FARM FISH POND PRODUCTION AS INFLUENCED BY CLIMATIC CONDITIONS

by

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INTRODUCTION

Thousands of acres of new water are being added to our inland water resource by construction of farm ponds. Farmers and stockmen all over the United States are benefiting materially by the addition of a farm pond to their property. Water conservation is currently important to farm production, and will play a leading role in the productivity of a farm or ranch in future years. An adequate farm pond is a reservoir for stock water, means for irrigation, safeguard for fire protection, source of fish food, place for relaxation and recreation, and an excellent habitat for farm game.

Prior to 1935 farm pond construction in the United States was negligible. From 1935 to 1948 approximately 1,103,400 farm ponds were constructed in the United States under supervision of the Soil Conservation Service (78, p. 295). Many other small farm ponds were constructed by individual farmers or by groups of farmers. This figure is about one hundred times as many ponds as were constructed during the entire two preceding centuries. By January, 1952, the Fish and Wildlife Service estimated that there would be approximately 1,666,000 farm and ranch ponds in operation (22, p. 239). The exact number of farm ponds recently constructed in Oregon is not known. Conservative estimates by several specialists at Oregon State College working with farm ponds indicate that there are at least eight thousand farm ponds in Oregon.

The reason for this large-scale construction of farm ponds is apparent. Our soils were being wasted away at an unbelievable rate, and it was quite obvious to conservationists that various soil conservation measures had to be taken. The construction of a farm pond is a good soil conservation measure, and through the efforts of several agencies the farm pond program materialized.

The United States Department of Agriculture initiated a program wherein farmers would be reimbursed proportional amounts of the initial cost for the construction of farm ponds on their land if the pond was constructed under the supervision of the Soil Conservation Service. The Production and Marketing Administration, formerly the Agricultural Adjustment Administration, is the agency that aids farmers and stockmen in their pond construction programs. This agency, plus the Fish and Wildlife Service and State Conservation agencies, have shared the responsibility of the recent farm pond program.

This program started in the southeastern and midwestern states, and has now spread to the Pacific Coast States. The construction of these new impoundments provides a new habitat of thousands of acres for fish production that formerly did not exist. By 1949, 529,500 acres of new water area were added to our natural waters by the construction of these farm ponds (78, p. 295). With the coming of this large-scale construction of farm ponds, research has been initiated in various sections of the country to find suitable fish for farm pond life. The Fish and Wildlife Service, State Game and Fish Commissions, and experimental stations have done much to provide farmers with suitable species of fish for farm pond production.

Most of the farm pond research has been started after 1940 as before then there was no great demand for fish suitable for pond life. The majority of research has been conducted in the southeastern and midwestern states. Important studies have also been conducted in Michigan, Texas, and some Atlantic Coast States.

The farm fish pond is indeed a microcosm. Here a continuous life cycle is in effect with the desired end product being harvested on a sustained yield basis. The preferred fish are the largemouth black bass, Micropterus salmoides (Lacepede), and the bluegill, Lepomis macrochirus (Rafinesque). This study deals almost exclusively with the two species mentioned. Trout production will be briefly discussed.

Growth rates, production of fish pounds per acre of surface water, and climatic conditions shall be used as criteria to evaluate the success of the bluegill and bass stocking combination in various states. Oregon, because of wide climatic variances, is divided into areas for more efficient analysis.

A farm pond questionnaire was sent to a conservation agency in each state requesting information concerning fish stocking policies for farm ponds in the state. A one hundred per cent return of the questionnaire facilitates complete analysis of information from each state.

Figure I. A small farm fish pond in Benton County, Oregon.

A scale analysis to determine the body-scale relationship of sixty-five largemouth black bass scales and one hundred and sixty bluegill scales was made possible by excellent facilities made available by the Oregon State Game Commission at their office at Camp Adair. The length-age relationship of bass and bluegill was calculated, and is shown in Tables 6 and 7. Back-calculations of the age of bluegill and bass at annuli formations were used to estimate the rate of growth of both species. Additional bass growth rate information from Oregon was obtained from Becker (7) and Hermann (37), and is included in Tables 12 and 14.

METHODS OF DATA ANALYSIS

Farm Pond Questionnaire Evaluation

In August, 1955, a one-page questionnaire was sent to the conservation agency in each state responsible for farm fish pond recommendations. A sample questionaire is shown on page 89 of the appendix. Information from each state is compiled in Tables 3, 18, and 19. To facilitate comparisons between Table 15 and Tables 18 and 19, the states are arranged in identical order from highest to lowest annual temperature.

Climatological Data

Climatological data were obtained from two of the best available sources (90, pp. 5-7; 91) (89, pp. 685-1209). These data for each state appear in Table 15 of the appendix. Tables 16 and 17 of the appendix include climatological data for the State of Oregon.

The amount of summer and winter precipitation and the duration of the frost-free period for each state were compiled from "Climate and Man" (89, p. 685-1902). The annual temperature of each state was obtained from "Climatological Data of the United States by Sections" (90, pp. 5-7). The summer and winter temperatures for each state were calculated from the same source.

The winter temperature is an average temperature for the three winter months of December, January, and February, while the summer temperature was calculated from the months of June, July, and

August. Oregon is divided into four climatic areas in Table 16 of the appendix. Data used to complete this table were obtained from "Climatological Data of the United States by Sections" (91, p. 439; 92, vol. 6). Table 17 is composed of temperature conditions for Oregon from 1950 to 1955, including data from the Willamette Valley and the Oregon Coast.

Scale Analysis

All bass and bluegill scales were cleaned with "clorox," and temporarily mounted between slides. Scales were then projected by an Eberbach Scale projector at the Oregon State Game Commission office at Camp Adair. The scale radius and length at each annulus was recorded with a magnification of 90X.

The Lee method of body-scale relationship to calculate regression of body length to scale length was used to determine the regression line for both bass and bluegill (47, p. 121). Back-calculations of fish lengths at annuli formation were accomplished by the formula recommended by Lagler (47, p. 125).

$$L_1 = \frac{S_1 (L_2 - a)}{S_2} + a$$

Where:

L_1 = length of fish at any annulus

S_1 = length of scale at any corresponding annulus

L_2 = length of fish at capture

S_2 = length of scale (center of focus to scale margin) at capture

a = a constant, determined previously (Y intercept of regression line)

The "a" constant for largemouth black bass and bluegill was calculated to be one inch and eight-tenths of an inch, respectively. All bass and bluegill scales were collected during the spring, summer, and fall of 1955.

LIFE HISTORIES OF BASS AND BLUEGILL

To manage a species properly, a thorough understanding of the life history of that particular species must be known. This knowledge also helps the biologist evaluate ecological factors of importance which affect the fish in their natural environment.

Habits and Requirements of Largemouth Black Bass

Largemouth black bass were originally found east of the Rocky Mountains from Southern Canada to Florida and Mexico. Mr. Gideon Steiner of Salem (48, p. 83), in 1883, was the first man to introduce bass into Oregon waters. He obtained largemouth black bass from the Maumee River, Ohio, and planted them in the Willamette River near Salem. The largest release of bass on record for Oregon was made in the Willamette River near Salem in 1892 (48, p. 88). Five hundred yearling fish were released here in July of that year by the United States Fish Commission.

Spawning temperatures vary with geographic distribution. In northern states bass spawn around 63° F., and at approximately 70° F. in many southern states (82, p. 298). Surber (73, p. 3) found that nest building occurs at 60° F., and spawning at 62° to 64° F. A single female may spawn more than once each year. The incubation period is two to five days, depending upon the water temperature.

The spawning season usually extends over a two-week period.

The male fans the eggs while guarding the nest. If the water temperature drops below 55° F. the male deserts the nest, and the eggs are subsequently destroyed by silting which smothers the eggs.

The eggs require a relatively long period of time to develop within the ovary. The ovary first begins to swell in September, and eggs are distinguishable in October. The eggs continue to develop all winter, and spawning occurs during March, April, May, June, or July, depending upon the geographic location.

Redds are dug in water six inches to six feet in depth, and are usually two to three feet in diameter. Bass are capable of spawning on almost any hard surface or hard object in the water. The average female may deposit from 5,000 to 10,000 eggs. Large-mouth black bass never spawn at less than ten months of age or less than five to six ounces in weight (80, p. 4). Adult bass must have food fishes to eat during the spawning months, and will not successfully spawn in overcrowded ponds because the young will eat the eggs.

Lydell (54, p. 50) found that young bass swarm up from the nest into a school twelve or thirteen days after hatching. His studies show that bass reach two inches in length in forty days. Meehean (56, p. 11) studied the growth of young bass, and obtained the same results as did Lydell. Meehean also found that after this first fast initial growth of the young, growth levels off to a slower rate.

In southern states bass will feed down to 47° F., and will grow slowly until water temperatures reach 80° F. (78, p. 298). This species is not adapted to colder waters, and most of the growth is made in the summer months. This fish will not spawn or exist in waters which remain muddy for long periods of time. Swingle and Smith (86, p. 335) found that bass consume one third as much food at 50° F. as they do at 68° F.

Juvenile bass feed on insects, crustaceans, and small fishes. They are sometimes very cannibalistic on fish of the same age class. Adults will eat almost any small fish. They are very predaceous and voracious. Frogs and crayfish are a preferred food of bass, and will be readily consumed if available.

King (44, p. 248) states "that Swingle, Eschmeyer, and the author have all carried out research in southeastern states and found that bass seldom live longer than six years." However, bass will live longer than six years in most states.

Habits and Requirements of Bluegill

The bluegill sunfish were originally distributed from Southern Canada and North Dakota south to Florida and Arkansas. They have been widely introduced west of the Rocky Mountains. The exact date that bluegills were first introduced into Oregon is not known, but first records of them appearing in catches were in 1895 (48, p. 115).

Young bluegill feed mostly upon aquatic insects and small crustaceans. As soon as their mouths are large enough they begin to consume insects which are the majority of their diet for the rest of their lives. They will also eat their own eggs if food is scarce.

As contrasted to bass, bluegill eggs need a relatively short period of time to mature. There is no egg development in the fall. During December well-fed adults will begin to develop eggs. The first spawning usually occurs in May or June. Bluegill will spawn at intervals throughout the summer months until October if food is plentiful and water temperatures are high enough (80, p. 3).

Bluegills are very prolific usually spawning in water from six inches to four feet in depth. An eight- to ten-inch female is capable of laying from 15,000 to 58,000 eggs. They reach sexual maturity in less than one year, and will spawn after four months in areas where growth is very rapid. They are colony spawners being tolerant of nearby redds. The males guard the nest and protect the young for a short period of time after hatching.

Bluegill will feed down to 39° F., but most of their growth is made when water temperatures range from 60° to 80° F. (78, p. 298). Above 80° F. almost all of the bluegill's energy is expended in spawning (78, p. 299). They require surface temperatures of 75° to 80° F. to spawn.

Adaptability to Farm Pond Life

When considering a species to stock in any body of water the following requirements must be fulfilled. The fish in question must be from a similar habitat, must be able to spawn successfully in the new habitat, and must be able to utilize the food available in the new habitat. Furthermore, it is imperative that the species be regarded highly as good food, good sport, and be capable of reaching a balanced condition with other fish in the pond.

Both previously mentioned species do well in farm ponds as they are native inhabitants of lakes, sloughs, and slow moving waters. They are capable of reproduction without the help of artificial aids, and aquatic food is similar to their original habitat forms. Furthermore, they are considered fine food, and in most states considered excellent sport fishes. The one serious condition that they fail to meet is that of attaining a well-balanced condition in many ponds. This factor merits discussion, and will be adequately treated in another section.

REGIONAL PREFERENCE AND SUCCESS OF BLUEGILL AND BASS IN FARM PONDS

Results from the Farm Pond Questionnaire

Largemouth black bass are the most sought after warm water game fish in Texas, Kentucky, Delaware, New Jersey, and Indiana. Bass are one of the most sought after game fish in twenty-five other states. Bluegill are angled for most in Mississippi, Alabama, South Carolina, Georgia, North Carolina, and Tennessee. Angling pressure is greatest on these two species in southeastern, midwestern, and southwestern states.

Texas now stocks redear or shellcracker sunfish, *Lepomis microlophus*, in preference to bluegill as this sunfish is not as prolific a spawner as the bluegill, and better population balance is attained in Texas with their use. Other states that recommend the use of redear sunfish in their farm ponds are Oklahoma, California, Tennessee, Kentucky, New Mexico, and Indiana.

The thirty-seven states that recommend the bluegill and bass combination for use in their farm fish ponds are listed in Table 18 of the appendix. The states which recommend stocking crappie and channel catfish in varying ratios are also listed in Table 18 of the appendix.

In most northern states where trout were natively found, they are the preferred species. In some northern states pickerel are important in the catch, as are catfish in some of our southern and midwestern states. Crappie and perch are sometimes very important in different localities, but without a doubt, nationwide, more angling effort is expended on bass and bluegill than any other warm water game fish. The state conservation agencies that recommend the stocking of trout in the farm ponds in their states are listed in Table 18 of the appendix.

Success of the Bluegill and Bass Stocking Combination

Bass and bluegill are stocked in varying ratios in thirty-seven states with the recommendations by the Fish and Wildlife Service or the particular state conservation agency responsible for the farm pond program in that state. These recommendations are listed in Table 18 of the appendix. Success of these stocking combinations in different areas of the United States meets with varying results, as shown in Table 1.

Results from the following investigators are compiled in Table 1. Meehean surveyed ponds in the Southwestern United States and in the Midwest. Fuqua made his study of farm ponds in Oklahoma, Texas, and New Mexico. Anderson analyzed ponds in Ohio, Indiana, Illinois, Missouri, and Iowa. Carlander and Fessler investigated ponds in Iowa. Sharp checked ponds in North and South Dakota, Iowa, Minnesota, Illinois, Indiana, Ohio, and Michigan. Holloway studied ponds in Kentucky, South Carolina, Arkansas, Mississippi, Georgia, and Tennessee. Rawson and Rutton (65, p. 287) have reported that all bluegill and bass plants in Saskatchewan have died.

TABLE 1

SUCCESS OF FARM FISH PONDS IN MAINTAINING BALANCE

Investigator	Meehean (58)	Fuqua (33)	Anderson (1)	Carlander (18)	Fessler (32)	Sharp (69)	Holloway (38)
Per cent of ponds in a balanced condition	53.4* 64.0 69.0* 45.5	55.0	48.5	56.8	45.0	28.3	36.0
Per cent overpopulated with bass	-	-	5.1	6.3	10.0	-	7.0
Per cent overpopulated with bluegill	-	-	10.1	15.3	21.0	30.2	44.0
Per cent overpopulated with other species	-	-	36.3	19.8	24.0	27.6	-
No fish at all	-	-	-	1.8	-	13.9	-
Fertilized ponds (No.)	178	-	-	-	-	-	-
Unfertilized ponds (No.)	39	-	-	-	-	-	-
Fertilized status not known (No.)	-	80	99	111	33	106	323

(No.) Indicates number of ponds analyzed by each investigator.
( ) Number inside of parenthesis indicates reference number in the bibliography.
* Meehean calculated per cent of ponds in balanced condition for both fertilized and unfertilized ponds. First asterisk is per cent of fertilized ponds in balance in southwestern states. The second asterisk indicates the per cent of fertilized ponds in balance in the Midwest.

Data in Table 1 show that from twenty-eight to fifty-seven per cent of the farm ponds investigated were in a balanced condition between bass and bluegill. Five to ten per cent were overpopulated with bass, while ten to forty-four per cent were overpopulated with bluegill. Twenty to thirty-six per cent were overpopulated with other species of fish.

Trout Farm Ponds

Trout farm ponds are numerous in many of our more northern states. Good growth does occur in most suitable trout ponds, and fair yields occur in one year in many of the ponds. Most state conservation agencies do not recommend stocking trout in ponds where summer water temperatures range between 70° to 80° F. State conservation agencies that recommend stocking of trout in farm ponds are listed in the appendix, Table 18.

Reproduction in these ponds is hardly possible unless suitable inlets make spawning areas available for adult spawners. Sometimes artificial spawning aids can be successfully utilized to obtain reproduction in these ponds. This is the one serious handicap of trout ponds as they must be managed on a "put and take" basis, and this is not considered feasible by some pond owners.

In Oregon, trout are stocked at the rate of 300 to 600 fingerling per acre of surface water. Schneider and Griffiths (67, p. 151) found that the survival of trout in a small pond in western Oregon for one year was 71.3 per cent. With only natural feeding, they obtained a yield of 46.5 pounds per acre with cutthroat and rainbow trout. To produce a satisfactory angling return of two fish per hour, it was necessary to have a population density of one hundred fish per surface acre of water.

Eipper (31, p. 1) obtained yields of trout from 89 to 151 pounds per surface acre in New York ponds. He estimated that the average production was 119 pounds per surface acre. The normal stocking rate in New York is 350 fingerlings per acre of surface water.

MANAGEMENT OF THE BLUEGILL AND BASS STOCKING COMBINATION

Farm Pond Management Principles

The following three important fish management concepts mentioned by Moyle (60, p. 283) have done much to develop recent trends in farm pond management.

1. "The concept of carrying capacity; that is, the fertility and basic productivity of any water allows the maintenance of a fish population or standing fish crop of a certain maximum poundage, and usually the size of the fish population in a water tends to be close to this carrying capacity.

2. "The concept of population balance. There is a certain balance of poundage ratio between species of fish in a water, especially predaceous and forage fish, that can be expected to result in best growth for all species.

3. "The concept of sustained yield. With proper management there will be an annual crop of fish of a fairly constant size that can be harvested or replaced each year by population growth."

The following principles have been found by Swingle (81, p. 3-10) and other research workers to be necessary for a healthy population which will produce sustained yields of harvestable fish.

1. Stocking should be determined by the natural carrying capacity of the pond.

2. The production of a pond can be increased by the use of fertilizer; however, only ponds on which a very intensified fishing program is planned should be fertilized.

3. Fish grow rapidly if food is plentiful, but slowly if food is scarce.

4. Too many fish in a pond cause stunted fish and poor fishing.

5. Within one year after stocking, a pond is usually supporting close to the maximum weight of fish for which there is food. After the first spawning more small fish are present than can adequately be supported by the food in the pond.

6. If the number of fish in a pond is reduced, the average size of the remaining fish increases.

7. Bluegill cannot be raised successfully in ponds containing only bluegill. Largemouth black bass should be used in ponds with bluegill. The bass will eat enough young bluegill to keep the population in balance if enough bass are in the pond.

8. Adequate angling pressure on both bass and bluegill must be maintained.

Farm Pond Life Cycle

Food in a farm pond life cycle is in continuous circulation. Aquatic plants and phytoplankton convert mineral salts, nitrogen, phosphorous, and carbon dioxide into foodstuffs that are consumed by protozoans. Small crustaceans and insects eat these protozoans, and in turn are eaten by young game or forage fish which become the prey of the larger predaceous game fish. The adult fish die, and their flesh is broken down by bacteria and other organisms into inorganic salts to complete the cycle.

Balance of the Fish Population

One of the well established principles of pond management is that the fish must reach some form of balance between species in a pond in order to insure maximum production. An unbalanced population will propagate stunted populations with one of the species completely dominating the pond.

Dr. H. S. Swingle of Alabama has done much of the pioneer work in population balance for bluegill and bass ponds. He found that all ponds should be checked the second summer after stocking to see if the pond has achieved a balanced condition (76, p. 246).

Swingle (76, p. 263) suggests the following reasons as explanations why many new ponds do not achieve a satisfactory balance. "(1) Competition with wild fishes already present in the pond before the hatchery fish are stocked. This is the most common cause of pond failures. (2) Thoughtless stocking of new ponds with adult fish before the hatchery fish arrive. This mispractice causes overstocking. (3) Heavy mortality among the hatchery fish after they are introduced into the pond. (4) Removal of bass by fishing before they have already spawned for the first time."

A simple method for testing ponds to determine if they are in a balanced condition has been devised by Swingle. This test is composed of a sample taken from the pond by seining which is followed by an examination of fish caught. If both bluegill and bass young of the same year class are present, and if there is not an over-abundance of medium sized bluegill, then the pond is considered to be in balance. If both bass young and bluegill young are numerous, the spawning members of the populations are abundant enough to classify the pond as balanced.

Swingle (82, p. 9) reports that in a balanced population the ratio of forage fish to carnivorous fish (F/C) should be from

3 to 6:1 pounds. He also uses "A_t," Y/C, and "E" values when working with fish populations in farm ponds (75, p. 218).

The "A_t" value is the percentage by weight of harvestable fish in the total population. This value measures the efficiency of the population. "A_t" values below 40% indicate unsatisfactory balance, and those below 33% indicate unbalanced populations. "A_t" values should range between 40% and 85% with 60% to 85% the most desirable range. The minimum size used to determine the "A_t" value for bluegill is six inches and for bass ten inches.

The Y/C value is the weight of small forage fishes to the total weight of carnivorous fishes. The desirable Y/C range is one to three pounds of small forage fish for each pound of carnivorous fish. The "E" value is the percentage by weight of all the different species in the total population. At least 35%, and preferably 60% to 70%, of the total weight of the bluegills should be usable size fish.

Productivity of Water

It is a well known fact that the productivity of any body of water is directly related to the soil productivity of the surrounding watershed. There is a definite carrying capacity for the fish population of any given body of water depending upon this soil fertility. Fish production is dependent upon the amount of food available in a pond. This food requirement varies with different fish.

If a soil is rich in basic nutrients, then the body of water will also be rich in the nutrients necessary to maintain a good population of fish. These basic inorganic nutrients are necessary to produce plankton and algae for indirect and direct fish consumption. The most important constitutents for production of plankton and algae are phosphate, nitrogen, and potash.

A pond rich in these elements will produce much plankton and algae for microcrustaceans and small fish to feed upon. This factor is an important one in understanding and managing a farm pond because with a lack of this food, fish will not grow, mature correctly, or maintain a balanced population.

Productivity of the Bluegill and Bass Combination in Farm Fish Ponds

Productivity of farm ponds is measured by pounds per acre of surface water. The weight includes the total number of fish captured by pond draining or poisoning. A comparison of fish production in different states is shown in Table 2. Available information from three states makes it possible to compare production in natural waters to production in fertilized ponds.

Results from one experimental farm pond in Oregon show that production of bass and bluegill in Oregon is equal to or greater than four of the other states listed in Table 2. Since the fish population in this pond was considered unbalanced, it is possible that a balanced population of bass and bluegill could yield more pounds per acre than did this one experimental pond.

TABLE 2

PRODUCTIVITY PER ACRE OF BLUEGILL AND BASS IN FARM PONDS

State	Investigator	Fertilized ponds (lbs.)	Unfertilized ponds (lbs.)	Year
Alabama	Swingle	400 - 600	40 - 200	1947
Illinois	Bennett		70 - 145	1952
Indiana	Krumholz		250 - 600 (400 ave.)	1952
Kansas	Tiemeier		200 - 500	—
Kentucky	Clark		200 - 1000	1952
Michigan	Ball	193 - 721*	196 - 379*	1952
Missouri	Barnickol		364**	1952
New York	Eipper		270*	1953
Oregon	Grenfell		260**	1953
Texas	Brown	156 - 248	137 - 239	1950
West Virginia	Surber	200		1947

* three ponds
** one pond

Farm Pond Fertilization

There are currently twenty-four states that recommend the use of commercial inorganic fertilizer to increase the productivity of ponds in infertile areas of their states. These states are listed in Table 3. All of these fertilizers are chiefly composed of phosphate, nitrogen, and potash.

When fertilizer is added to a pond, phosphate, nitrogen, and potash go into solution and become readily available for food for phytoplankton. The increase in available food causes an increase in the plankton which results in a bloom in most ponds. With the abundance of this food, insects, crustaceans, and small fish flourish, and the food for larger fish also proportionally increases resulting in increased pond production as illustrated in Table 2.

TABLE 3

THE USE OF COMMERCIAL INORGANIC FERTILIZER IN FARM FISH PONDS IN THE UNITED STATES

States which recommend fertilizer		States which do not recommend fertilizer	
Florida	Maryland	Texas	Iowa
Louisiana	West Virginia	Oklahoma	Utah
Mississippi	Indiana	California	Idaho
Georgia	New Jersey	Kentucky	South Dakota
Alabama	Pennsylvania	Kansas	Michigan
South Carolina	Rhode Island	Delaware	Wisconsin
Arkansas	Nebraska	New Mexico	Montana
Arizona	Connecticut	Illinois	New Hampshire
North Carolina	Massachusetts	Ohio	Maine
Tennessee	New York	Nevada	Wyoming
Virginia	Colorado	Oregon	Minnesota
Missouri	Vermont	Washington	North Dakota

The best fertilizer recommended for farm ponds is one hundred pounds of 6-8-4 (nitrogen-phosphate-potash), plus ten pounds of nitrate of soda per surface acre of water (77, pp. 20-21). The fertilizer is applied around the edges of the pond in water one to six feet in depth. The first application is in the spring as soon as warm weather arrives, and then about every three or four weeks depending upon the microscopic life in the pond. The usual cost is approximately $25 per surface acre of water (76, p. 247). Ponds that stay muddy and those which have excessive amounts of water passing through them during the growing season cannot economically be fertilized.

Swingle (76, p. 247) lists the following advantages derived from the use of fertilizer in ponds in the southeastern states.

"(1) Increases fish production, (2) controls water weeds, (3) reduces or prevents mosquitos from reproduction, (4) increases the catch of fish, and (5) makes use of one stocking rate."

That proper fertilizer in ponds will produce greater yields is illustrated by Ball (5, p. 17) as he obtained yields in three fertilized ponds varying from 193 to 721 pounds per acre as compared with three unfertilized ponds varying from 196 to 379 pounds per acre. Swingle (81, pp. 3-4) found that properly fertilized ponds in Alabama will produce between 400 to 600 pounds per acre as compared to 40 to 200 pounds per acre for unfertilized ponds.

Barnickol and Campbell (6, p. 273) evaluated the changes that fertilization causes in Missouri ponds, and found that growth of bass and bluegill in fertilized ponds was faster than in unfertilized ponds with other things being equal. They show that fertilized ponds produce much more plankton than do unfertilized ponds, and that second year algae blooms of the same species reappear in only fertilized ponds.

Ball (3, pp. 222-223) (5, pp. 19-22) lists the following disadvantages of farm pond fertilization in Michigan waters. Fertilization results in a winter-kill of warm water fishes in shallow ponds; increases the synthesis of organic matter in the form of bacteria, phytoplankton, filamentous algae, and higher aquatic plants (the latter two being a detrimental condition in any pond); and most pond owners do not conscientiously continue a good fertilization program which results in wasted effort and time.

These disadvantages usually cause a pond to become overpopulated with one species or the other.

Zeller (95, p. 281) studied the effects of fertilizer in ponds and found that the presence of filamentous algae in ponds greatly reduced the effects of the fertilizer. He concludes that the filamentous algae absorbs the nutrients added to the water from the fertilizer.

States that do not recommend the use of commercial fertilizers are listed in Table 3. They believe that their soils are rich enough to keep fish populations high enough for the amount of fishing pressure that is exerted upon them, and that this fertilizer will just be wasted effort and money. Another important reason that most states do not recommend the use of fertilizers is that the harvestable fish crop is seldom, if ever, fished to the correct maximum extent to keep the pond in balance.

Table 4 shows the results of some studies which have been conducted to measure the effects of fertilization on pond balance.

Meehean (58, pp. 235-236) states "that in the southeastern states 61% of ponds having more than 10% of the bottom covered with submerged vegetation were in balance. Ponds having less than 10% submerged vegetation on the bottom were only 45% in balance." He also discovered that out of 418 problem fish ponds, 90% were unfertilized indicating that fertilization is a necessity for pond success in this area.

TABLE 4

EFFECTS OF POND FERTILIZATION ON BALANCE IN FARM FISH PONDS

Area	Fertilized ponds Per cent in balance	Unfertilized ponds Per cent in balance	Investigator
Southwestern States	53.4	64.0	Meehean (58)
Southeastern States	30.3	25.3	Holloway (38)
New Mexico, Texas, and Oklahoma	55.0	64.5	Fuqua (33)
Midwestern States	69.0	45.5	Meehean (58)

( ) Number inside parenthesis indicates reference number in the bibliography.

Stocking Ratios; Stocking Rates; and Size of Fish at Liberation

Much effort has been expended by many different conservation agencies and research stations to find suitable stocking ratios which will provide new impoundments with quick fishing and a sustained yield harvest. The initial correct stocking ratio is very important because a stunted or out-of-balance fish population results with improper stocking. Stocking ratios vary greatly in the United States, and this is illustrated by returns from the questionnaire in Table 18 of the appendix.

In some areas it does not seem to make any difference at what ratio bass and bluegill are stocked initially. Dr. Swingle (76, p. 245), through many experiments at Auburn, Alabama, found that a ten bluegill fingerling to one bass fingerling ratio now gives the best results in ponds in the southeastern states. This ratio is also recommended by the Fish and Wildlife Service for most areas in our country (57, p. 3). Several states are currently involved in research in an endeavor to find the best ratio for their respective state.

Experiments conducted by Dr. Ball (3, p. 224) indicated that just the reverse ratio works best in Michigan with one adult bluegill stocked with ten fingerling bass. In southern states and some midwestern states bass mature and spawn after one year, but in Michigan and other northern states bass do not mature and spawn until two or three years of age. In these colder states, the bass should have young bluegill to feed upon the summer after stocking, and this is the reason for stocking adult bluegill with fingerling bass.

Several midwestern states found that the best ratio for pond balance and good angling returns for their areas was one bluegill to one bass. Still other states recommend varying ratios as their experiments have deemed necessary. The Oregon Game Commission recommends the stocking ratio for new ponds of three to six fingerling bluegill to one fingerling bass. Ten states do not recommend stocking of bass and bluegill for different reasons, but chiefly because climatic conditions are too adverse for bass or bluegill.

Bluegill and bass ratios are stocked per acre of water surface. Rates vary with natural or fertilized ponds. Many states have the same ratio for both naturally productive ponds and fertilized ponds, but the stocking rates differ. Usually the unfertilized pond receives fewer fish per acre. The correct stocking ratio is important to bring the pond in balance and to give a good sustained yield. Stocking rates are also important because overstocking will immediately result in stunted populations.

As with stocking ratios, states vary in the size of fish stocked as shown in Table 18 of the appendix. In most states fingerling bass and bluegill are stocked. Several states now stock new farm ponds with fry as the mortality in hatcheries from the fry to fingerling stage is relatively large, and bass fry survive well in new impoundments.

Adult fish are seldom used, except in several states as shown in Table 18 of the appendix. Adult bluegill are stocked here to insure the bass of an adequate food supply for the next year.

Surber (74, p. 141) found that the stocking ratio was not important to providing maximum yield in well-managed ponds. He stocked ponds with ratios varying from 8 to 1 and 15 to 1, and found that approximately two hundred pounds of edible fish per acre could be produced annually regardless of the stocking ratio employed.

Brown (14, p. 210) at San Marcos, Texas, found that high production in total pounds of edible fish in bluegill and bass combination was not dependent on stocking ratio alone. Yields from bass and bluegill ponds indicate that the weight of edible bass per acre is decreased as the stocking ratio of bluegills is increased. The average weight of bluegill was found to vary inversely with the number stocked.

Physically Unsuited Ponds

It is conceivable that one of the biggest mistakes in the past policies of stocking ponds was the stocking of physically unsuited ponds with fish which cannot grow well or reproduce in these handicapped ponds.

Smith, Kirkwood, and Hall (70, p. 39) found in an experiment in stocking ratios and rates of bass and bluegill in Kentucky that "The problem of physically unsuited ponds merits far greater attention than it has thus far received. It ranks of paramount importance in accounting for the failure of the majority of ponds investigated." They found that out of 238 ponds, 126 were unmanageable because of detrimental physical conditions.

They found the following factors tend to render a pond unmanageable in Kentucky: "Extensive siltation and/or turbidity from livestock use; inadequate depth; extreme water fluctuation; dam failures; extensive siltation from watersheds; excessive watershed; and overflow by streams."

Swingle found that the bluegill to bass combination cannot be used in ponds that are too small to insure reproduction (ponds must be one half acre or larger), ponds where summer temperatures of the surface water remains below 80° F., in water carrying heavy loads of silt, or highly alkaline waters. Swingle also found that bass and bluegill have failed to spawn in brackish waters having a salinity of 0.5%, and in ponds deeper than fifteen feet as bluegill will not feed down further than this.

Kimsey (43, p. 1) states "that in 1953, 12,000 ponds were scheduled to be constructed in the soil conservation districts of California, Oregon, Washington, Idaho, and Nevada. The fact that most of these are not suitable for any significant fish production has not been adequately pointed out. Little farm pond investigation work has been carried out in the Far West, and a pond seriously used for irrigation cannot be expected to produce an adequate fish crop."

Chemical and Thermal Stratification of Ponds

Carlander (18, p. 261) reports that some ponds in Iowa have been found to be thermally and chemically stratified with only three to five feet of surface water holding sufficient dissolved oxygen for fish life during the summer months. He believes that this reduction in living space after the spawning season has contributed to slow growth and stunted fish populations.

Barnickol and Campbell (6, p. 270) found that ponds in Missouri show a pronounced warming in ponds six to eight feet in depth during the summer months, and that there is a frequent absence of a clearly defined epilimnion, thermocline, and hypolimnion. They noticed a vertical distribution of nutrients added by fertilization (6, p. 271). This distribution was related to thermal stratification as bottom concentrations of phosphate phosphorus were two to ten times as great as were surface concentrations.

Byrd (15, p. 162) studied stratification of farm ponds in Alabama and found that there was a definite stratified condition during the summer months. Fish traps were used in the study. Byrd found that bluegills could not efficiently utilize the colder and deeper waters because of low concentrations of dissolved oxygen and high concentrations of carbon dioxide. During this summer stratification, bluegill were found in greatest numbers in shallow water.

Byrd states "bluegills were unable to live for extended periods of 6 to 45 hours at water depths where the dissolved oxygen concentration was 0.3 ppm. or less accompanied by a carbon dioxide concentration of 4.4 ppm. or more. The critical depth where chemical stratification occurred was at five feet in a two-acre pond and at seven feet in a 22-acre pond (15, p. 162)."

Angling Pressure and the Results of Underfishing

The following statements have been included to demonstrate the complete agreement of fishery workers in different areas of the United States as to the importance in farm pond management of adequately harvesting the species stocked. This is a relatively new concept in the management of warm water pond species, and conclusive evidence of the merits of this concept is illustrated by these quotations.

Bennett (9, p. 252) in Illinois found, from what dependable data were available, that the angling pressure on farm ponds is on an average 100 man hours per acre of water each season. Fishing clubs received from 200 to 250 man hours of angling per acre per season.

Dickson (29, pp. 40-41) in Georgia deems it necessary to harvest three to seven pounds of bluegill for each pound of bass. Ponds containing only bass and bluegill have never been ruined by overfishing because there is always many fish of spawning size left. Georgia recommends angling for adult bluegill when on the nest because they are easiest to catch at this time, they need to be harvested, and if only one pair of bluegill were allowed to spawn it would be adequate to reseed the pond.

Dequine (28, p. 235) studied the degree of sportsmen catch on Lake Okeechobee, Florida. There had been a commercial fishery on this lake and other large lakes in the visinity. Sportsmen thought that the commercial fishery was taking all the bass, and they were responsible for legislation which closed these waters to commercial netting. Dequine found that sportsmen were catching only 23 to 25 per cent of the legal sized bass, and only 4 to 5 per cent of the available bluegill. He also pointed out that the commercial seining was not causing any measurable harm to Lake Okeechobee, and that commercial seining would probably help the bass population because fishing success improved after each seining.

In 1950 Bennett (8, p. 231) reported the following results from a nine-year study of an eighteen-acre lake in Illinois. Small bass were removed by anglers as well as by use of a drain pipe. At the termination of the study the bass population had maintained a high level, in spite of this so called "mispractice" of discarding the small bass by sportsmen and by draining the lake. He concluded "that the size limit has no value in bass conservation."

Barnickol and Campbell (6, p. 274) drained a 3.5 acre lake in Missouri after a 79-day fishing season to determine the standing crop of fish population. This lake received 3,457 man hours of fishing pressure during the 79-day season. The total catch from this lake was 1,247 fish weighing 404.2 pounds, which is a yield of 155.5 pounds per acre of surface water.

A complete census by draining the lake revealed that after the close of the season a standing crop of 47, 185 fish weighing 729.4 pounds remained in the lake. This was 208.4 pounds per acre, making a total of 363.9 pounds per acre. There were 67 usable bass weighing 80 pounds and 160 usable bluegill weighing 42.5 pounds. Sixty-two channel catfish were also left. There were 728 small bass and 46,186 small bluegill left in the lake after the fishing season.

Cooper (24, p. 3) states "that most ponds in the Midwest will vary from 100 to 160 pounds per acre each year in production. It is advisable to remove about half of this crop annually in order to maintain a healthy growing population of fish which insures continual good angling. Since hook and line fishing seldom, if ever, is efficient enough to harvest warm water fishes at this rate, other means to thin the population periodically are necessary."

Krumholz (45, p. 254) believes that one of the two greatest factors which cause the low percentage of good fish ponds in Indiana is inadequate fishing. The best ponds in Iowa, as reported by Carlander (18, p. 261), are not fished enough to harvest available adult fish. Clark (21, p. 263) reports that good, intensive fishing is necessary to keep the ponds in Kentucky in balance. If the ponds are not fished sufficiently, bass will not be able to spawn because of the overpopulation of bluegills which will eat the bass eggs in periods of food scarcity.

In Kansas, Tiemeier (87, p. 24) states that "the greatest problem in management of fish in a farm pond is getting the owners to fish sufficiently for them. It is especially hard to get people to fish for bluegill as people in Kansas angle almost exclusively for bass. It is recommended that any small bluegill caught not be thrown back into the pond as this leads to over-population of the pond by bluegills."

The Closed Season in Warm Water Game Fish Management

In 1942 Swingle and Smith found from research that in most cases it is impossible to take more than fifty per cent of the existing stock of catchable fish in a pond by angling (81, p. 23). Also, the failure of a size limit as a tool for managing many species of fish has resulted in a continuous open season for bass and bluegill in many states.

The current warm water game fish regulations were reviewed in Field and Stream (36, pp. 34-39). Twenty states now have no closed season on largemouth black bass, and thirty states have no closed season on bluegill. In 1949 the number of states permitting year around angling for bass and bluegill was fifteen (62, p. 243).

In 1947 King (44, p. 247) is quoted as writing "Since North Carolina, Alabama, Georgia, South Carolina, and Florida have abolished the closed season on warm-water species, except bass, there are more fish being taken with no evidence to indicate that any harm is resulting from the removal of the closed season." He further points out that the open season has resulted in a doubling of the catch of fish from TVA reservoirs and is credited with bringing an additional $5,000,000 worth of related business to the communities serving the reservoirs.

Murphy (62, p. 247-248) studied abundance of fingerling bass in an area closed to angling during the spawning season in comparison to the abundance of fingerlings in an area open to angling during the spawning season. During his three-year study he found the survival rate to be positively correlated with the abundance of forage fish present, and not correlated with the angling pressure on the adult fish during the spawning season.

Mortality of Young Bass and Bluegill

To stock a new impoundment successfully, the mortality rates of fish stocked should be known. This information enables the biologist to estimate the number of fish which will survive until the first spawning. Brown (13, p. 79), Surber (74, p. 142), and Swingle (83, p. 63) conducted experiments to find the percentage of survival of young bass and bluegill. Their results are listed in Table 5.

TABLE 5

MORTALITY OF YOUNG BLUEGILL AND BASS WHEN STOCKED IN A NEW IMPOUNDMENT

Investigator	Percentage survival Bass	Percentage survival Bluegill	Length of experiment
Swingle (83)	75% fingerling 80 - 90% adv. fry	76 - 85% fing.	9-12 months
Brown (13)	(1) 47.1 - 83.3% fing. 65% average		18 months
	(2) 64.9 - 85.3% fing. 71.3% average		15 months
Surber* (74)	83%	86.3%	15 months

* The only investigator to allow angling during the experiment.

Swingle (83, p. 67) explains the greater survival of bass fry by stating "the greater survival for bass fry planted in new ponds, as compared to that for fingerling, is explained by the relative abundance of food available for each immediately following stocking. The fry, which are planted in the spring, thrive on microcrustacea and aquatic insects for some time, and young bluegills are available by the time the fry are large enough to eat them. The fingerlings are usually stocked in the fall and winter when food is less abundant and they should have fish to prey upon. They are forced to eat insects and whatever is available, hence the lower survival rate."

Brown (13, p. 215) endorses the stocking of bass fry instead of fingerling because fry survive better, mortality from fry to fingerling is high in hatcheries, and the cost is greater in stocking fingerlings.

Swingle (75, pp. 227-228) determined the natural mortality for bass, when no fishing was allowed, averaged 25.6% during the first six months, and an additional 20.4% died during their second year. An average of 15.4% of the bluegill stocked died during the first year, and an additional 19.1% died during their second year.

CLIMATIC CONDITIONS WHICH AFFECT THE SUCCESS OF FARM FISH PONDS

James (41, p. 3) states "The climate of a section of the country in which water areas are located may, in a general way, determine the climate within these bodies of water, but there is much variation between water areas in the same region. It is upon these climates, of habitat conditions within each body of water, that the natural distribution of fishes depends. It is these factors which determine what species of fish grow best and produce best fishing and, therefore, should determine the fishes to be stocked.

"One of the fundamental climatic factors is temperature. It determines, in a broad way, the general types of fishes to be found, or to be stocked, in a body of water."

Effect of Annual Temperature

The annual temperature, as previously mentioned by James, is responsible for the types of fishes found in any one area. Air temperatures govern to a large extent water temperatures, and certain water temperature limits restrict any species to certain areas where this requirement is fulfilled.

Successful introduction can sometimes be accomplished if temperature conditions are similar between two areas, other factors being equal. In the complex scheme of ecology, every species has certain temperature requirements which it must have for successful existence. On the periphery of this temperature range, the species in question can hardly be expected to be as successful as in the center or optimum of its range.

The average temperature for each state in the United States has been compiled from the most accurate source available, and presented in the appendix, Table 15. States vary greatly in climatic conditions. These are the most accurate data available for comparison.

Winter Temperature

Winter temperatures are exceedingly important because they are the limiting factor in the distribution of some fishes. The annual temperature for two given areas could be almost identical, yet one area could have a much colder winter and warmer summer than the other area. This would confuse the true climatic picture by giving the same annual temperature as the other area.

Winter kills from some northern states have completely destroyed fish populations in farm ponds in Michigan, Minnesota, North Dakota, and probably other northern states. This makes a state's winter temperature of importance to the warm-water fish biologist. Winter temperatures are also listed in Table 15 of the appendix.

Summer Temperature

Summer temperatures can also inhibit the distribution of some fishes. If winters are mild enough to support bass and bluegill but summer temperatures do not adequately increase water temperatures high enough to permit successful spawning, then these species cannot successfully perpetuate themselves. Summer temperatures are also found in Table 15 of the appendix.

Frost-free Period

This period of time in itself is not a critical factor, but its implications can tell the biologist much. This period is the number of days from the last killing frost in spring until the first killing frost in the fall. The investigator then knows that for a certain area the temperature has not been below 32° F. for that period of time.

Several research workers have found that the growing season of bass and bluegill in some states is directly parallel to this period. However, such is not always the case as Jones (42, p. 183) calculated the growing season of largemouth black bass in Norris Reservoir to be not more than four months. The agricultural growing season for this area in Tennessee is seven months. This was determined by scales taken from fish in May, 1939, September, 1939 and April and May, 1940. The frost-free period for each state is tabulated in Table 15 of the appendix.

Annual Rainfall

The knowledge of annual rainfall for a given locality will greatly aid in determining the watershed area necessary for different sized ponds in that locality. This is important if good fishing is desired because incorrect calculations concerning necessary watershed run-off could lead to a pond physically unsuited for fish. Dangers from this error in calculations could develop into either a drying pond in the summer or a violently fluctuating pond. Average rainfall figures are listed in Table 15 of the appendix. These are state averages, and could be misleading due to the varied climates of many states. The soil conservation service has published charts to use in the different regions and sub-regions when calculating desired watershed drainage area.

Summer Rainfall

In some states farm fish ponds could not be maintained without adequate summer rainfall because their winter rainfall would not be sufficient to maintain constant levels. Summer evaporation is another factor that varies with different states and with the amount of summer rainfall. Without this summer rainfall the southeastern states could not produce the excellent farm pond fishing that they do. The summer water level fluctuation would be too great to support good populations of fish. These data are also available in Table 15 of the appendix.

Ice Cover of Ponds

Most states in the northern half of the United States have ice covers of varying durations over their ponds during winter months. This sometimes results in complete mortality in some ponds when excessive aquatic plant growths are present. The decaying plant material consumes all of the dissolved oxygen in the water, and the fish die under the ice. This is another climatic effect on populations of warm-water game fish in northern states.

Ball and Tait (5, p. 22) found that the prolonged ice cover in Michigan may be ten to thirty inches thick and last from sixty to one hundred and twenty days or more. If fertilization was practiced in shallow ponds where there is no constant flow of water into the pond, winter kills are almost certain to occur.

Brown and Thoreson (12, p. 277), while investigating ponds in Montana, found that as much as forty inches of ice on ponds for as long as five months is not uncommon. They believe that the so called "warm-water" ponds in Montana are not suited for the bass and bluegill combination as it takes bass four summers to get ten inches long and bluegill until their fifth summer to get six inches long.

In 1950 Sharp surveyed ponds in North Dakota and found eleven out of eighteen ponds were failures because of winter kills (69, p. 147).

AGE AND LENGTH RELATIONSHIP OF BLUEGILL AND BASS

The analysis of scales has proven a very effective tool in determining the growth rate of some fishes. Scales are used to determine the age of the fish at capture, the length at any annulus during the fish's life, and the average growth made by the fish during each year of life (47, p. 120).

The growth rates of sixty-five largemouth black bass and one hundred and sixty bluegill were estimated. Fish lengths at each annulus formation were calculated by the use of the formula described on page eight. All of these scales were collected in western Oregon by Mr. Ralph Grenfell and Mr. Andrew Landforce. Scales were not available from the other climatic areas in the state.

The results of these estimates are compiled in Tables 6 and 7. Tables 8 and 9 are a comparison between the growth rates of bass from the Willamette Valley and those from coastal lakes. A similar comparison of growth rates of bluegill between these two areas is computed in Tables 10 and 11. Tables 13 and 14 are a comparison of growth rates of bluegill and bass from various states. The position of the states in these tables is based upon their annual temperature as in Table 15 of the appendix. Table 12 is a summary of bass growth, which was calculated by different authors, in Oregon. Becker studied fifty-seven bass scales that were collected in 1954 from lakes, ponds, and rivers in Oregon, and his results are included in Table 12. In 1955 Hermann calculated the growth rates of sixty-six bass collected during 1953, 1954, and 1955 from Oregon lakes, reservoirs, and farm ponds. His results are also listed in Table 12.

Bass growth in Oregon is comparable with that made in New York, Michigan, Wisconsin, Montana, and Minnesota, as shown in Table 14. Bass growth for all other states listed is much faster than experienced in Oregon.

Bluegill growth in Oregon during the first three years of life is approximately equal to or greater than growth in all other states, except California, Tennessee, Kentucky, and West Virginia, which are listed in Table 13. After three years, bluegill growth in Oregon decreases somewhat to that calculated in other states.

It is apparent from Table 12 that largemouth black bass grow more rapidly in our coastal lakes than in the Willamette Valley. However, one instance of bass attaining the length of 14.2 inches in three years has been recorded in one of the experimental ponds of the Oregon State Game Commission. Becker and the author found that growth is less in coastal lakes during the first year, but greater every year after the initial year of life than growth of Willamette Valley bass. Becker (Table 12) found that growth of bass in southern Oregon was slower during the first four years of life than in other climatic areas of Oregon.

Bluegill growth, estimated from the scale sample, is approximately the same between coastal lakes and reservoirs, lakes, and farm ponds in the Willamette Valley.

TABLE 6

GROWTH RATES OF 65 LARGEMOUTH BLACK BASS COLLECTED FROM FARM PONDS, LAKES, AND RESERVOIRS IN WESTERN OREGON

Age group	Total number	Average fork length (inches)	Calculated fork length (inches) at time of annulus formation				
			I	II	III	IV	V
I	18	6.6	2.3				
II	14	7.8	3.0	5.8			
III	19	10.6	3.9	7.8	9.8		
IV	10	11.7	2.9	6.6	9.5	10.9	
V	4	13.6	3.1	6.4	9.8	11.7	12.9
Average length			3.0	6.7	9.7	11.3	12.9
Increment of growth			3.0	3.7	3.0	1.6	1.6
Total number			65	47	33	14	4

TABLE 7

GROWTH RATES OF 160 BLUEGILL COLLECTED FROM PONDS, LAKES, AND RESERVOIRS IN WESTERN OREGON

Age group	Total number	Average fork length (inches)	Calculated fork length (inches) at time of annulus formation						
			I	II	III	IV	V	VI	VII
I	19	3.7	3.1						
II	55	4.8	3.2	4.4					
III	61	6.1	3.6	4.9	5.7				
IV	15	6.9	3.4	5.0	6.1	6.7			
V	3	7.0	3.5	4.4	6.2	6.5	6.8		
VII	7	8.0	3.4	4.8	5.9	6.5	7.0	7.4	7.8
Average length			3.4	4.7	5.9	6.6	6.9	7.4	7.8
Increment of growth			3.4	1.3	1.2	.7	.3	.5	.4
Total number			160	141	86	25	10		7

TABLE 8

GROWTH RATES OF 53 LARGEMOUTH BLACK BASS COLLECTED FROM FARM PONDS, LAKES, AND RESERVOIRS IN THE WILLAMETTE VALLEY

Age group	Total number	Average fork length (inches)	Calculated fork length (inches) at time of annulus formation				
			I	II	III	IV	V
I	18	6.6	2.3				
II	13	7.8	3.2	5.8			
III	14	10.6	4.3	8.1	9.7		
IV	7	11.3	2.9	6.6	9.5	10.6	
V	1	12.1	3.1	5.7	7.9	9.8	10.9
Average length			3.3	6.6	9.0	10.2	10.9
Increment of growth			3.3	3.3	2.4	1.3	.7
Total number			53	35	22	8	1

TABLE 9

GROWTH RATES OF 12 LARGEMOUTH BLACK BASS COLLECTED FROM LAKES ON THE OREGON COAST

Age group	Total number	Average fork length (inches)	Calculated fork length (inches) at time of annulus formation				
			I	II	III	IV	V
I	0						
II	1	8.7	1.9	6.7			
III	5	10.6	2.9	6.8	9.9		
IV	3	12.7	3.1	6.9	10.1	12.3	
V	3	14.1	3.1	6.6	10.5	12.3	13.6
Average length			2.8	6.8	10.2	12.3	13.6
Increment of growth			2.8	4.0	3.4	2.1	1.3
Total number				12	11	6	3

TABLE 10

GROWTH RATES OF 138 BLUEGILL COLLECTED FROM FARM PONDS, LAKES, AND RESERVOIRS IN THE WILLAMETTE VALLEY

Age group	Total number	Average fork length (inches)	Calculated fork length (inches) at time of annulus formation				
			I	II	III	IV	V
I	16	3.8	3.1				
II	51	4.8	3.2	4.3			
III	57	6.2	3.6	4.9	5.8		
IV	12	7.1	3.4	5.1	6.2	6.8	
V	2	7.0	3.4	4.2	6.1	6.5	6.8
Average length			3.3	4.6	6.0	6.7	6.8
Increment of growth			3.3	1.3	1.4	.7	.1
Total number			138	122	71	14	2

TABLE 11

GROWTH RATES OF 22 BLUEGILL COLLECTED FROM LAKES ON THE OREGON COAST

Age group	Total number	Average fork length (inches)	Calculated fork length (inches) at time of annulus formation						
			I	II	III	IV	V	VI	VII
I	3	3.9	3.2						
II	4	5.3	3.6	4.9					
III	4	5.2	3.1	3.9	4.6				
IV	3	6.6	3.3	4.8	5.7	6.3			
V	1	7.1	3.7	5.0	6.2	6.6	6.9		
VII	7	8.0	3.4	4.8	5.9	6.6	6.9	7.4	7.8
Average length			3.4	4.7	5.6	6.5	6.9	7.4	7.8
Increment of growth			3.4	1.3	.9	.9	.4	.5	.4
Total number			22	19	15	11	8		7

TABLE 12

GROWTH RATES OF LARGEMOUTH BLACK BASS FROM VARIOUS CLIMATIC AREAS OF OREGON

Climatic area and author	Total number	Calculated fork length (inches) at time of annulus formation						
		I	II	III	IV	V	VI	VII
State of Oregon								
Locke	*	5.9	8.5	9.0	11.2	13.9	13.4	16.0
Becker	57	2.5	5.1	8.1	10.4	12.3	14.3	14.9
Hermann	36	3.5	6.3	8.6	10.3	11.0		
Oakley	65	3.0	6.7	9.7	11.3	12.9		
	Average	3.7	6.7	8.8	10.8	12.5	13.9	15.5
	Annual Increment	3.7	3.0	2.1	2.0	1.7	1.4	1.6
Willamette Valley								
Becker	42	2.1	5.5	8.5	10.6	12.4	14.1	14.9
Hermann	*	3.5	6.4	8.4	10.3			
Oakley	53	3.3	6.6	9.0	10.2	10.9		
	Average	3.0	6.2	8.6	10.4	11.7	14.1	14.9
	Annual Increment	3.0	3.2	2.4	1.8	1.3	2.4	.8
Oregon Coast								
Becker	3	2.2	5.9	12.8	15.8			
Hermann	*	3.9	5.4	9.9	13.6			
Oakley	12	2.8	6.8	10.2	12.3	13.6		
	Average	2.9	6.0	10.9	13.9	13.6		
	Annual Increment	2.9	3.1	4.9	3.0			
Southern Oregon								
Becker	12	1.5	4.5	6.6	10.1	11.7	14.6	
	Annual Increment	1.5	3.0	2.1	3.5	1.6	2.9	

* Number of scale samples not known.

TABLE 13

AGE AND LENGTH RELATIONSHIPS OF BLUEGILL FROM VARIOUS STATES

State and Investigator	Age classes (total length in inches) 1	2	3	4	5	6	7	8
Oklahoma (45)	4.1	4.9	6.1					
North Carolina (17)	3.1	3.9	5.5	7.1	8.5	9.2		
California (57)	4.1	6.5	8.1	8.9	9.1			
Tennessee (19)	5.6	6.7	7.6	8.4	9.5	10.2		
Tennessee (45)	3.1	3.7	4.5	4.9				
Kentucky (66)	4.5	5.6	6.3	6.8	7.8			
Virginia (19)	2.2	4.1	6.4	8.0	8.9	9.8		
Missouri (45)	2.5	4.2	5.6	6.6				
West Virginia (17)		6.3	9.1					
Illinois (45)	1.3	3.5	4.9	6.0				
Illinois (45)	2.8	4.5	5.3	5.6				
Illinois (45)	1.8	4.8	6.4	7.4				
Indiana (45)	1.5	3.0	4.8	6.5				
Indiana (17)	1.8	4.1	5.9	6.9				
Ohio (45)	1.3	3.0	4.5	5.7				
Ohio (45)	4.0	5.2	6.6					
Ohio (57)	3.6	5.1	5.9	6.9	7.4			
Oregon (Oakley)	3.5	4.8	6.1	6.8	7.1	7.6	8.0	
Oregon (48)	3.3	4.8	6.0	6.5	6.6	6.7	7.3	7.4
Iowa (45)	1.4	3.4	6.1	7.2				
Iowa (46)	1.7	3.6	5.6	7.0	7.5	7.9		
Iowa (46)	1.4	3.4	6.1	7.2	8.1	8.6	10.3	
New York (28)	3.5	4.3	6.3					
Michigan (57)	3.1	4.3	5.4	6.6	7.3			
Michigan (2)	2.5	4.2	5.4	6.4	8.1	8.9	9.4	9.9
Wisconsin (19)	4.7	5.3	6.2	7.4	7.8	8.1	8.5	
Montana (19)	1.1	3.1	5.4	6.5	6.8	7.8		
Minnesota (17)	1.9	3.4	4.9	6.1	7.1	7.8	8.3	

TABLE 14

AGE AND LENGTH RELATIONSHIPS OF LARGEMOUTH BLACK BASS FROM VARIOUS STATES

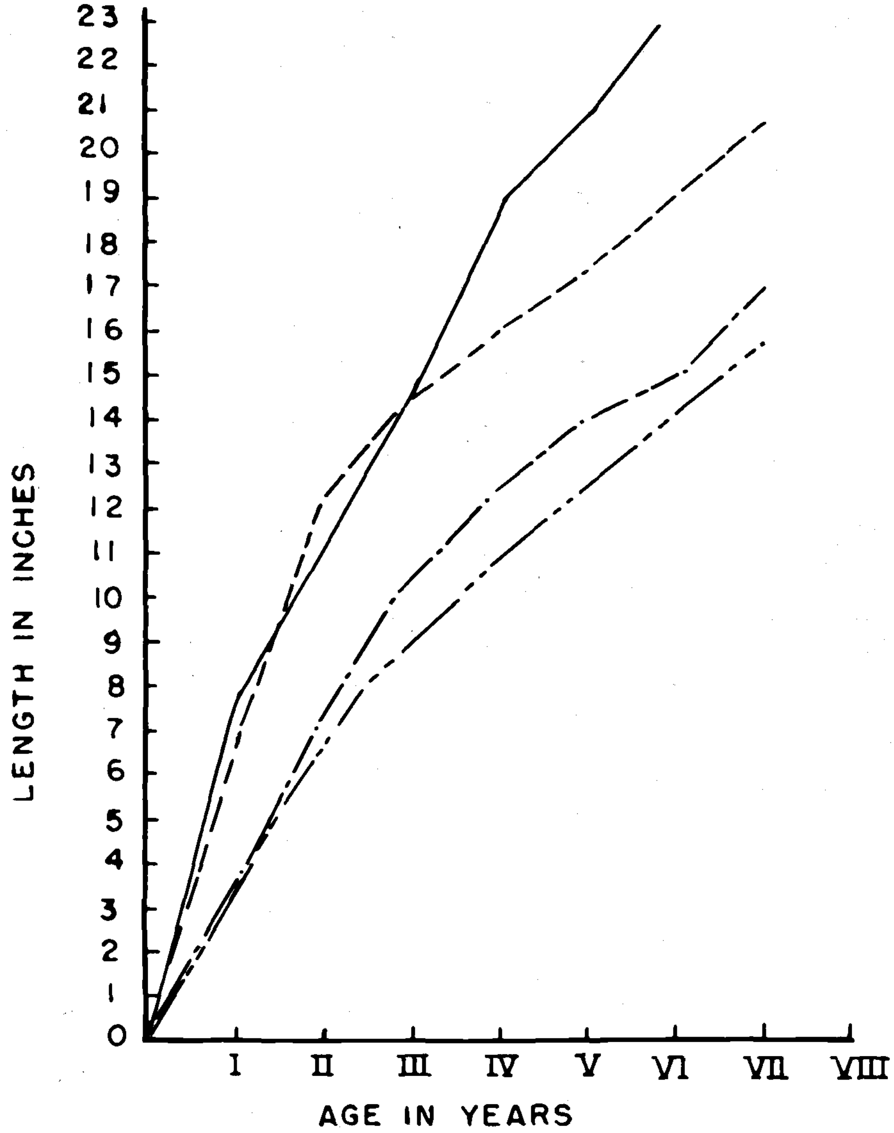
State and Investigator	Age classes (total length in inches)							
	1	2	3	4	5	6	7	8
Florida (19)	7.0	11.0						
Louisiana (57)	7.7	11.3	14.6	19.0	21.0	23.6	25.0	
Oklahoma (19)	4.6	7.6	10.4	13.1	15.8	19.8		
Oklahoma (19)	3.7	7.8	10.4	13.2	14.9	18.6	20.7	
North Carolina (19)	8.0	10.8	12.7	15.0	16.9	19.0	20.7	22.1
California (27)	6.9	10.1	13.7	15.5	17.0			
California (57)	6.7	12.2	14.8	16.7	19.8	21.4		
Tennessee (57)	6.9	12.2	14.6	16.2	17.5	19.3	20.8	
Kentucky (19)	5.9	11.5	14.5	15.6	19.0			
Kentucky (66)	5.8	10.0	14.0	15.7	17.4	18.9	20.7	21.9
Virginia (19)	5.6	10.8	14.0	15.9	16.9	17.8		
Missouri (19)	3.7	8.8	11.9	14.8	17.6			
New Mexico (55)	10.7	13.4	16.2	18.1	20.6	21.3	23.0	23.5
Illinois (17)	3.8	8.1	11.4	13.3	14.9	16.6	19.6	19.5
Indiana (17)	4.0	7.2	9.4	14.6				
New Jersey (19)	7.6	11.0	13.0	14.3	16.8	17.3	18.8	20.2
Ohio (17)	3.5	7.0	10.1	12.5	14.5	16.1	17.7	18.9
Nevada (27)	10.3	12.6	13.4	14.6	15.2	16.4	20.1	
Nebraska (17)	3.6	7.6	10.9	13.5	15.8	17.6	18.9	19.8
Oregon (43)*	5.9	8.5	9.0	11.2	13.9	13.4	16.0	16.0
Oregon (Oakley)*	3.0	6.7	9.7	11.3	12.9			
Oregon (7)*	2.6	5.1	8.1	10.4	12.3	14.3	14.9	
Oregon (37)*	3.5	6.3	8.6	10.3	11.0			
Connecticut (17)	5.1	8.3	10.7	12.9	14.7	16.2	17.5	
Iowa (46)	4.4	8.2	10.9	13.7	14.8	15.8	20.5	26.6
Iowa (46)	5.3	9.5	12.5	14.5	17.3		21.4	23.9
New York (28)	5.2	7.4	10.2					
Michigan (57)	6.1	8.7	10.0	12.1	13.7	15.1		
Michigan (2)	5.9	9.5	10.6	11.5	12.9	13.7	15.4	19.0
Wisconsin (9)	3.5	7.5	10.5	12.5	14.0	15.0	16.5	17.5
Montana (19)	2.1	6.4	10.3	10.8				
Minnesota (17)	3.5	6.7	9.3	11.5	13.1	15.1	16.3	17.6

* Fork length was used for fish measurements.

FIGURE II – GROWTH RATES OF LARGEMOUTH BLACK BASS FROM FOUR STATES

LEGEND
LOUISIANA ———— OREGON —— - - ——
TENNESSEE - - - - WISCONSIN —·——·

DATA FROM TABLE 14



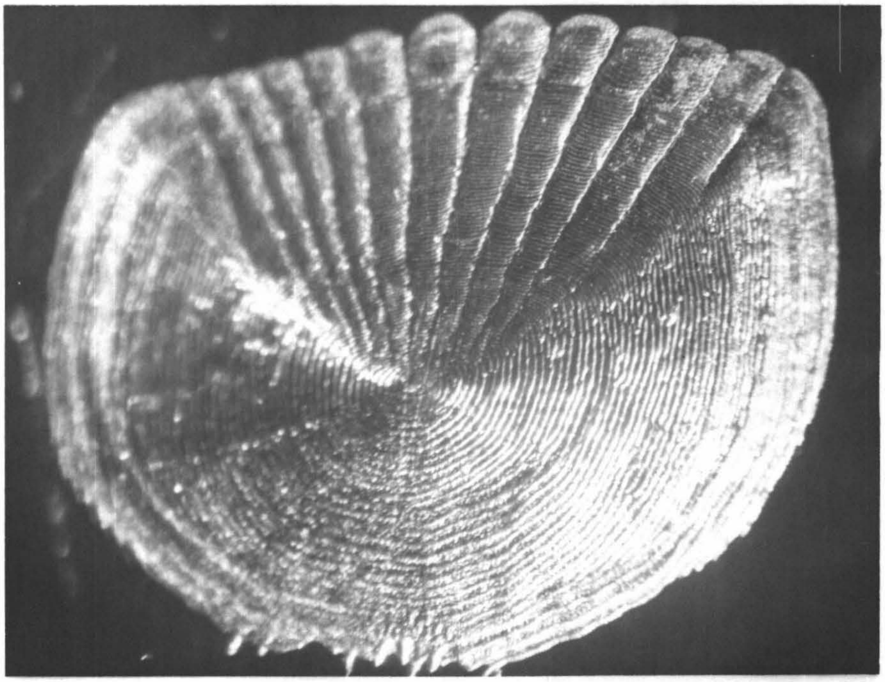


Figure III. Bluegill scale showing two annuli.

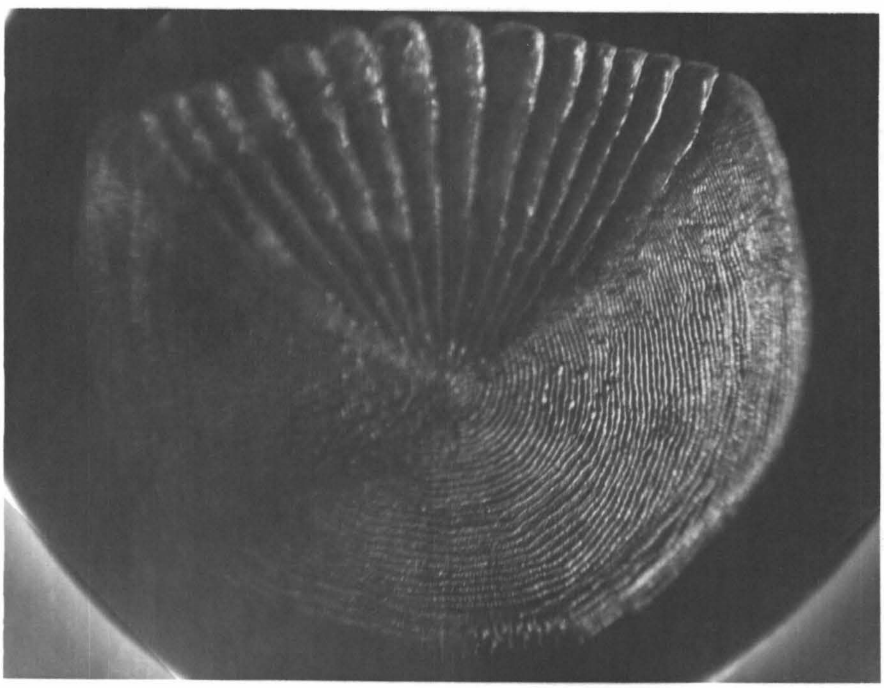


Figure IV. Bluegill scale showing three annuli.

THE BASS AND BLUEGILL IN OREGON

As was previously mentioned, bass and bluegill were introduced into Oregon waters in the late nineteenth century. Until recent years very little angling pressure has been exerted on warm water species because of the wonderful salmon and trout fishing areas in Oregon which have lured people from all over the world. However, with increased angling pressure exerted on salmonid fish paralleled by the rapid increase in Oregon's populace, demand for good warm water angling has increased.

In 1950 the Oregon State Game Commission began to expand its warm water game fish program (51, p. 151). Some of the early projects included stomach analysis of largemouth black bass, bass spawning studies along the Willamette River, and angling success on warm water fishes.

Several lakes in the vicinity of Salem were used to determine the success of angling for warm water game fish. The average catch by anglers in these lakes was approximately one fish per hour (51, p. 154). This is a relatively low return for warm water game fish. Crappie were the most abundant fish taken in trap nets, but showed a poor return to anglers, possibly because of the angling methods employed on these lakes. The order of importance, as shown by this creel census program, was bluegill, bass, and crappie.

The construction of a hatchery for the propagation of warm water game fish was considered, but decided against as the cost of construction and maintenance was too great (51, p. 154). Also, bass fingerling could be obtained from other sources.

Initial recommendations for management practices of warm water game fish included public encouragement to utilize the existing fishery, the procurement by purchase or lease to existing restricted fishing areas near larger cities, the construction of rearing ponds on owned or leased land, and the establishment of additional warm water game fish areas near larger cities to provide good angling within short distances for the majority of Oregon's people (51, p. 157).

In 1951 the growth rates of warm water game fishes in Oregon was studied. Age-length relationships of bluegill and bass in Oregon are listed in Tables 13 and 14. The average length for bluegill sunfish was calculated to be six inches (52, p. 236). Bluegill reach a larger size in Siltcoos Lake as they average 7.3 inches in length there.

Maximum length of bass growth in Oregon is eight to ten inches in the second summer of life, and approximately fourteen inches in their third summer of life. No bass have been known to spawn in Oregon during their second summer of life or when one year old. Locke (52, p. 238) states that "It is conceivable under ideal conditions that largemouth bass in Oregon could spawn in their second summer, but such would be an exception rather than the rule."

In 1952 Locke found that two year old bass transported to a new area just prior to the time of spawning failed to reproduce, while similar fish retained in the pond produced fry (53, p. 270). The latter fish reproduced without the aid of forage species. Recently hatched fry have been observed as early as June 15 and as late as August 1 in Oregon.

In Oregon bluegill normally spawn in their second summer. Maximum growth of bluegill in Oregon in their third summer is approximately eight inches (53, p. 271). Reproduction extends over a considerable period of time when surface temperatures reach 75° to 80° F. It is believed that in some bodies of water, low temperatures prevailing throughout the summer may inhibit bluegill reproduction (53, p. 271).

In 1951 a two-acre farm pond in Marion County was stocked at the rate of 200 yearling bluegill to 100 yearling bass per acre. This pond was drained in 1953, and 520 pounds of bass and bluegill were recovered for a yield of 260 pounds per acre of water. Approximately 90 pounds per acre were adult fish. This pond was considered to be out of balance. Grenfell feels that this stocking ratio of 2:1 is in need of modification to result in a balanced population for the bluegill and bass ponds in the Willamette Valley (34, p. 344). Four additional farm ponds were stocked in several different ratios to obtain a good ratio that will result in balanced populations in the Willamette Valley.

In 1954 another creel census study was conducted by Grenfell. He found an average return of 1.18 warm water fish per angler (32, p. 213). The catch was composed of bluegill (43%), bullheads

(31%), largemouth bass (9%), yellow perch (9%), and crappie (8%).

A 2.3-acre pond was stocked in 1952 with 15,000 largemouth bass fry ranging from one to one and one-half inches in length. This pond was drained in 1954. The fish were twenty-two months old and ranged from 5.0 to 11.6 inches in length (35, p. 207). At the time of drawdown, 2,140 fish were removed. These fish had successfully spawned at the age of two years. The total weight of fish removed was 124.78 pounds, or 54.2 pounds per acre.

SUMMARY AND RECOMMENDATIONS

Summary

The true success of the bluegill and bass stocking combination for farm fish ponds in Oregon has not yet been demonstrated as farm pond research in Oregon is still in its infancy. Therefore, comparisons with other areas of optimum bluegill and bass productivity must be made to evaluate this stocking combination in Oregon.

Many factors, which were discussed in the text, influence the success or productivity of this stocking combination. By far the greatest factor which will determine the future success of these fish in Oregon or other states is climate. Bass and bluegill are natural inhabitants of the warmer waters of the United States. Their best habitat includes areas where bass spawn after one year and bluegill spawn in less than one year or at least before two years. In the same areas, bass spawn first in March and April with some spawning in May. Bluegill spawn first from March to June in these states. These are areas with an annual temperature of 53° F. or higher. These same areas have a summer temperature of approximately 71° F. or higher, accompanied by winter temperatures that are higher than 33° F. These areas experience a frost-free period of at least one hundred and seventy days. Also, approximately one half of the total precipitation occurs during the summer months. This summer precipitation in all of these states, except Arizona and

New Mexico, is at least twenty inches.

States that meet the preceding climatic conditions should have good fish production because bass and bluegill grow and mature rapidly when exposed to these conditions. The majority of these conditions is fulfilled by states from Florida to West Virginia in Table 15 of the appendix. States from Pennsylvania to North Dakota in Table 15 of the appendix will not have optimum bass and bluegill production because the majority of climatic conditions necessary for good production is not fulfilled.

The State of Oregon has an annual temperature of 48.9° F. The average summer and winter temperatures are 64.1° F. and 33.9° F. The frost-free period varies from 52 to 275 days. Summer rainfall varies from 6 to 22 inches. Oregon has the nineteenth highest winter temperature, and the next to lowest summer temperature of all states.

The Willamette Valley has an annual temperature of 52.7° F., an average winter temperature of 40.8° F., and an average summer temperature of 64.4° F. There are an average of 189 frost-free days each year in this area. Warm season precipitation is 8.15 inches, with a total precipitation of 39.08 inches. Bass spawn first after two years, and spawning first begins in May. Bluegill spawn after one year, and June is the month when they first spawn in the Willamette Valley.

Southern Oregon has an annual temperature of approximately 53.6° F. The average winter temperature is 40.7° F., and the average summer temperature is 67.8° F. for this area. Annual precipitation is 24.32 inches, with 5.61 inches during the warm season. The frost-free period is 180 days.

The Oregon Coast has an average winter temperature of 45.7° F. The summer temperature averages 58.1° F. This area has an annual temperature of 51.9° F. The frost-free period extends for 247 days. Total precipitation is 76.76 inches, of which 16.46 inches is warm season precipitation.

Eastern Oregon has an annual temperature of 50.1° F., an average summer temperature of 68.3° F., and an average winter temperature of 32.8° F. The frost-free period is approximately 131 days. Annual precipitation is 11.29 inches, of which 3.79 inches is warm season precipitation.

Growth rates of bass from various states are compared in Table 14 of the text. In three years of growth, bass in Oregon average approximately 8.8 inches. During the same period of time bass in Kentucky, Tennessee, Virginia, New Mexico, and Louisiana grow to lengths of 14.5, 14.6, 14.0, 16.2, and 14.6 inches respectively. These states have annual temperatures of 56.8° F., 58.8° F., 55.9° F., 53.7° F., and 67.0° F. respectively. Oregon has an annual temperature of 48.9° F. These five states that obtain good bass growth have summer temperatures higher than 71° F. and winter temperatures higher than 35° F. These states also have frost-free seasons that extend for at least 170 days.

The Willamette Valley, southern Oregon, and the Oregon Coast all have mild winters which should eliminate winter kills of bass or bluegill. These areas all have frost-free periods of 180 days or more. Rainfall is adequate to maintain nearly the same water levels in ponds. All of these mentioned climatic conditions are favorable for excellent bass growth. However, the one serious detrimental climatic condition to bass growth in western and southern Oregon is the low summer temperature. Oregon has a summer temperature of 64.1° F., which is the next to coldest summer temperature of the forty-eight states. This relative cold summer condition causes bass to spawn later in the year, and grow less during summer months when most of the growth is attained. It is not conceivable that any other factor influences bass growth in Oregon as drastically as does this cold summer temperature.

Bluegill growth during the first three years in Oregon approximately parallels that recorded from most states in Table 13. States that have faster bluegill growth than Oregon are California, Tennessee, Kentucky, and West Virginia. These states all have favorable climatic conditions for faster bass or bluegill growth.

Bass and bluegill growth in eastern Oregon is inhibited by low winter temperatures. Furthermore, the warm season rainfall of 3.79 inches and short frost-free period of approximately 131 days is detrimental to good bass and bluegill growth.

Comparisons between bass growth rates in the Willamette Valley and coastal lakes is illustrated in Tables 8 and 9. Bass growth in coastal lakes is less the first year than in the Willamette Valley. The Willamette Valley has a summer temperature of approximately 64.4° F., while the average summer temperature of the Oregon Coast is only 58.1° F. This indicates that the colder summer of the coast inhibits bass spawning until later than bass spawning in the Willamette Valley. Therefore, less growth of coastal bass during their first year of life results.

After the first year of growth, bass from the coastal area exhibit greater growth than do bass from the Willamette Valley. After four years of life, coastal bass average 13.2 inches, while bass taken from the Willamette Valley average 10.5 inches. These data are from Table 12. This greater growth, after the first year of life, may be explained by a longer growing season on the Oregon Coast. The Willamette Valley has a frost-free period of approximately 189 days as compared to a frost-free period of approximately 247 days on the Oregon Coast.

A comparison of bluegill growth between the Willamette Valley and coastal area is calculated in Tables 10 and 11. Bluegill growth was approximately the same between the Willamette Valley and the coastal area. No correlation between bass and bluegill growth (Tables 6, 7, 8, 9, 10, and 11) and climatic conditions (Table 17, appendix) could be found from fish growth during 1950 to 1955.

Information concerning the productivity of bluegill and bass per acre of surface water in Oregon is based on the results of one pond. This pond was considered out of balance, yet the production was two hundred and sixty pounds per acre which is good production as compared with that of other states for unfertilized ponds. This production from one pond is favorable information when considering the low summer temperature of western Oregon. Fertilization is not recommended in Oregon because natural waters are fertile enough for fish production in proportion to angling intensity.

Results from the questionnaire show that thirty-seven states recommend the bluegill and bass stocking ratio for farm ponds in their states. Nine of the ten states that do not recommend the bluegill and bass stocking ratio have annual temperatures which are lower than 48.9° F. The northern distribution of bass and bluegill probably stops in areas where the winter temperature is approximately 20° F., accompanied by a frost-free period of approximately 140 days.

Fourteen state conservation agencies recommend the stocking of trout in farm ponds of their individual states. Trout should be stocked in farm ponds that do not have surface summer temperatures higher than 70° F.

Twenty-four states recommend the use of inorganic commercial fertilizers for increased fish production in farm ponds. These states are mostly southern, eastern, and midwestern states. Fertilization does increase the production of fish (Table 2), but in most cases is an extra expense as the surplus created is seldom harvested. In southeastern states, fertilizer must be used to offset poor soil conditions. Data from Table 4 indicate that pond fertilization does not increase the number of ponds which attain balanced conditions in several states.

The age and time of spawning of bass and bluegill are directly correlated with temperature conditions. Generally, bass spawn after one year in states with a minimum annual temperature of 53.0° F. In states with less than 53° F. annual temperature, bass require two years or longer to spawn. Bluegill spawn in approximately four months in states having a minimum annual temperature of 63° F. West Virginia is the exception to this spawning age. Bluegill spawn after one year in states which range in annual temperature from 45.5° F. to 63.0° F. Bluegill require two years to spawn in all other states. The age of spawning is important to properly managed bluegill and bass farm ponds.

Only 28 to 57 per cent of all farm ponds analyzed by other authors were in a balanced condition. Improper stocking ratios, unfavorable climatic conditions, stocking of physically unsuited ponds, lack of interest in ponds expressed by owners, and under-fishing are the main factors which cause this high percentage of pond failures.

The correct stocking ratio is necessary for a productive fish population. Tabulations from the questionnaire show that the most used ratio is ten bluegill for each largemouth black bass stocked. Seventeen states utilize this ratio in stocking farm ponds in their states. This is based mainly on results obtained by Mr. Swingle, and evidently the ratio works well in the fertilized ponds of our southeastern states. However, the ratio has failed in other states where climatic conditions vary greatly from those of the southeastern states. Five states that recommend adult bluegill stocked with small bass to insure an immediate food supply for the small bass are listed in Table 18 of the appendix. They are California, Kentucky, Iowa, Michigan, and Wisconsin. In general, more bluegill in proportion to bass are planted as temperatures increase.

The Oregon State Game Commission currently endorses the stocking ratio of three to six fingerling bluegill for each fingerling bass stocked. Research is being conducted by the Game Commission to determine an adequate stocking ratio for Oregon's farm ponds. The stocking ratio of 2:1 failed in one pond, and perhaps a ratio of one bluegill to one bass stocked would give better results. Another possibility is that of stocking one adult bluegill with ten bass fingerling.

Recommendations

1. Low summer temperature in western Oregon is a limiting factor in bass and bluegill growth, and consequently affects the productivity of these species in farm ponds. However, farm ponds in western Oregon are naturally fertile, and the correct stocking ratio with adequate pond management should somewhat compensate for the low summer temperature. More extensive research should be conducted to determine proper size, ratio, and rate of fish to be stocked. This knowledge is imperative because the demand for these two species may increase in future years.

2. Eastern Oregon presents more adverse climatic conditions than does western Oregon. Many areas east of the Cascades are probably just too cold for good bass and bluegill production. However, some of the low elevation areas could feasibly produce good bass and bluegill angling. Since there is a wide variation between western and eastern Oregon, research should be carried out in this area of the state to determine the growth rates of bass and bluegill, the stocking ratio, and the rate which will produce the best yields there.

3. Trout should be stocked in farm ponds that maintain temperatures too low for bass and bluegill. If the surface temperature stays below 70° F. during most of the summer months, trout should be utilized. The majority of these ponds are in higher elevation areas of the state and on the coast. Trout can also be utilized in some ponds in the Willamette Valley.

4. Fertilization of farm ponds in Oregon is not necessary to produce average returns to pond owners. Natural fertility of farm ponds in Oregon is usually good, and most owners would not harvest enough fish to merit the use of commercial fertilizers.

5. Bluegill should be stocked with bass in ponds to obtain greater fish yields, unless the owner is definitely interested only in bass. A pond stocked only with bass produced 54.2 pounds of fish per surface acre of water. Another pond in Marion county, stocked

with bass and bluegill, produced 260 pounds per surface acre of water.

6. The pond owner should be encouraged to catch as many fish as possible during all seasons of the year. Both bass and bluegill should be angled for intensively. Pond owners should be encouraged to allow public angling if they do not adequately catch the fish population. After the fish have spawned for the first time, all small fish should not be returned to the pond alive.

7. All ponds should be checked periodically to determine the condition of the fish population. A drain installed during pond construction is the best tool for population management in farm ponds.

8. Physically unsuited ponds should not be stocked with bluegill and bass. These ponds are those in which surface temperatures stay below 75° F. during the summer months, carry excessive loads of siltation for long periods of time, have extreme water fluctuations, have inadequate depth or size, and are subject to overflow by streams.

BIBLIOGRAPHY

1. Anderson, W. L. Results of an analysis of farm ponds in the midwest. Progressive fish culturist 10(3):111-117. 1948.

2. Applegate, Vernon C. and W. F. Carbine. The fish population of Deep Lake, Michigan. Transactions of the American fisheries society 75:200-227. 1945.

3. Ball, Robert C. Farm pond management in Michigan. Journal of wildlife management 16(3):266-269. 1952.

4. Ball, Robert C. and Howard A. Tanner. The biological effects of fertilizer on a warm-water lake. East Lansing, Michigan state college, 1951. 31p. (Michigan state college. Agricultural experiment station. Technical bulletin 223)

5. Ball, Robert C. and Howard D. Tait. Production of bass and bluegill in Michigan ponds. East Lansing, Michigan state college, 1952. 24p. (Michigan state college. Agricultural experiment station. Technical bulletin 231)

6. Barnickol, Paul B. and R. S. Campbell. Summary of selected pond studies in Missouri. Journal of wildlife management 16(3):270-274. 1952.

7. Becker, Clarence D. Unpublished research on growth studies of the largemouth black bass, Micropterus salmoides (Lacepede), in Oregon. Corvallis, Oregon state college, Dept. of fish and game management, 1954.

8. Bennett, George W. Experimental largemouth bass management in Illinois. Transactions of the American fisheries society 80:231-237. 1950.

9. Bennett, George W. Pond management in Illinois. Journal of wildlife management 16(3):249-253. 1952.

10. Bennett, George W. The growth of the largemouth black bass, Huro salmoides, in the waters of Wisconsin. Copeia, no. 2, 1937, pp. 104-118.

11. Bloss, John. Propagation of largemouth black bass and bluegill sunfish in federal hatcheries of the southwest. Progressive fish culturist 14(2):61-67. 1952.

12. Brown, C. J. and Nels A. Thoreson. Ranch farm ponds in Montana. Journal of wildlife management 16(3):275-278. 1952.

13. Brown, William H. Rate of survival of largemouth black bass fingerling stocked in experimental farm ponds. Progressive fish culturist 14(2):79-81. 1952.

14. Brown, William H. Results of stocking largemouth black bass and challel catfish in experimental Texas farm ponds. Transactions of the American fisheries society 80: 210-217. 1950.

15. Byrd, I. B. Depth distribution of the bluegill, Lepomis macrochirus (Rafinesque), in farm ponds during summer stratification. Transactions of the American fisheries society 81:162-169. 1951.

16. Carbine, W. F. Observations on the spawning habits of centrarchid fishes in Deep Lake, Oakland County, Michigan. Transactions of the North American wildlife conference 4:275-287. 1939.

17. Carlander, Kenneth D. Handbook of freshwater fishery biology. Dubuque, Iowa, William C. Brown Company, 1950. 281 p.

18. Carlander, Kenneth D. Farm fish pond research in Iowa. Journal of wildlife management 16(3):258-261. 1952.

19. Carlander, Kenneth D. First supplement to handbook of freshwater fishery biology. Dubuque, Iowa, William C. Brown Company, 1953. 429p.

20. Clark, Minor. Bass production in a Kentucky pond. Progressive fish culturist 12(3):147-151. 1950.

21. Clark, Minor. Kentucky's farm fish pond program. Journal of wildlife management 16(3):262-265. 1952.

22. Compton, D. M. Farm and ranch ponds. Journal of wildlife management 16(3):238-244. 1952.

23. Compton, Lawrence V. Techniques of fishpond management. Washington, U. S. Government printing office, 1942. 22p. (U. S. Dept. of agriculture. Miscellaneous publication no. 528)

24. Cooper, Edwin L. Small ponds for fishing. Wisconsin conservation bulletin 20:1-4. 1955.

25. Cooper, Gerald P. Food habits, rate of growth, and cannibalism of young largemouth black bass in state operated rearing ponds in Michigan during 1935. Progressive fish culturist Mem. I-131, 1936, no. 23, pp. 15-16.

26. Curtis, R. The warm water fishes of California. California fish and game 35(4):255-275. 1949.

27. Davison, Verne, E. Farm fishponds for food and good land use. Washington, U. S. Government printing office, 1947. 29p. (U. S. Dept. of agriculture. Farmers' bulletin 1983)

28. Dequine, John F. A brief progress report on management of the St. Johns River and Lake Okeechobee, and several other large Florida fresh waters. Transactions of the North American wildlife conference 17:235-237. 1952.

29. Dickson, Fred J. Georgia fish pond management. Atlanta, Georgia, 1955. 89p. (Georgia game and fish commission pamphlet)

30. Dill, William A. The fishery of the Lower Colorado River. California fish and game 30(2):109-212. 1944.

31. Eipper, Alfred W. Fish production in New York. Abstract of a talk given at the seventh annual meeting of the empire state chapter, soil conservation society of America, Ithaca, New York, January 19, 1953. 3p.

32. Fessler, Floyd R. Fish populations in some Iowa farm ponds. Progressive fish culturist 12(1):3-13. 1950.

33. Fuqua, Charles L. Analysis of farm ponds in Oklahoma, Texas, and New Mexico. Progressive fish culturist 11(3):179-185. 1949.

34. Grenfell, Ralph A. Warm water game fish. In the Annual report of the Oregon state game commission. Fishery division. Portland, Oregon. 1953. pp. 333-[illegible].

35. Grenfell, Ralph A. Warm water game fish. In the Annual report of the Oregon state game commission. Fishery division. Portland, Oregon. 1954. pp. 208-215.

36. Grey, Hugh (ed.). New fish laws. Field and stream 59:34-39. April, 1955.

37. Hermann, Robert. Unpublished research on growth of largemouth black bass in Oregon. Corvallis, Oregon state college, Dept. of fish and game management, 1955.

38. Holloway, Ancil D. An evaluation of fish pond stocking policy and success in the southeastern states. Progressive fish culturist 13(4):171-181. 1951.

39. Holloway, Ancil D. Farm ponds. Progressive fish culturist 9(2):155-159. 1947.

40. James, M. C. Propagation of pond fishes. In the Bureau of fisheries document no. 1056. Washington, Government printing office, 1929. pp. 19-50.

41. James, M. C., Lloyd O. Meehean, and E. J. Douglass. Fish stocking as related to the management of inland waters. Washington, U. S. Government printing office, 1944. 22p. (U. S. Dept. of the interior. Fish and wildlife service. Conservation bulletin no. 35)

42. Jones, Alden M. The length of the growing season of largemouth black bass in Norris Reservoir, Tennessee. Transactions of the American fisheries society 70:183-187. 1940.

43. Kimsey, J. B. Farm pond management problems in the far west. Presented as a talk at the western association of state game and fish commissioners meeting at Las Vegas, Nevada, May 4, 1954. 5p.

44. King, Willis. How can we provide more successful fishing trips in the southeast? Transactions of the North American wildlife conference 12:243-252. 1947.

45. Krumholz, Louis A. Management of Indiana ponds for fishing. Journal of wildlife management 16(3):254-257. 1952.

46. Krumholz, Louis A. New fish stocking policies for Indiana ponds. Transactions of the North American wildlife conference 15:251-269. 1950.

47. Lagler, Karl F. Freshwater fishery biology. Dubuque, Iowa, William C. Brown Company, 1952. 360p.

48. Lampman, Ben Hur. The coming of the pond fishes. Portland, Oregon, Metropolitian Press, 1946. 177p.

49. Lane, Charles E. Jr. Age and growth of bluegill, Lepomis macrochirus (Rafinesque), in a new Missouri impoundment. Journal of wildlife management 18(3): 358-365. 1954.

50. Lewis, William M. Fisheries investigation on two artificial lakes in southern Iowa. Iowa state college journal of science 24(3):187-324. 1950.

51. Locke, Fred E. Warm water game fish. In the Annual report of the Oregon state game commission. Fishery division. Portland, Oregon, 1950. pp. 151-167.

52. Locke, Fred E. Warm water game fish. In the Annual report of the Oregon state game commission. Fishery division. Portland, Oregon, 1951. pp. 230-240.

53. Locke, Fred E. Warm water game fish. In the Annual report of the Oregon state game commission. Fishery division. Portland, Oregon, 1952. pp. 255-272.

54. Lydell, Dewight. The habits and culture of the black bass. Transactions of the American fisheries society 31: 45-75. 1901.

55. Maciolek, John A. Artificial fertilization of lakes and ponds. Washington, U. S. Government printing office, 1954. 41p. (U. S. Dept. of the interior. Fish and wildlife service. Special scientific report - fisheries no. 113)

56. Meehean, Lloyd O. A method for the production of largemouth black bass on natural foods in fertilized ponds. Progressive fish culturist Mem. I-131, 1939, no. 47, pp. 1-19.

57. Meehean, Lloyd O. Farm fish ponds and their management. Washington, U. S. Government printing office, 1945. 9p. (U. S. Dept. of the interior. Fish and wildlife service. Fishery leaflet 27)

58. Meehean, Lloyd O. Problems of farm pond management. Journal of wildlife management 16(3):233-238. 1952.

59. Mottley, C. M. and T. K. Chamberlain. Management of game fish of Conchas Reservoir. Progressive fish culturist 10(4):177-187. 1948.

60. Moyle, John B. Fish population concepts and management of Minnesota lakes for sport fishing. Transactions of the North American wildlife conference 14:283-294. 1949.

61. Murphy, Garth I. Fishery of Clear Lake, Lake County, California. California fish and game 37(4): 439-485. 1951.

62. Murphy, Garth I. The closed season in warm-water fish management. Transactions of the North American wildlife conference 15:235-249. 1950.

63. Murphy, Garth I. The food of young largemouth black bass in Clear Lake, California. California fish and game 35(3):159-164. 1949.

64. Percy, Viosca Jr. Phenomenal growth rates of largemouth black bass in Louisiana waters. Transactions of the American fisheries society 72:68-71. 1942.

65. Rawson, D. S. and R. A. Rutton. Pond fish studies in Saskatchewan. Journal of wildlife management 16(3):282-288. 1952.

66. Saila, Saul B. Some results of farm pond management studies in New York. Journal of wildlife management 16(3): 279-282. 1952.

67. Schneider, Phillip W. and Francis P. Griffiths. Production of trout in a small artificial pond in western Oregon. Journal of wildlife management 7(2): 149-154. 1943.

68. Seaman, W. R. Fish culture - for fun:for profit. Denver, Colorado, n.d. 16p. (Colorado. Dept. of game and fish. Information pamphlet no. 6)

69. Sharp, R. W. Summary of farm pond inspections. Progressive fish culturist 12(3):147-151. 1950.

70. Smith, William A. Jr., James B. Kirkwood, and John F. Hall. A survey of the success of various stocking rates and ratios of bass and bluegill in Kentucky farm ponds. Frankfort, Kentucky, 1955. 42p. (Kentucky. Dept. of fish and wildlife resources. Division of fisheries. Fisheries bulletin no. 16)

71. Sprugel, George Jr. Growth of the bluegill in a new lake, with particular reference to a false annuli. Transactions of the American fisheries society 83: 58-75. 1953.

72. Stroud, Richard H. Management of warm-water fish populations in Massachusett lakes, ponds, and reservoirs. Transactions of the North American wildlife conference 17:214-220. 1952.

73. Surber, Eugene W. Production of bass fry. Progressive fish culturist Mem. I-131, no. 8, pp. 1-6.

74. Surber, Eugene W. Results of varying the ratio of largemouth black bass and bluegills in the stocking of experimental farm ponds. Transactions of the American fisheries society 77:141-151. 1947.

75. Swingle, H. S. Experiments with various rates of stocking bluegills, Lepomis macrochirus Rafinesque, and largemouth bass, Micropterus salmoides Lacepede, in ponds. Transactions of the American fisheries society 80:218-229. 1950.

76. Swingle, H. S. Farm pond investigations in Alabama. Journal of wildlife management 16(3):243-249. 1952.

77. Swingle, H. S. Fish populations in Alabama rivers and impoundments. Transactions of the American fisheries society 83:47-57. 1953.

78. Swingle, H. S. Some recent developments in pond management. Transactions of the North American wildlife conference 14:295-311. 1949.

79. Swingle, H. S. and E. V. Smith. Experiments on the stocking of fish ponds. Transactions of the North American wildlife conference 5:267-276. 1940

80. Swingle, H. S. and E. V. Smith. Factors affecting the reproduction of bluegill and black bass in ponds. Auburn, Alabama, 1943. 8p. (Alabama polytechnic institute. Agricultural experiment station. Circular no. 87)

81. Swingle, H. S. and E. V. Smith. Management of farm fish ponds. 2nd ed. Auburn, Alabama, 1947. 30p. (Alabama polytechnic institute. Agricultural experiment station. Bulletin no. 254)

82. Swingle, H. S. and E. V. Smith. Managing ponds for fish production. Progressive fish culturist Mem. I-131, 1941, no. 53, pp. 8-13.

83. Swingle, H. S. and E. V. Smith. Percentage of survival of bluegills (Lepomis macrochirus) and largemouth black bass (Micropterus salmoides) when planted in new ponds. Transactions of the American fisheries society 72: 63-67. 1942.

84. Swingle, H. S. and E. V. Smith. Results of further experiments on the stocking of fish ponds. Transactions of the North American wildlife conference 8:168-173. 1943.

85. Swingle, H. S. and E. V. Smith. The management of ponds with stunted fish populations. Transactions of the American fisheries society 71:102-105. 1941.

86. Swingle, H. S. and E. V. Smith. Winter and summer growth of bluegills in fertilized ponds. Transactions of the American fisheries society 70:335-338. 1940.

87. Tiemeier, Otto W. The construction and management of Kansas ponds. Pratt, Kansas, n.d. 36p. (Kansas. Forestry, fish and game commission. Bulletin no. 9)

88. Toole, Marion. The management of fresh-water fisheries in Texas. Transactions of the North American wildlife conference 12:233-242. 1947.

89. U. S. Department of Agriculture. Climate and man. Agriculture yearbook, 1941. Washington, U. S. Government printing office. 1248p.

90. U. S. Department of Commerce. Weather Bureau. Climatological data for the United States by sections. National summary. Vol. 4, no. 13. Washington, U. S. Government printing office, 1953.

91. U. S. Department of Commerce. Weather Bureau. Climatological data for the United States by sections. Vol. 5, no. 12. Washington, U. S. Government printing office, 1954.

92. U. S. Department of Commerce. Weather Bureau. Climatological data for the United States by sections. Vol. 6, no. 1-11. Washington, U. S. Government printing office, 1955.

93. U. S. Department of the Interior. The black basses. Washington, U. S. Government printing office, 1944. 4p. (Fish and wildlife service. Fishery leaflet no.76)

94. Whitney, Richard R. and Kenneth D. Carlander. Interpretation of body-scale regression for computing body length of fish. Journal of wildlife management 20(1):21-27. 1956.

95. Zeller, Howard D. Nitrogen and phosphorus concentrations in fertilized and unfertilized farm ponds in central Missouri. Transactions of the American fisheries society 82:282-288. 1952.

APPENDIX

TABLE 15

CLIMATIC CONDITIONS FOR STATES IN THE UNITED STATES

State*	Annual Temp.	Winter Temp.	Summer Temp.	Frost-Free Period	Summer Precp.	Total Precp.
Florida	70.9	59.9 (1)	30.9 (3)	240-365	32-42	48-64
Louisiana	67.0	52.0 (2)	81.0 (2)	220-350	28	54
Mississippi	64.7	48.5 (4)	80.3 (5)	230	26	54
Georgia	64.6	48.6 (3)	79.5 (6)	245	26	50
Texas	64.3	48.5 (5)	81.4 (1)	180-320	6-28	10-50
Alabama	64.0	47.8 (6)	79.5 (7)	250	30	57
South Carolina	63.2	46.9 (7)	78.9 (9)	190-290	28	48
Arkansas	61.4	42.5 (11)	79.2 (8)	220	26	48
Oklahoma	60.8	40.4 (13)	80.6 (4)	215	22	34
Arizona	60.0	42.8 (10)	77.6 (10)	180-320	6	6-28
North Carolina	59.7	42.9 (9)	76.1 (13)	160-280	26	51
California	59.2	45.4 (8)	73.2 (20)	80-340	1-10	10-70
Tennessee	58.8	40.3 (12)	76.5 (12)	200	25	52
Kentucky	56.8	37.1 (15)	75.6 (15)	190	24	46
Virginia	55.9	37.3 (14)	74.4 (16)	160-230	24	40-42
Kansas	55.2	32.4 (24)	77.2 (11)	180	20	28
Delaware	55.1	35.5 (17)	74.0 (18)	190	22	42
Missouri	55.0	32.8 (22)	75.8 (14)	185	24	40
Maryland	54.1	34.2 (18)	73.1 (21)	180	20-30	36-46
New Mexico	53.7	35.8 (16)	71.7 (24)	100-220	10	16
West Virginia	53.0	33.8 (20)	71.6 (27)	170	24	44
Illinois	52.8	29.6 (29)	74.3 (17)	180	22	38
Indiana	52.5	30.3 (27)	73.5 (19)	170	22	40
New Jersey	52.2	31.9 (25)	71.7 (25)	170	24	44
Ohio	51.4	30.3 (28)	71.7 (26)	160	22	38
Nevada	51.0	32.8 (23)	70.0 (30)	80-280	4	10

TABLE 15 (CONTINUED)

State*	Annual Temp.	Winter Temp.	Summer Temp.	Frost-Free Period	Summer Precp.	Total Precp.
Pennsylvania	50.3	29.5 (30)	70.2 (28)	160	22	40
Rhode Island	49.6	30.6 (26)	68.1 (34)	170	21	44
Nebraska	49.5	25.6 (35)	72.6 (22)	150	18	24
Oregon	48.9	33.9 (19)	64.1 (47)	52-275	6-22	8-120
Washington	48.9	33.0 (21)	64.5 (45)	100-300	6-14	16-60
Connecticut	48.7	28.0 (31)	68.4 (32)	170	24	46
Iowa	48.6	22.2 (38)	72.3 (23)	155	23	32
Massachusetts	48.3	27.7 (32)	68.2 (33)	160	22	44
Utah	48.0	27.3 (33)	68.7 (31)	60-200	6	12
New York	46.0	23.7 (37)	67.1 (36)	150	23	42
Idaho	45.6	25.9 (34)	65.1 (42)	60-120	4-10	8-50
South Dakota	45.5	19.4 (44)	70.1 (29)	140	14	19
Colorado	45.3	25.5 (36)	64.9 (43)	40-180	4-16	10-22
Michigan	44.7	21.6 (39)	66.6 (38)	140	18	30
Wisconsin	43.4	17.0 (46)	67.4 (35)	140	21	30
Vermont	43.3	19.5 (43)	65.5 (41)	140	22	40
Montana	43.2	20.8 (44)	64.9 (44)	130	10	16
New Hampshire	43.2	20.7 (42)	65.5 (40)	140	24	42
Maine	42.9	19.2 (45)	64.3 (46)	140	22	40
Wyoming	42.0	21.0 (40)	63.9 (48)	40-140	10	16
Minnesota	41.3	12.1 (47)	67.1 (37)	130	18	26
North Dakota	40.0	10.4 (48)	66.5 (39)	120	12	18

* States are listed in rank of warmest annual temperature to coldest annual temperature.
( ) Indicates rank of state in comparison with other states for winter and summer temperatures.

TABLE 16

CLIMATIC CONDITIONS FOR OREGON

Area	Annual Temp. (degrees)	Winter Temp. (degrees)	Summer Temp. (degrees)	Frost-Free Period (days)	Annual Precp. (inches)	Warm Season* Precp. (inches)
Willamette Valley						
Portland	53.1	40.9	63.6	207	39.91	8.77
Salem	52.9	41.1	65.2	188	39.85	7.84
Corvallis	52.4	40.8	64.4	183	39.06	7.86
Eugene	52.5	40.5	64.5	181	37.51	8.14
Average	52.7	40.8	64.4	189	39.08	8.15
Southern Oregon						
Medford	53.8	39.4	69.8	174	18.15	4.39
Roseburg	53.4	42.1	65.9	187	30.50	6.86
Average	53.6	40.7	67.8	180	24.32	5.61
Coastal Area						
Seaside	51.9	45.2	58.9	187	75.86	18.38
Tillamook	50.6	43.6	57.8	-	93.50	21.68
North Bend	51.9	45.0	58.8	263	64.13	12.98
Gold Beach	52.3	47.3	57.3	266	75.67	13.68
Brookings	53.0	47.4	58.0	275	78.68	15.62
Average	51.9	45.7	58.1	247	76.76	16.46
Eastern Oregon						
The Dalles	53.1	35.4	70.2	192	15.49	2.90
Arlington	54.1	35.6	72.5	178	12.72	4.38
Antelope	48.3	32.5	64.6	97	9.05	2.21
Bend	46.7	32.1	65.6	52	11.63	4.38
La Grande	49.2	32.2	66.7	136	19.35	7.51

TABLE 16 (CONTINUED)

Area	Annual Temp. (degrees)	Winter Temp. (degrees)	Summer Temp. (degrees)	Frost-Free Period (days)	Annual Precp. (inches)	Warm Season* Precp. (inches)
Hermiston	52.7	33.5	71.4	160	8.24	2.55
Baker	45.3	27.0	62.9	115	10.02	4.64
Warm Springs Res.	49.2	29.5	68.5	134	7.53	3.08
Paisley	48.4	34.2	70.0	96	8.60	2.08
Pendleton	52.0	35.3	69.1	117	12.96	4.52
Owyhee Dam	52.4	34.2	70.0	172	8.66	3.45
Average	50.1	32.8	68.3	131	11.29	3.79

* April through September

TABLE 17

TEMPERATURE CONDITIONS FOR OREGON FROM 1950 TO 1955

Year	State of Oregon			Willamette Valley		Oregon Coast	
	Annual Temp.	Winter Temp.	Summer Temp.	Winter Temp.	Summer Temp.	Winter Temp.	Summer Temp.
1950	48.3	32.7	64.3	37.9	65.9	42.6	58.6
1951	48.4	33.0	64.3	44.0	66.0	47.1	57.2
1952	48.5	33.0	63.7	39.5	64.6	43.7	57.6
1953	49.5	38.3	61.8	44.0	63.1	47.1	58.3
1954	48.2	35.6	60.7	42.1	61.3	46.6	57.1
1955	46.3	31.9	62.7	40.2	62.5	44.2	56.6

TABLE 18

SPECIES RECOMMENDED FOR STOCKING FARM FISH PONDS IN THE UNITED STATES

State	Bass & Bluegill in combination	Stocking ratio Bluegill:Bass	Size at liberation	Trout	Crappie	Channel Catfish	Redear
Florida	Yes	10:1	Fingerling	No	No	No	No
Louisiana	Yes	15:1	Fry	No	Yes	No	No
Mississippi	Yes	10:1	Fingerling	No	No	No	No
Georgia	Yes	10:1	Fingerling	No	No	No	No
Texas	No	Redear:Bass 1-1.5:2	Fry	No	No	Yes	Yes
Alabama	Yes	10:1	Bass fry Fingerling bg.	No	No	No	No
South Carolina	Yes	10:1	Fingerling	No	No	No	No
Arkansas	Yes	10:1	Fingerling	No	Yes	Yes	No
Oklahoma	Yes	3:4	Fingerling	No	No	Yes	Yes
Arizona	Yes	2:1	Fingerling	No	No	No	No
North Carolina	Yes	**	-	No	No	No	No
California	Yes	1:10	Adult bg. Bass fry	No	No	No	Yes

TABLE 18 (CONTINUED)

State	Bass & Bluegill in combination	Stocking ratio Bluegill:Bass	Size at liberation	Trout	Crappie	Channel Catfish	Redear
Tennessee	Yes	10:1	Fingerling	No	No	Yes	Yes
Kentucky	Yes	4:10	Adult bg. Bass fry	No	No	No	Yes
Virginia	Yes	10:1	Fingerling	No	No	No	No
Kansas	Yes	3:1	Fingerling	No	Yes	Yes	No
Delaware	Yes	**	Fingerling	No	No	No	No
Missouri	Yes	10:1	Fingerling	No	No	Yes	No
Maryland	Yes	10:1	Fingerling	No	No	No	No
New Mexico	Yes	10:1	Fingerling	No	No	Yes	Yes
West Virginia	Yes	10:1	Fingerling	Yes	No	No	No
Illinois	Yes	1:1	Fingerling	No	No	Yes	No
Indiana	Yes	1:1	Fingerling	No	Yes	Yes	No
New Jersey	Yes	1-3:1	Fingerling	No	No	No	No
Ohio	Yes	1:1	Fingerling	No	No	No	No
Nevada	No	Bass only	Fingerling	Yes	No	No	No

TABLE 18 (CONTINUED)

State	Bass & Bluegill in combination	Stocking ratio Bluegill:Bass	Size at liberation	Trout	Crappie	Channel Catfish	Redear
Pennsylvania	Yes	10:1	Fingerling	Yes	No	No	No
Rhode Island	Yes	10:1	Fingerling	Yes	No	No	No
Nebraska	Yes	1:1	Fingerling	No	Yes	Yes	No
Oregon	Yes	3-6:1	Fingerling	Yes	No	No	No
Washington	No	*	-	Yes	No	No	No
Connecticut	No	*	-	Yes	No	No	No
Iowa	Yes	1:10	Adult bg. Bass fry	No	No	Yes	No
Massachusetts	Yes	10:1	Fingerling	Yes	No	No	No
Utah	No	**	-	No	No	No	No
New York	No	**	-	Yes	No	No	No
Idaho	No	*	-	No	No	No	No
South Dakota	Yes	10:1	Fingerling	No	No	Yes	No
Colorado	Yes	4:1	Fingerling	No	Yes	Yes	No
Michigan	Yes	1:10	Adult bg. Bass fry	Yes	No	No	No

TABLE 18 (CONTINUED)

State	Bass & Bluegill in combination	Stocking ratio Bluegill:Bass	Size at liberation	Trout	Crappie	Channel Catfish	Redear
Wisconsin	Yes	1:10	Adult bg. Bass fry	No	No	No	No
Vermont	Yes	10:1	Fingerling	Yes	No	No	No
Montana	Yes	2-5:1	Fingerling	Yes	No	No	No
New Hampshire	No	*	-	No	No	No	No
Maine	No	*	-	Yes	No	No	No
Wyoming	No	Bass alone	Fingerling	Yes	No	No	No
Minnesota	No	*	-	No	No	No	No
North Dakota	Yes	6:1	Fingerling	No	No	No	No

* Do not recommend the bluegill:bass stocking ratio.
** Research in progress to determine the best species and correct numbers for stocking.

TABLE 19

AGE AND SPAWNING OF BASS AND BLUEGILL

State	Age at first spawning (years)		Month when spawning first occurs	
	Bass	Bluegill	Bass	Bluegill
Florida	One	Less than one	March	May
Louisiana	One	Less than one	March	May
Mississippi	One	Less than one	May	June
Georgia	One	Less than one	April	May
Texas	One	Less than one	March	March
Alabama	One	Less than one	April	May
South Carolina	One	Less than one	May	May
Arkansas	One	One	March	April
Oklahoma	Two	One	April	May
Arizona	Two	One	April	May
North Carolina	One	One	April	May
California	One	One	March	May
Tennessee	One	One	April	May
Kentucky	One	One	April	May
Virginia	One	One	April	May
Kansas	Two	One	May	May
Delaware	One	Two	May	May
Missouri	One	One	May	May
Maryland	One	Two	May	May
New Mexico	One	One	April	May
West Virginia	One	Less than one	April	May
Illinois	Two	One	May	May
Indiana	Two	Two	May	May
New Jersey	Two	Two	May	May
Ohio	One	One	April	May
Nevada	Two	Two	April	June
Pennsylvania	Three	Two	May	May

TABLE 19 (CONTINUED)

State	Age at first spawning (years)		Month when spawning first occurs	
	Bass	Bluegill	Bass	Bluegill
Rhode Island	Two	One	May	June
Nebraska	Two	One	May	June
Oregon	Two	One	May	June
Washington	Two	One	*	*
Connecticut	Two	Two	June	July
Iowa	Two	One	May	June
Massachusetts	Two	Two	June	June
Utah	*	*	*	*
New York	Two	One	May	June
Idaho	*	*	May	May
South Dakota	Two	One	May	June
Colorado	Two	Two	May	July
Michigan	Two	Two	June	May
Wisconsin	Two	Two	June	May
Vermont	Two	Two	June	May
Montana	Three	Two	May	May
New Hampshire	Two	*	*	*
Maine	*	*	*	*
Wyoming	Two	Two	July	May
Minnesota	Two	Two	May	May
North Dakota	Two	Two	June	June

* No available information

FARM POND QUESTIONNAIRE

Do you recommend the largemouth black bass and bluegill combination for stocking farm ponds in your state? (Yes or No) What stocking ratio gives the best results? Do you recommend the stocking of fry or fingerling in the initial stocking?

Do you recommend other stocking combinations, or the stocking of other individual fish species in the farm ponds of your state?

Do you recommend the same stocking combination and ratio for ponds located in every area of your state? (Yes or No) If you recommend different species, or different ratios, please briefly explain why you do.

Do you recommend commercial fertilizers for use in the farm ponds of your state? (Yes or No) Why?

As a general rule, when (what month) do largemouth black bass spawn in your state? Does this date differ in the northern and southern areas of your state? (Yes or No)

How old are largemouth black bass in your state when they become sexually mature? Do they spawn successfully at this age? (Yes or No)

How long is the growing season for largemouth black bass in your state? For bluegill?

As a general rule, when (what month) do bluegill first begin to spawn in your state? Do they continue to spawn all summer in your state? (Yes or No)

How old are bluegill in your state when they become sexually mature? Do they spawn successfully at this age? (Yes or No)

Is the largemouth black bass one of the most sought after game fish in your state? (Yes or No) Is it the <u>most</u> sought after game fish in your state by anglers? (Yes or No)