reared on a farm at little expense.

The amount of food required must be governed by the appetite of the fish. They should be given all they show eagerness for once a day. During the nesting season and the cold months practically no food is required, but especial care should be taken to feed them well both before and after the spawning period.

Crappie can rarely be taught to take artificial food, but fortunately it is seldom necessary to feed them or the breeders of other small species adapted to pond culture—the sunfishes and the rock bass. Catfish quickly learn the lesson and will consume with avidity raw or cooked meats, vegetables, and even hard grains.

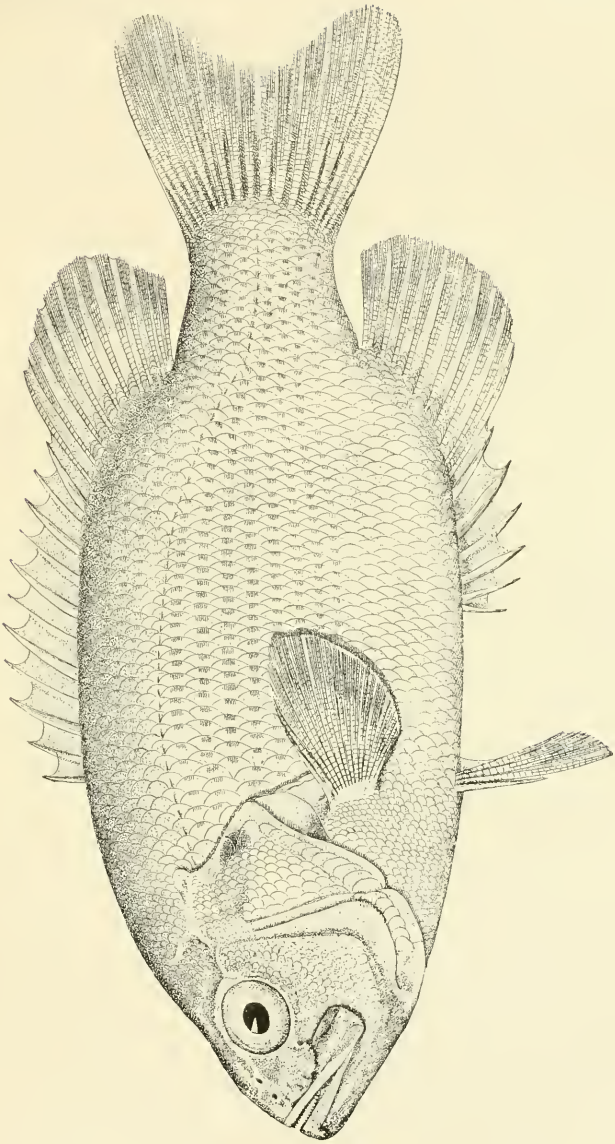
## DISEASES.

There are no diseases of pond fishes that can be successfully combated by artificial means. A well-fed fish is usually a healthy fish, whereas thin specimens are wanting in resistance to their habitual parasites and can not readily recover from external injuries. If they are fed well on as nearly appropriate foods as can be secured and are carried in ponds of natural characteristics, sickness will be of rare occurrence.

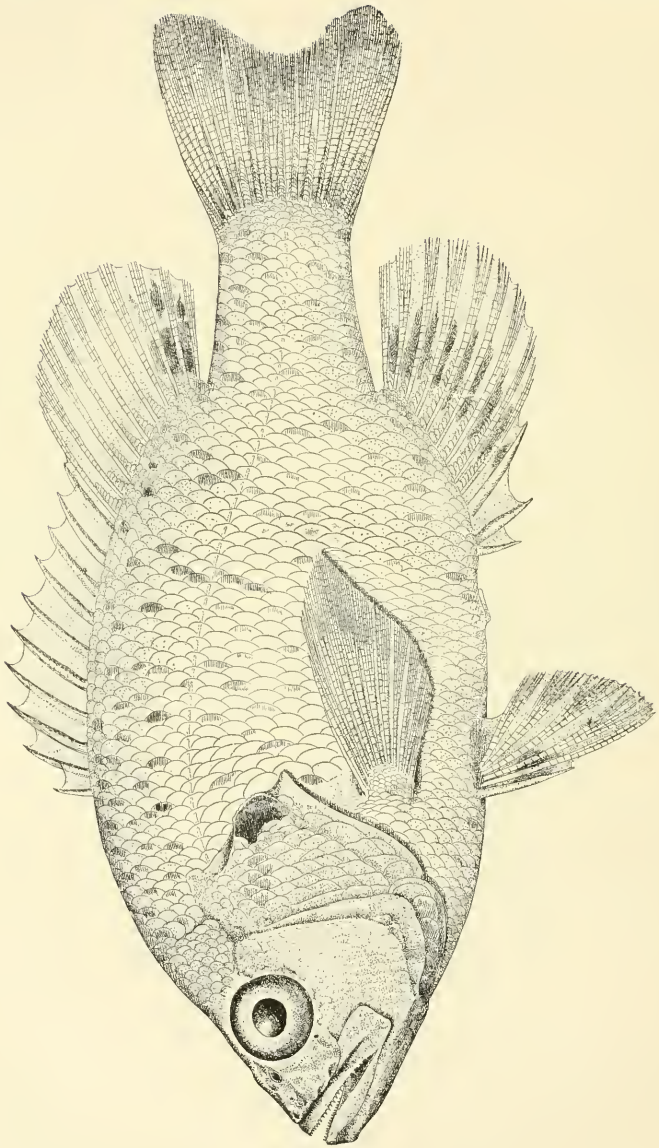
## STOCKING PONDS WITH BROOD FISH.

The most successful and the speediest results in pond culture are attainable by the use of adult fish for the original brood stock. These can in most cases be secured from the public waters of the immediate locality during the open season prescribed by the State laws.

It is such a common failing to want something new and strange that many prospective fish-culturists endeavor to procure some species



ROCK BASS.



WARMOUTH BASS.

of fish that is foreign to their community with which to begin their operations. To illustrate some of the impractical ideas entertained, the Bureau of Fisheries is often asked to furnish the species of trout indigenous to the Great Lakes for stocking southern waters, or the flounder (a salt-water fish) for introduction into the ponds in the interior.

In general it may be assumed that the species which is the most prolific in the public waters of the region in question will be the likeliest to produce material results, and by procuring adult fish for breeders the pond in which they are placed should become stocked to its maximum capacity within a year. On the other hand, if State or Federal aid is relied upon only a limited number of fingerling or, at best, yearling fish will be available for beginning operations, and it will require from two to three years for them to mature and stock the ponds through natural reproduction.

The wisest course, then, will be to choose some native species and to make a persistent effort to secure adult specimens. This can best be done in the fall months, when the fish will more quickly recover from slight injuries which, during a period of high temperature, might develop into ugly sores and possibly kill them.

Fish hooked only in the mouth are in no way harmed for breeders, but the greatest precaution must be taken in holding them and in transporting them to the pond. Loosening or rubbing off of scales induces a fungus growth which will eventually spread over the body and result fatally. As the fish are captured they may be placed in buckets or tubs, which may be darkened by throwing an old blanket or carpet over the top. In changing the water, which should be done as often as the fish seem to require it, care should be taken not to excite them. When the fish are to be held for several days before they can be transferred to the pond, it is advisable to excavate a shallow basin at the margin of the lake or river where the collection is being made and arrange for a moderate flow of water from the main body through its entire length. A pool of running water 6 feet long, 3 feet wide, and from 12 to 18 inches deep will hold two or three dozen large fish with safety. Live boxes should not be used, as fish held in them will bruise themselves beyond recovery.

In conveying fish a considerable distance by rail or wagon, receptacles of such diameter that each specimen may lie at full length on the bottom should be provided. The depth of the water is a matter of less importance, but it should be kept at the proper temperature and well aerated. If necessary, ice may be used to maintain an even temperature corresponding to that from which the fish were taken; but if that be high and the distance to the pond great, it will be found easier to reduce the temperature to 65°, and gradually raise it

when nearing the destination to conform to that of the water in which the fish are to be liberated. During conveyance the water in the receptacles will be kept in motion and adequately aerated; but when standing still it must be artificially aerated by dipping out some water and pouring it back into the receptacle from a height.

The ordinary 10-gallon can is employed by the Bureau of Fisheries for the transportation of small fish, but if the fish are too long for its diameter nothing is better than wash boilers. Any clean receptacle may be used, but those mentioned are the most convenient to handle.

If the use of artificial food is not contemplated, the number of brood fish allotted to a pond must be apportioned to the natural food available for both the adults and the expected fry and fingerlings. Fifty of either species of black bass or 100 specimens of any of the smaller species are maximum numbers for an acre of water, where the offspring is to remain in the brood pond. These numbers should produce a much larger number of fry than the waters can sustain until mature, but allowance will have to be made for losses through cannibalism and the ordinary vicissitudes of their environment. Promiscuous collections of fish will invariably run about equally as to sex, and the numbers recommended will therefore give 25 and 50 pairs, respectively.

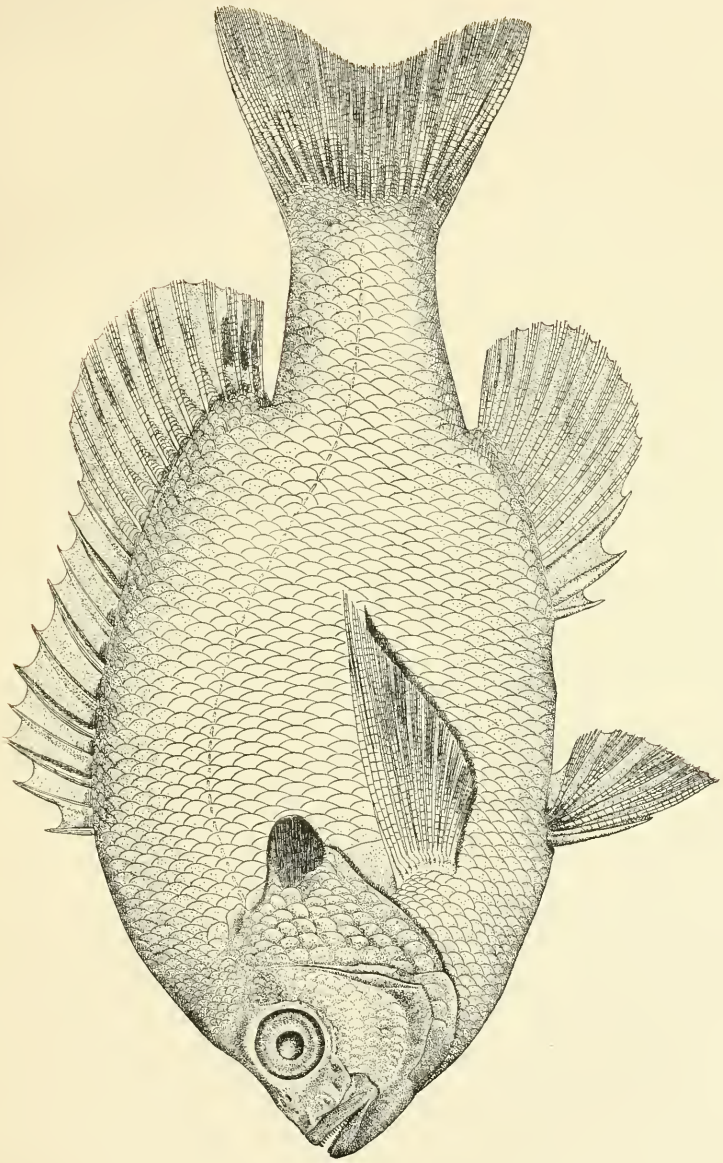
There are no external markings by which the sex of pond fishes can be positively determined, but the female black bass usually presents a more mottled appearance than the male and her colors are brighter.

## SPAWNING SEASON.

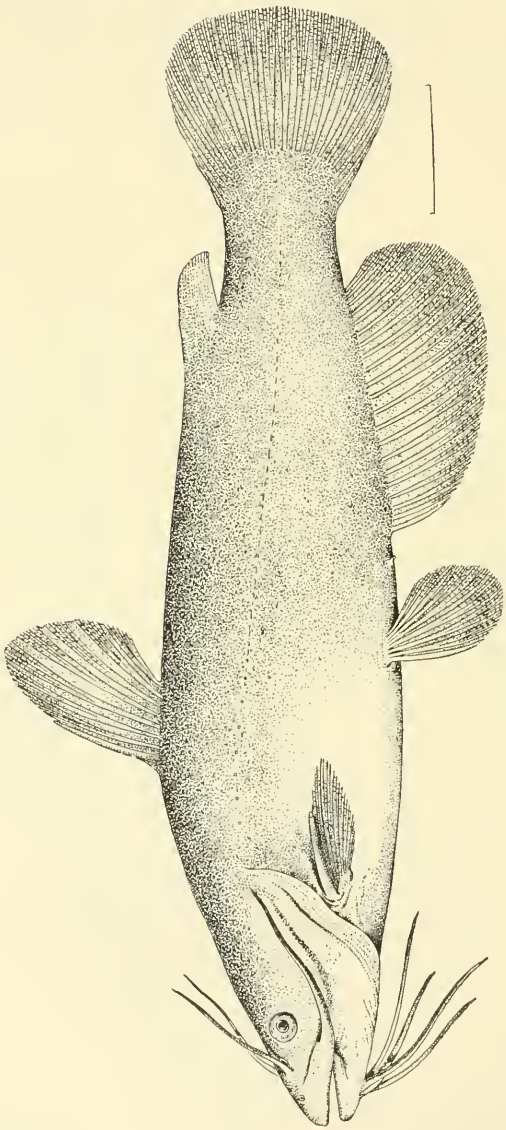
Black bass will nest in the spring when the water temperature rises above 60° F. Ordinarily 63° F. will bring about deposits of eggs, but if the season is a backward one, the fish may spawn at 58° F. On the other hand, an unusually advanced season may not bring results until the temperature exceeds 65° or 68° F.

Suitable temperatures for spawning prevail in the more southerly States as early as February; in the latitude of Tennessee, in March; in southern Illinois, during April; in Iowa, during May; and in northern Minnesota, in June. The spawning season extends over two or more weeks, and is usually marked by two periods of intense activity, following a rise in temperature after several days of abnormally cool weather. In the Southern States the nesting season is not so sharply defined, owing to the almost continuously favorable temperatures throughout the year, which cause rapid development of the ova. At the Texas station of the Bureau of Fisheries there regularly occurs a hatching period in February, one in April, and scattering hatches throughout the summer. The crappies, sunfishes, rock bass, and catfishes will spawn from one to two months later than

PLATE XV.



BLUEGILL SUNFISH.



CATFISH OR BULLHEAD.

the black bass in the same waters, and the sunfishes and rock bass will continue nesting to some extent until the approach of cool weather in the fall.

## SPAWNING HABITS.

Ordinarily ponds will require no special preparation for the spawning season. Some of the species choose the roots of water plants on which to spawn, while others seek out gravel spots and find them, however much they may be hidden by deposits of mud. Catfish burrow into embankments and under rocks and logs, and it is well to provide substitutes for such shelters where this species is being propagated, for which purpose heavy planks weighted to the bottom of the pond will be suitable and will offer the least impediment to seining operations later on.

With the right material at hand the male will prepare the nest to his precise taste and after its completion will seek a partner. There are many ups and downs in the domestic life of fishes, especially in the case of such pugnacious species as the black basses. The battles of the males for favorite females are liable to cause injuries resulting in death; or after being won, a consort may prove not sufficiently advanced in maturity, in which case the fish separate and the male continues his search for a more congenial mate.

Actual spawning will extend over several hours, the eggs being emitted and fertilized at varying intervals.

All the eggs carried by a female may not be ripe at one time, and the male will repeatedly seek new mates until the nest has been stocked to his satisfaction, driving each companion away when she ceases to perform the function for which she was obtained. The eggs are adhesive, and attach themselves to gravel, roots, or other material on the beds. The male remains on the nest during the entire period of incubation, fanning the eggs clean of sediment with a gentle motion of his fins and watchfully guarding against the encroachment of other fishes on his domain. He is the personification of valor at this time, and all other creatures in the pond apparently have the greatest respect for him. Nothing but the loss or death of the eggs from low temperatures, heavy deposits of sediment, or other adverse conditions will cause him to abandon his nest. Notwithstanding their ferocity, black bass will nest in close proximity to one another and attend to their respective parental duties in entire amity, whereas the approach of a strange fish will be resented.

Sunfish are decidedly gregarious during the spawning season and will locate their nests very closely together. With them all is harmony, the sole thought of each appearing to be centered upon his own particular business.

The crappies spawn in comparatively deep water on isolated nests. Owing to their color, the depth of the water, and its usual turbidity, but few observations have been made of their peculiar characteristics at this period.

Rock bass and warmouth bass deposit their eggs on gravel beds of greatly varying diameters, and their spawning instincts are somewhat similar to those of the black bass, though in a less marked degree.

By reason of their intrepidity at the time, all of the species referred to appear to be very tame while guarding their nests, but this instinct should not be presumed upon by permitting unnecessary disturbances about the beds.

The incubation period of eggs of the various pond fishes ranges from a few days to two weeks or more, depending upon the mean water temperature. A drop below 55° F. is invariably fatal, while the percentage of hatch below 58° F. is greatly reduced.

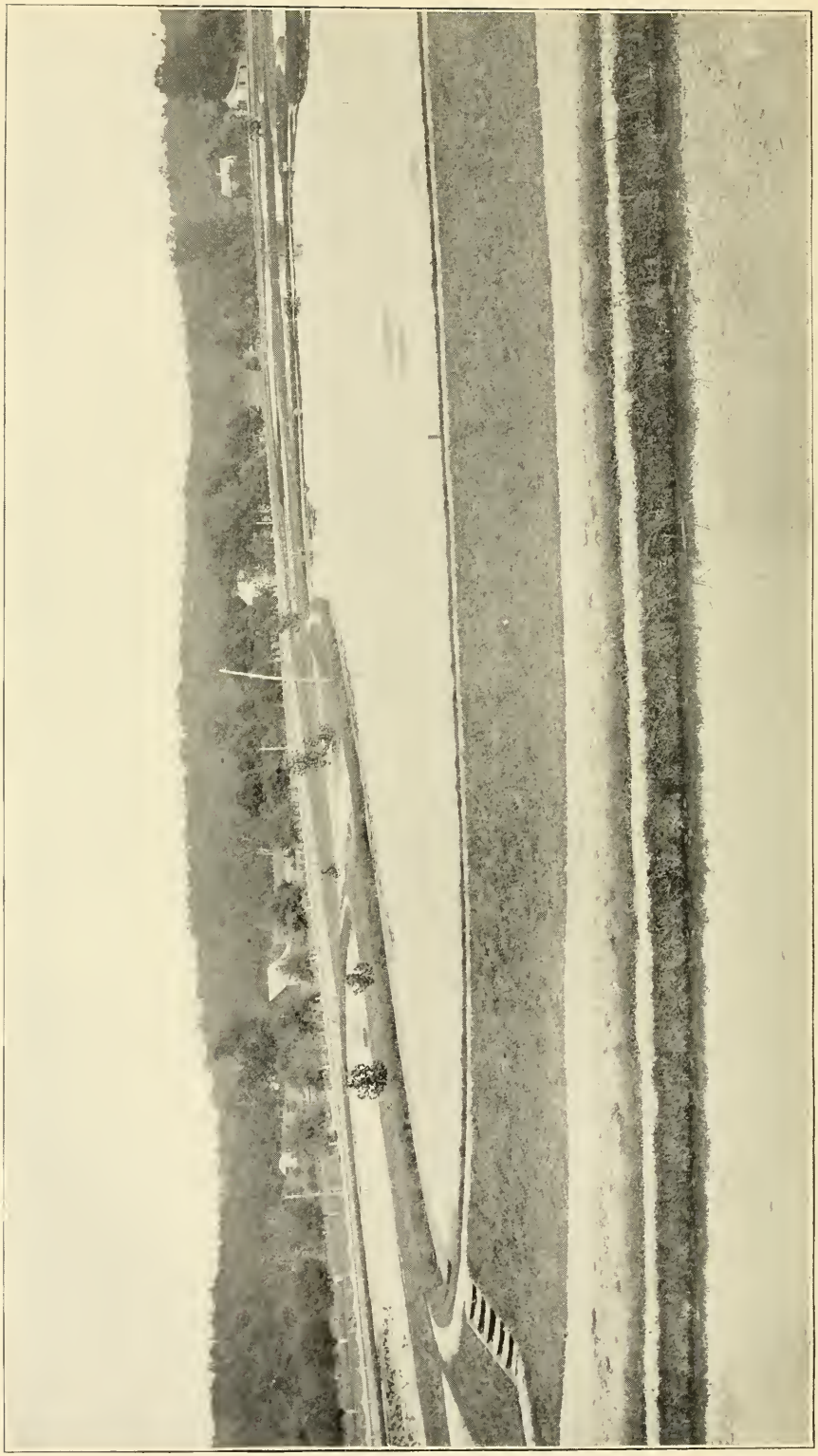
Under uniformly favorable conditions healthy eggs will hatch without any loss to speak of, but the average hatch of domesticated stock is not over 50 per cent. This, however, is a sufficiently large percentage to make pond-fish culture profitable.

## CHARACTERISTICS OF THE YOUNG FISH—THEIR FOOD AND GROWTH.

When first hatched the fry of most of these species are colorless, and because of their tendency to collect among the roots and in the crevices of the spawning beds are difficult to find. They become darker in a few days, however, and are easily distinguished. In a short time they rise a few inches off the bed during the day and return to the bottom at night, increasing the distance each day until they eventually reach the surface. During all this time the parent fish has given them the same sedulous attention as when they were in the egg stage. Gradually the school enlarges in circumference to such an extent that he has difficulty in keeping his brood together. He crowds them into shoal water—their natural feeding ground—and patrols the shore in an effort to ward off enemies, but they finally separate into small bands, escape the vigilance of their guardian, and become free lances in the strife for survival.

The largemouth black bass and catfish fry school much longer than the other species mentioned; in fact, catfish fry retain this gregarious tendency throughout the first year, while young black bass remain together until 2 inches or more in length.

Young sunfish and catfish are easily taught to take artificial food, when the natural food of the pond is insufficient for their nourishment. As with the adult fish, animal tissue is the most readily ac-



BASS PONDS AT NEOSHO, STATION, MISSOURI.

cepted, and will produce the strongest growth, though cooked cereals or vegetables will answer, and are even relished by young catfish when given in the raw state.

The food should be scattered along the natural feeding grounds, starting with a small amount and increasing the quantity to what the fish will daily consume. Care should be taken to prevent the pollution of the pond through the decomposition of excess food.

The young basses and crappies can not be successfully fed, and must depend entirely upon the insect life in the pond for their sustenance. For this reason no more young fish of these species should be carried in a pond than the natural food supply contained therein will support.

When such food is inadequate for the number of fish in a pond the only alternative will be the provision of additional ponds, to which a portion of the fry may be transferred for rearing. A public-spirited course would be to plant the surplus stock in neighboring public waters, taking care not to introduce them into streams and lakes which should be reserved to trout or salmon, as their presence would be detrimental to the latter species. Such a policy pursued by several fish-culturists in a given vicinity would maintain good public fishing, without diminishing to any appreciable extent the quantity of edible fish in the waters under private control. Ordinarily well-constructed ponds are capable of producing from two to ten times the number of fry that can be reared therein. The surplus is of some value as food for the stronger specimens, but would be of much greater value if liberated in adjacent lakes or streams.

## CAPACITY OF A POND FOR THE PRODUCTION OF FISH.

It is difficult to estimate the capacity of ponds for the various stages in the growth of fish. It depends for the most part upon the amount of appropriate food available. A 2-acre pond producing 10,000 one-year-old black bass from 4 to 6 inches long would be a remarkably successful enterprise, and 20,000 one and one-half to two inch yearling crappie or sunfish to an acre of water would be likewise notable. These numbers have been realized and in some instances exceeded, but the average results are doubtless much smaller.

The stock will be decreased through cannibalism at least 100 per cent by the end of the second year, and the yearlings held over will consume a large percentage of the fry hatched during the second and succeeding years of operations. Enough should survive, however, to maintain the adult stock at the maximum number that the pond will support.

In waters of high temperature those species adapted to culture in ponds will attain maturity and reproduce at the age of 2 years. In

cool waters reproduction may be delayed until the fourth year, or in case the species is very poorly adapted to the temperature conditions the fish may remain small, stunted specimens throughout life and never reproduce.

## ENEMIES.

There are many enemies of fish, especially of fry and fingerlings, against which the fish culturist must wage continual warfare. The heaviest losses will be from cannibalism, and these will be gauged by the balance of the food and fish in the pond. Some species are more predaceous than others. For this reason black basses, the scourge of restricted waters, are recommended only for large areas of the highest fertility. Such species as pike and pickerel should never be selected for culture in ponds, as they are the most piratical and devastating fishes inhabiting fresh waters.

It is necessary to guard closely against the inadvertent establishment in a pond of any undesirable species of fish or animal. Turtles and snakes will consume large numbers of fry and fingerlings in the course of a season and should be barred from the waters as strictly as possible. Kingfishers, herons, ducks, mudhens, fish hawks, etc., soon locate a pond and prove most persistent poachers. Powder and shot is their most effective deterrent. If inroads on the stock are made by mink, they should be trapped in season—at a time when they will, at least in part, make reimbursement for their board. Muskrats, while not fish destroyers, work havoc with pond embankments and should be exterminated.

## METHODS EMPLOYED BY THE BUREAU OF FISHERIES IN THE DISTRIBUTION OF FISH.

The Bureau of Fisheries will undertake to furnish fish to individuals for stocking public and private waters. Blanks upon which to submit formal application will be supplied on request. Assignments of fish are made large enough to form the nucleus for a brood stock for a given area of water, and are delivered at the applicant's railroad station free of charge. From the information given in these applications the Bureau decides as to the suitability of the waters for the fish asked for and reserves the right to substitute other species if in its judgment the applicant's selection is ill chosen or it is impossible, with its limited facilities, to supply the species specified within a reasonable length of time.

None of the pond fishes recommended in the foregoing pages will be furnished by the Bureau for stocking lakes or streams in Washington, Oregon, California, Idaho, Nevada, or the western portions of Wyoming or Montana, as it is believed their introduction into such

waters might prove detrimental to the important salmon and trout fisheries of the Pacific coast.

Basses, crappie, and sunfishes are propagated at 13 of the Bureau's stations, ranging in location from Vermont to South Carolina and from Texas to Iowa. However, the facilities at these stations are entirely inadequate to fill the rapidly growing demands, and the Bureau has for some years supplemented its supplies by collecting young fish of the species named from the overflow waters of certain rivers in the Mississippi Valley, where they are indigenous.

No source of supply can be relied upon. A sudden change in temperature during the spawning season may cause a year's failure at an important pond-culture station, and, unfortunately, this critical period occurs at a time when sudden climatic changes are natural. The success attained in collecting young fish from overflow waters depends upon favorable water stages, not only at spawning time but throughout the collecting season; as widely varying water stages are encountered from week to week and from year to year, the results of a season's work can not be foretold with any degree of certainty.

It is the policy of the Bureau to fill applications, so far as practicable, in the order of their receipt, and the allotments are as liberal as circumstances will permit. Aside from the uncertainty as to the stock of fish available for distribution, there are other factors governing the size of allotments and the time of delivery that are not generally understood.

On account of the greater value of fingerlings than fry for stocking purposes and the proportionate difficulty and expense of producing the larger fish, it is of course impossible to supply them except in comparatively limited numbers. It has been estimated that 350 fish 1 inch long are of more value than 1,000 fry, and that 25 fish 6 inches long are the equivalent of 100 only half as long. This is approximately the ratio of decrease experienced in rearing fingerling fish at the Bureau's stations, and allotments to applicants are governed accordingly.

The distribution operations of the Bureau of Fisheries close with the fiscal year ending June 30. At the opening of the new fiscal year all applications on hand are listed and arrangements are made to supply the fish assigned thereon before the following winter so far as the stock available will permit. Applications received after the opening of the fiscal year can not be filled in the same calendar year, unless there happens to be a surplus stock after deliveries have been made on all listed applications.

There are two distinct periods of distribution—one of fry in the late spring months, the shipments being forwarded in charge of messengers direct from the stations where the fish are propagated, and the other by the Bureau's cars, which extends from early in July

until late in the fall. The later distribution is of fingerling fish, their size increasing as the work progresses.

The distributions are arranged to cover the country by States or groups of States, and individual trips are routed in such a way as to most effectively and economically supply all applicants of a particular section of a State. The Bureau does not carry at all times a supply of fish that can be delivered on demand. Fish reproduce only once a year, and when the supply for any one year is exhausted it is necessary to wait another year, or until the next breeding season, before another supply can be obtained. Rarely is a second trip made over a route in the course of a year, and if for any reason an applicant fails to meet the Bureau's messenger and receive his consignment, the application is held for another attempt the following year. Only in extraordinarily good seasons can the entire area of the United States be covered. Each section is supplied in turn, so far as practicable, priority being given to the older applications on file.

Applicants are notified from 30 to 60 days in advance of the contemplated shipments of their fish, and a second notice, specifying the exact time of arrival, is sent by the messenger while en route. Every precaution is taken by the Bureau to avoid misunderstandings, and it is essential that applicants follow all the instructions they may receive.

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LOADING CAR WITH FISH FOR DISTRIBUTION.

DELIVERING FISH TO AN APPLICANT AT RAILROAD STATION.

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