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Jim, thought you might be interested in this report.
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A SURVEY OF THE SUCCESS OF VARIOUS STOCKING RATES AND RATIOS OF BASS AND BLUEGILL IN KENTUCKY FARM PONDS

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Federal Aid to Fisheries, Project F-3-R

Job Completion Reports

JOB COMPLETION REPORTS

Investigations Project

State of Kentucky

Project F-3-R, FARM POND INVESTIGATIONS

Work Plan No. II, EXAMINATION OF PAST STOCKING RESULTS

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Introduction

The Kentucky Department of Fish and Wildlife Resources' farm pond stocking program was inaugurated in 1945 with the stocking of 150 ponds. Prior to this date pond stocking by this agency had been limited to incidental stocking of less than 100 ponds in the central area of the state. Over 24,000 ponds were reported stocked by Departmental personnel during the period 1945 through 1953, with a high of 6223 ponds being stocked in 1953. In view of present widespread pond construction and relaxation of size requirements, indications point to increased stocking with no leveling off point yet in sight.

Largemouth bass, Micropterus salmoides (Lacépède), and Kentucky bass, M. punctulatus (Rafinesque), have been available for pond stocking through state hatcheries since the outset of the stocking program; however, until 1947 bluegill, Lepomis macrochirus Rafinesque, were seined locally and delivered directly to the ponds of requesting individuals. Due to a greatly increased number of stocking requests during 1947, it was necessary to revamp the entire stocking procedure. Under the plan adopted at that time, and still in current use, bass and bluegill were delivered to a central point in each county, rather than to individual ponds.

Since 1947, bluegill have been largely supplied by U. S. Fish and Wildlife Service hatcheries, with some adult bluegill being procured by state fisheries personnel from ponds overcrowded with bluegill.

Two types of stocking have been used intermittently since 1945; adult bluegill with fingerling or fry bass and, fingerling bluegill with fingerling or fry bass. Adult bluegill ratios and rates were developed from an initial series of ponds stocked in 1945. Fingerling ratios and rates used were those recommended by the Alabama Agricultural Experiment Station and the U. S. Fish and Wildlife Service, with some later modifications being made by Kentucky fisheries personnel.

Clark (1952) reported that stocking a small number of adult bluegill with fry bass was more conducive to producing balanced bass - bluegill populations in Kentucky ponds than was the stocking of relatively larger numbers of fingerling bluegill with fry bass.

Current investigations were begun in November, 1951, as a part of the Dingle-Johnson program. The immediate project objectives are the testing of various stocking ratios, rates, and methods of stocking. The ultimate objectives are the development of stocking ratios, rates, and methods best adapted to Kentucky's climatic and soil characteristics.

An initial phase of the project was the evaluation of past stocking results. This phase was intended to serve the three-fold purpose of (1) ascertaining the relative success of various ratios and rates used previously, (2) determining the extent and effect of factors other than stocking ratios and rates on population balance, and (3) allowing directed stocking of third-series experimental ponds through augmentation of data obtained from first and second-series experimental ponds.

Major emphasis was placed on a determination of the relative success of the various ratios and rates used previously, with other probable factors contributing to pond failure being relegated to a secondary role. Placement of emphasis primarily on ratios and rates, however, is not to be construed as meaning that other factors were considered to be of lesser importance in determining pond success or failure.

Applicable findings resulting from this study have been applied to the remaining series of experimental ponds.

Certain portions of the data previously presented in quarterly progress reports are repeated here and the entire work plan presented as a unit in the interest of clarity and coherency.

JOB NO. II-A, SELECTION OF PONDS TO BE SURVEYED

Objectives

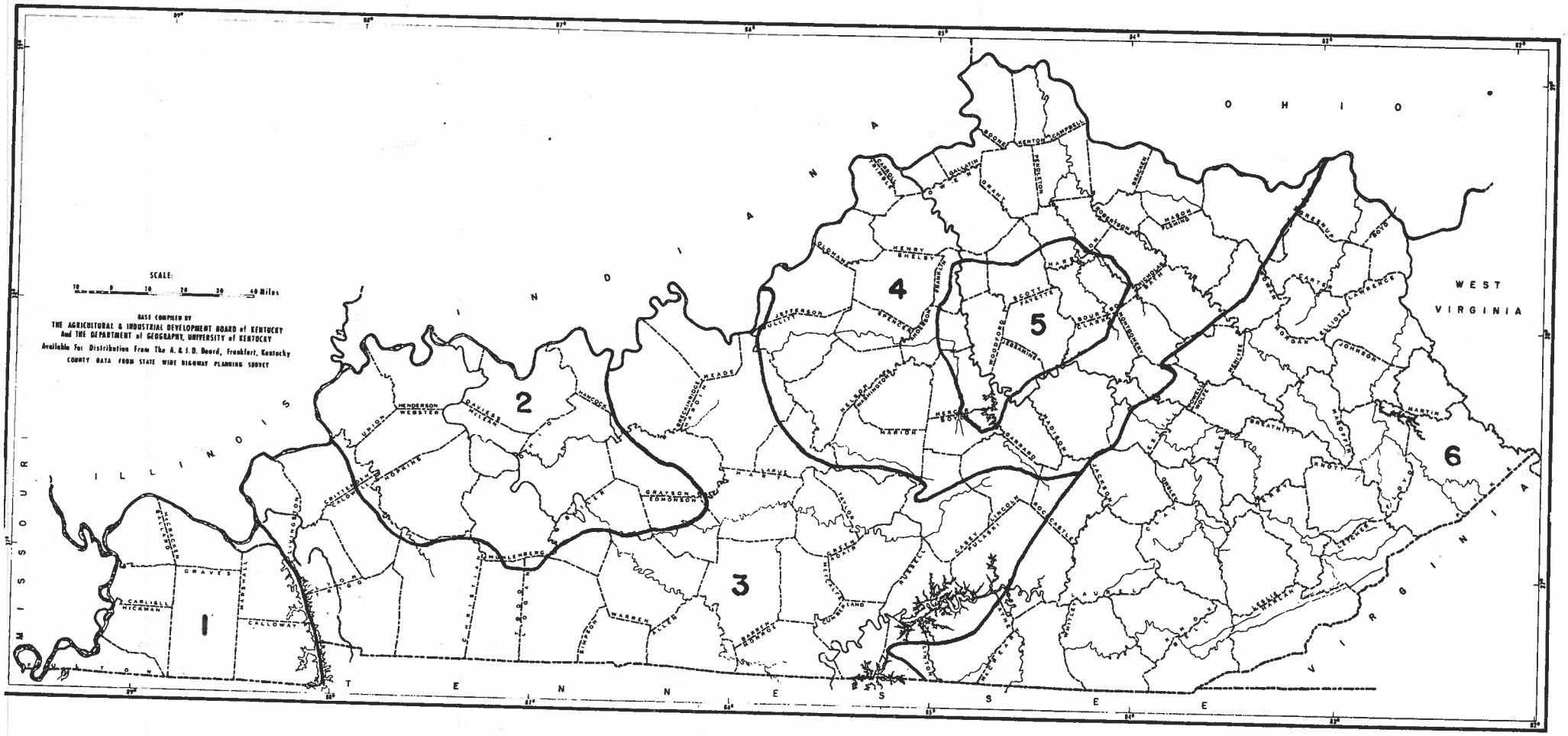
To select a number of ponds from the farm pond records of previous stockings, based on variations in size and soils regions, to use in evaluating past stocking ratios.

Techniques Used

Prior to the selection of any ponds, the state was divided into six major soils regions (Figure 1). These regions were based on recommendations of the Soils Department of the University of Kentucky and from publications of that institution and the U. S. Department of Agriculture. Kerraker (1950) described, in part, each of the major soils groups as follows:

1. Jackson Purchase: The Purchase consists of that portion of Kentucky lying west of the Tennessee River. Here most of the soils are derived from loess which ranges from 2 to 20 feet in thickness, and if unlimed

Fig. 1. MAJOR PHYSICAL DIVISIONS OF KENTUCKY



Legend

1. Jackson Purchase
2. Western Coalfields
3. Pennyroyal
4. Outer Bluegrass
5. Inner Bluegrass
6. Eastern Coalfields

are moderately to strongly acidic. They are low in phosphates but not as much so as the other soils outside of the bluegrass area.

2. Western Coalfields: In this section the upland soils are derived from sandstone and shale. They are low in phosphates and usually moderately to strongly acidic. Considerable loess has been deposited in that part of the area next to the Ohio River, but this and the overflow area contain few farm ponds.

3. Pennyroyal: The soils of this area are derived from sandstone, shales and limestone, either singly or in various combinations. All are slightly to strongly acidic and low in phosphates. The topography is generally sloping to hilly.

4. Outer Bluegrass: In this section the topography is rolling to hilly. The soil is derived from limestone and calcareous shales, with the latter predominating in the outer sections. The majority of the soils range from slightly to moderately acidic.

5. Inner Bluegrass: This area is well known for its productive soils derived from phosphatic limestone. Topographically it consists of gently rolling upland.

6. Eastern Coalfields: This region is typified by rugged and partly mountainous topography with very little bottom land. The soils are derived from sandstone and some shales. The greater portion of the area is in forest, and not suitable for agriculture. Very few farm ponds are located in this section, most of them being confined to a few southern counties.

A survey of Kentucky's past stocking records disclosed numerous ratios, both adult and fingerling, which were used frequently during the past six years (1946-1952). The ratios which were used most frequently, and all of those still in use, were given the most attention.

In order to expedite the field checking of ponds, stocking record cards were selected at random, first from counties containing the greatest numbers of ponds in each soils region, and then from counties containing fewer ponds until adequate numbers of ponds in each size group stocked with various ratios were obtained. The bulk of the ponds selected were stocked from 1948 through 1950, and the average age was three years. The accompanying tables (1 and 2) include the ratios used most frequently during the past six years and list the ponds selected for survey purposes in various size groups and soils regions. Not included in these tables are about 200 ponds stocked with various extreme ratios and some intermediate ratios thought worthy of attention in providing additional pertinent information. The selections were the widest available and the lack of ponds in certain soils regions and size groupings indicates non-availability.

Eight hundred seventy-two ponds were selected from the files for survey purposes. Two hundred seventy-two of these ponds were field checked during the summer of 1952. Following the field work in 1952, it was apparent that Job II-B could be greatly expedited and considerable time and effort saved if ponds of the following classifications could be eliminated without field checks by project personnel: (1) those poor physically, (2) those containing species other than bass and bluegill, (3) those inaccurately measured, and (4) those with a critically low water level during the first summer following stocking.

Table 1. RATIOS OF FINGERLING OR FRY BASS TO FINGERLING BLUEGILL

	Size in Acres	50:500	60:500	80:500	100:500	80:1000	100:1000	120:100
Pennyroyal	< ½	6	0	7	6	2	7	7
	½ - 1½	11	0	8	1	0	10	6
	1½ - 5	7	0	8	3	1	5	3
	5 - 15	1	0	3	1	0	0	0
Jackson Purchase	< ½	4	0	4	4	0	0	1
	½ - 1½	6	0	5	2	0	0	0
	1½ - 5	4	0	5	1	0	1	1
	5 - 15	0	0	2	0	0	0	0
Outer Bluegrass	< ½	1	5	7	1	0	3	4
	½ - 1½	11	1	9	2	3	6	7
	1½ - 5	5	0	7	0	1	6	4
	5 - 15	1	0	4	0	0	1	0
Eastern Coalfields	< ½	5	1	5	7	2	5	5
	½ - 1½	4	0	7	1	2	5	8
	1½ - 5	0	0	7	0	0	0	1
	5 - 15	0	0	2	0	0	0	0
Inner Bluegrass	< ½	0	6	6	1	0	2	3
	½ - 1½	3	1	9	2	1	2	5
	1½ - 5	1	0	4	0	0	6	0
	5 - 15	0	0	0	0	0	1	0
Western Coalfields	< ½	1	0	5	5	2	5	0
	½ - 1½	10	0	7	4	6	7	4
	1½ - 5	4	0	7	0	1	4	1
	5 - 15	1	0	5	0	0	0	0
Total		86	14	124	41	21	76	60

Table 2. RATIOS OF FINGERLING OR FRY BASS TO ADULT BLUEGILL

	Size in Acres	100:30	100:60	80:30	80:40	50:20
Pennyroyal	< ½	1	6	0	0	3
	½ - 1½	9	0	13	1	6
	1½ - 5	9	0	5	0	5
	5 - 15	5	0	0	0	1
Jackson Purchase	< ½	5	4	3	0	0
	½ - 1½	5	2	3	0	6
	1½ - 5	5	0	0	1	2
	5 - 15	0	0	0	0	1
Outer Bluegrass	< ½	0	7	2	0	0
	½ - 1½	10	2	7	2	0
	1½ - 5	7	0	2	1	0
	5 - 15	1	0	0	0	0
Eastern Coalfields	< ½	1	2	0	1	0
	½ - 1½	8	0	7	1	0
	1½ - 5	7	0	3	0	0
	5 - 15	0	0	0	0	0
Inner Bluegrass	< ½	0	7	0	1	0
	½ - 1½	9	3	12	1	2
	1½ - 5	3	0	0	0	0
	5 - 15	0	0	0	0	0
Western Coalfields	< ½	1	6	0	0	0
	½ - 1½	10	0	8	1	0
	1½ - 5	6	0	7	0	0
	5 - 15	2	1	5	0	0
Total		104	40	77	9	26

Questionnaires for each of the 600 ponds not checked were sent to conservation officers. These men were requested to contact each pond owner, complete, and return the questionnaires. The results of the questionnaire returns were as follows:

1. Questionnaires were returned for 499 ponds.
2. Conservation officers failed to report on the status of 101 ponds.
3. Eighty ponds had gone dry since being stocked.
4. Other fish were known to have been added to 78 of the remaining ponds which had not gone dry.
5. Questionnaires were returned on 156 ponds under ½ acre; of these, 49 had gone dry, and 56 of the remaining 107 were known to have had other fish added.

Approximately 100 ponds, based on questionnaire returns, appeared to warrant further investigation in the evaluation of past stocking ratios.

Job No. II-B, Field Survey of Past Stocking Results

Objective

To determine the relative success of past stocking ratios.

Techniques Used

Field work was begun in the Jackson Purchase (Figure 1) on May 19, 1952, but had to be delayed until early June because no bluegill fry were found during the week of May 19. When seining operations were resumed in early June, bluegill fry were readily obtained in ponds not overcrowded with these or other forage species.

Scale samples were taken for age and growth determinations from populations found in manageable and marginal ponds (defined below). In addition to obtaining average growth rates, it was surmised that differences in basic fertility of the major soils regions might be reflected in the growth rates of fishes from these regions.

All data and pertinent comments for each pond were entered on individual survey forms on location. Numbers, lengths, and size groupings of each species of fish were recorded as they were obtained in each seine haul.

Analysis and classification of fish populations - Populations were examined with seines ranging up to 150 feet in length; however, after the first two weeks' operations, use of all seines in excess of 75 feet in length was discontinued. In view of the additional effort and time required to secure samples with seines longer than 75 feet, their use could not be justified in general survey work.

A common-sense minnow seine, 10 by 4 feet, was used to capture recent spawn, being especially useful in early season operations and in ponds badly overcrowded with bass.

A ¼-inch square-mest seine, 30 by 6 feet, was used in capturing fish of intermediate sizes, i.e., between the fry and adult stages. Also, this size seine was useful in capturing adult fish, especially in the smaller ponds.

A 1¼-inch square-mest seine, 75 by 8 feet with No. 9 thread, was used to capture adult fish for age and growth studies and to obtain as complete a sample of the adult population as practicable.

Analysis and subsequent classification of the fish populations examined were based primarily on the precepts of Swingle (1945, 1950). Unbalanced populations were of two types - those overcrowded with bass; those overcrowded with bluegill and/or other forage species.

Ponds, which because of bass predation lacked adequate recruitment of small bluegill to replace those adults lost through angling and natural mortality, were classified as containing unbalanced populations because of overcrowded bass.

Ponds which were overcrowded with bluegill and/or other forage species, to the extent that either bass or bluegill or both had ceased reproduction, were classified as containing unbalanced populations.

Ponds in which adequate recruitment of the young of component species occurred, such that production of fish of a harvestable size of both the carnivorous and forage species was assured, were classified as containing balanced populations.

Classification of Ponds - Ponds were classified as manageable, marginal or unmanageable for purposes of this survey.

The term manageable is used in reference to those ponds that were immediately suitable for the sustained production of bass and bluegill of a harvestable size. It does not include ponds which could be made manageable by watershed improvements or by the exclusion of livestock.

Major points of judgement were as follows:

1. Adequate depth for continuous growth and carry-over of fish through periods of low rainfall (depends on water supply).
2. A relatively stable water level.
3. Moderate to nonexistent overflow of water from pond.
4. Absence of large areas of extremely shallow water.
5. Clear water except following extremely heavy rains.

Marginal ponds have only limited value in the sustained production of harvestable bass and bluegill. Ponds in this category are exemplified by one or more of the following characteristics:

1. Inadequate depth for continuous growth of bass and bluegill during moderately dry periods.
2. Widely-fluctuating water level.
3. Subject to heavy overflow of water during winter and early spring, resulting in an excessive loss of nutrients and adult fish.
4. Extensive areas of shallow water that hamper predator control of forage species and promote growth of emergent weeds.
5. Moderate siltation resulting in retardation of bass and bluegill growth, bass reproduction not being greatly affected.

The distinguishing critera of unmanageable ponds are similar to those for marginal ponds except the effects of siltation, water level fluctation, etc., are more pronounced. All ponds within this classification are partially or wholly unsuited to the sustained production of harvestable bass and bluegill. Ponds in this category are characterized by one or more of the following conditions:

1. Inadequate depth for carry-over of bass-bluegill population during prolonged periods of little or no rainfall.
2. Extreme water level fluctuation such that bluegill and/or bass growth is severely retarded for prolonged periods.
3. Pond subject to heavy overflow of water during major portion of growing season, resulting in severe loss of adult fishes and nutrients.
4. Major areas of pond consisting of water too shallow for efficient control of emergent and submergent weeds.

5. Extreme siltation resulting in severely retarded growth of bass and bluegill and greately curtailed or suspended bass reproduction.

In summation it may be said that manageable ponds are those ponds which are potentially good fish ponds; marginal ponds are those which are potentially only mediocre to poor fish ponds, and unmanageable ponds are those ponds which are, at best, poor fish ponds.

Job No. II-C. ANALYSIS OF DATA

Objective

To evolve ratios and rates to be used in the stocking of experimental ponds.

Findings

Success of various ratios and rates of bass-bluegill stocking - Data were obtained as to the relative success of various stocking rates and ratios of fingerling or fry bass to fingerling bluegill from 63 ponds (Table 4), and for fingerling or fry bass and adult bluegill from 50 ponds (Table 3). Ponds included in these tables contained only bass and bluegill, had not had additional bass and/or bluegill added, and were physically qualified as fish ponds. With the exception of the 101 ponds not reported on by conservation officers (see Job II-A), the preceding 113 ponds represent the maximum number of ponds meeting the above qualifications from the original 900 ponds selected.

The ratio of 3 bass to 1 bluegill produced the highest significant percentage (46%) of balanced populations of the adult ratios investigated. The ratio of 1 bass to 8 bluegill produced the highest percentage (87%) of balanced populations of the fingerling ratios.

TABLE 3. RELATIVE SUCCESS OF VARIOUS RATIOS AND RATES OF FINGERLING OR FRY BASS AND FINGERLING BLUEGILL STOCKING

Approximate Ratio of bass to bluegill	1:3 and 1:5				1:6		1:8			1:9 and 1:10					1:12
Rates per acre of bass and bluegill	80:250	60:330	100:500	200:1000	80:500	120:750	60:500	120:1000	340:2850	80:700	39:375	50:500	100:1000	250:2500	80:1000
Ponds with overcrowded bass populations					3	1									
Ponds with balanced populations	1	1	2		8		1	12		1		7	6	1	
Ponds with overcrowded bluegill populations			1	1	4			1	1		1	5	2		3
Ponds with overcrowded bass populations					4(25%)										
Ponds with balanced populations	4(67%)				8(50%)		13(87%)			15(65%)					
Ponds with overcrowded bluegill populations	2(33%)				4(25%)		2(13%)			8(35%)					3(100%)

TABLE 4. RELATIVE SUCCESS OF VARIOUS RATIOS AND RATES OF FINGERLING OR FRY BASS AND ADULT BLUEGILL STOCKING

Approximate Ratio of bass to bluegill	1:1 and 2:1							3:1							5:1		7:1	8:1 & 10:1	
Rates per acre of bass and bluegill	60:40	130:100	50:20	100:40	100:60	200:80	375:150	80:30	100:30	150:45	150:55	200:60	230:70	240:90	100:20	750:150	100:15	240:30	300:30
Ponds with overcrowded bass populations	1	1		4		1	1	1	4	1	1		1						
Ponds with balanced populations			1					9	6					1		1		1	
Ponds with overcrowded bluegill populations					1			4	6			1			1		1		1
Ponds with overcrowded bass populations	8(80%)							8(23%)											
Ponds with balanced populations	1(10%)							16(46%)							1 (50%)		1 (33%)		
Ponds with overcrowded bluegill populations	1(10%)							11(31%)							1 (50%)		2 (67%)		

An average of 4 years had elapsed since stocking for ponds stocked with adult bluegill (Table 4), and an average of 3 years had elapsed for ponds stocked with fingerling bluegill (Table 3). This population age difference is due to the fact that the two methods of stocking were generally not used concurrently.

Four to 8 years had elapsed since stocking for 31 of the ponds stocked with adult bluegill (Table 4) and 10 of the ponds stocked with fingerling bluegill (Table 3). Of the 31 ponds stocked with adult bluegill, 13 ponds (42%) contained balanced populations, while 9 ponds (29%) contained populations overcrowded with bluegill and 9 ponds (29%) contained populations overcrowded with bass. Six of the 10 ponds (60%) stocked with fingerling bluegill contained balanced populations, while 4 ponds (40%) contained populations overcrowded with bluegill.

Pond Size and Population Balance - It was observed early in the field investigations that ponds of less than ½ acre contained unbalanced populations more often than ponds which were ½ acre or larger. Swingle (1945) reported that unfertilized ponds of less than ½ acre and fertilized ponds of less than ¼ acre were too small to insure good results with the bluegill-largemouth bass combination because the limited numbers of bass which these ponds would support did not insure adequate reproduction.

The effect of pond size on population balance as a single factor could not be evaluated from the data obtained; however, it can be shown that unfertilized ponds ½ acre or larger contained balanced populations twice as often as did unfertilized ponds of less than ½ acre, without regard to other factors (Table 5).

Sixty ponds (25%) were reportedly fertilized the first year following stocking. Thirty-eight ponds (16%) received some fertilization during the year in which the ponds were investigated. Fourteen ponds (6%) were being fertilized adequately to maintain at least a light plankton growth. Swingle and Smith (1947) recommended that periodic applications of an inorganic fertilizer be made to ponds in the southeastern states in order to maintain a plankton density such that the pond bottom could not be seen in water more than 12 inches deep. None of the ponds investigated received adequate fertilization for maintaining a plankton density at this recommended level.

In many instances pond owners were wasting fertilizer materials by applying them to unmanageable ponds which were muddy and heavily silted and ponds which contained hopelessly unbalanced populations. A few owners were using an adequate amount of fertilizer materials, but had made only one or two applications per year at irregular intervals - a wasteful and apparently ineffective procedure.

Table 5. RELATIONSHIP OF POND SIZE TO POPULATION BALANCE*

	FERTILIZED**		UNFERTILIZED	
Pond size	Less than $\frac{1}{4}$ a.	$\frac{1}{4}$ a. or larger	Less than $\frac{1}{2}$ a.	$\frac{1}{2}$ a. or larger
No. ponds with balanced populations		10 (71%)	9 (18%)	62 (36%)
No. ponds with unbalanced populations	2 (100%)	4 (29%)	41 (82%)	111 (64%)
Total No. ponds	2	14	50	173

*Includes all ponds which were seined and for which the population balance could be determined.

**Fertilized adequately to maintain at least a light plankton growth.

Occurrence of species other than bass and/or bluegill - A random sample of 272 ponds was investigated during the summer of 1952. The status of each pond is given in Table 6.

Fourteen ponds were devoid of fishes. Fish were killed in 2 ponds in the Pennyroyal and 1 pond in the Inner Bluegrass through the use of agricultural insecticides on pastures and field crops. Oxygen depletion resulted in the loss of the fish population of 1 pond in the Pennyroyal. The fish populations of 2 ponds in the Western Coalfields and 1 pond in the Eastern Coalfields had been eradicated by rotenone. Fish populations failed to become established in 3 ponds in the Eastern Coalfields which received acid mine water. The fate of the fish populations of 1 pond in the Pennyroyal, 1 pond in the Western Coalfields, 1 pond in the Jackson Purchase and 1 pond in the Inner Bluegrass could not be determined.

The highest percentage of dry ponds (23%) occurred in the Inner Bluegrass, while the lowest (6%) occurred in the Eastern Coalfields.

The highest percentage (17%) of ponds which were investigated but did not warrant seining was in the Jackson Purchase. The majority of these ponds were little more than mudholes because of hog or cattle usage. Some ponds in this group were small and/or shallow and had been seined extensively for bass.

Six ponds could not be seined successfully because of obstructions in the water or because the pond was too deep to seine.

Table 6. STATUS OF 272 SURVEY PONDS

SOILS REGION	P	JP	WC	OB	IB	EC
Bass and blg. only	9 (24%)	16 (27%)	14 (21%)	9 (23%)	9 (23%)	16 (55%)
Containing species other than bass and blg.	12 (33%)	28 (48%)	30 (44%)	20 (50%)	17 (44%)	4 (14%)
No fish	4 (11%)	1 (2%)	3 (4%)	- - - -	2 (5%)	4 (14%)
Dry when Investigated	7 (19%)	3 (5%)	10 (15%)	7 (18%)	9 (23%)	2 (7%)
Investigated but not seined*	4 (11%)	11 (19%)	8 (12%)	4 (10%)	1 (3%)	2 (7%)
Not seinable	1 (3%)	- - - -	3 (4%)	- - - -	1 (3%)	1 (3%)
Total Ponds Checked	37	59	68	40	39	29

*Includes ponds which were small and overrun with hogs, hence, not worthy of seining, ponds which had been seined extensively and small ponds which were known by conservation officers to contain dominant populations of fish other than bass and bluegill.

Table 7 is a further breakdown of Table 6 into ponds containing bass and/or bluegill only and ponds containing other species; also shown is the occurrence of the principal groups of extraneous fishes.

One hundred eleven ponds (60%) contained species other than bass and/or bluegill. The soils regions having the highest percentage of ponds with extraneous species were the Western Coalfields and Outer Bluegrass (73%) each) and the one having the lowest percentage (24%) was the Eastern Coalfields.

Green sunfish, Lepomis cyanellus Rafinesque, was the principal extraneous species, occurring in 28% of the ponds which contained fish. Bullheads, Ameiurus natalis (LeSueur) and A. melas (Rafinesque), were found in 19% of all ponds containing fish and the crappies, Pomoxis nigro-maculatus (LeSueur) and P. annularis Rafinesque, in 14%. Other fishes found which were foreign to the listed stocking were orangespotted sunfish, Lepomis humilis (Girard); longear sunfish, Lepomis megalotis (Rafinesque);

gizzard shad, Dorsoma cepedianum (LeSueur); blue cat, Ictalurus furcatus (LeSueur); shellcracker, Lepomis microlophus (Gunther); warmouth, Chaenobryttus coronarius (Bartram); goldfish, Carrassius auratus Linnaeus; carp, Cyprinus carpio Linnaeus; golden shiner, Notemigonus crysoleucas Mitchell; and several other species of minnows. In addition to these species, largemouth or Kentucky bass were known to have been added to 4 ponds and bluegill to 1 pond.

The soils region with the highest percentage of ponds containing green sunfish (38%) was the Outer Bluegrass and the one with the lowest percentage (5%) was the Eastern Coalfields. The highest percentage of ponds with bullheads (23%) was in the Jackson Purchase, while none of the ponds examined in the Eastern Coalfields contained bullheads. The highest percentage of ponds containing crappie (24%) was in the Pennyroyal and the lowest (5%) was in the Eastern Coalfields.

Table 7. OCCURRENCE OF SPECIES OTHER THAN BASS AND BLUEGILL IN 184 SURVEY PONDS

SOILS REGION	P	JP	WC	OB	IB	EC
Bass and blg. only	9 (43%)	16 (36%)	14 (27%)	9 (27%)	9 (33%)	16 (76%)
Containing species other than bass and blg.	12 (57%)	28 (64%)	30 (73%)	20 (73%)	17 (67%)	4 (24%)
No. with green sunfish	4 (19%)	13 (30%)	15 (34%)	11 (38%)	7 (27%)	1 (5%)
No. with crappie	5 (24%)	9 (21%)	5 (11%)	2 (7%)	4 (15%)	1 (5%)
No. with bullheads	3 (14%)	10 (23%)	9 (21%)	5 (17%)	7 (27%)	- - - -
Total ponds seined	21	44	44	29	26	20

Relationship of wild fish to population balance - Inasmuch as wild fishes were found in 60% of all ponds containing fish which were examined during the summer of 1952 (Table 7), it is of interest to compare the success of ponds containing only bass and bluegill and those containing wild fishes.

Swingle (1952) reported competition with wild fishes which were present in the ponds before the hatchery fish were stocked as being the most common cause of pond failure in Alabama. He also listed the stocking of adult fishes before arrival of the hatchery stock as a second factor of considerable magnitude contributing to pond failure.

Inasmuch as ponds in this investigation were not examined until 2 or more years had elapsed following stocking, it was not possible to determine accurately the time or mode of entry of the extraneous species into the ponds. Consequently, all species occurring in survey ponds which were not stocked by the Division of Fisheries were arbitrarily classed as wild fishes.

The effect of wild fishes on population balance in 140 ponds is shown in Table 8. Three distinct types of ponds are recognized (see Job II-B) and the effect of wild fishes on population balance in each type determined.

In order to reduce variables to a minimum, only those ratios for which the relative success had been determined previously were included. Ponds used previously in determining ratio success qualified physically as fish ponds, contained only bass and bluegill and, insofar as could be determined, had not been subjected to other factors which might influence the population balance. Knowing the percentage of success of each ratio under favorable conditions, it was possible to determine the percentage of success that the aggregate ratios, considered under the three categories of ponds, would have

achieved under the same conditions. The calculated percentages of success, based on weighted averages, for the ratios included in Table 8 were: manageable ponds 65%; marginal ponds 61%, and unmanageable ponds 58%. The average number of years elapsed since stocking for manageable ponds was 3; marginal ponds 2½; and unmanageable ponds 3.

In view of the slight differences in aggregate ratio success and average population age between the three categories of ponds, it would appear that the inclusion of more than one ratio and population age has not greatly affected the validity of the data presented.

The presence of wild fishes in manageable ponds resulted in a 14% decrease in the relative number of balanced populations over ponds in the same classification containing bass and bluegill only, in marginal ponds 46%, and in unmanageable ponds 50%.

The relative number of balanced populations for ponds containing bass and bluegill only was four times as great for manageable ponds as for unmanageable ponds and twice as great for marginal ponds as for unmanageable ponds. The relative number of balanced populations in ponds containing wild fishes was six times as great for manageable ponds as for unmanageable ponds, and twice as great for marginal ponds as for unmanageable ponds.

It is noteworthy that pond owners interrogated prior to inspection of their ponds reported that fishing was "fair to good" in 53% of the manageable ponds, 16% of the marginal ponds and 10% of the unmanageable ponds.

The likelihood that fishing success was closely related to population balance could not be demonstrated conclusively because of the small numbers of balanced populations in the marginal and unmanageable categories.

Table 8. RELATIONSHIP OF WILD FISH TO POPULATION BALANCE IN THREE TYPES OF PONDS

		Manageable	Marginal	Unmanageable
Bass and bluegill only	No. balanced populations	31 (70%)	9 (35%)	4 (18%)
	No. unbalanced populations	13 (30%)	17 (65%)	18 (82%)
Bass, bluegill and wild fish*	No. balanced populations	6 (60%)	3 (19%)	2 (9%)
	No. unbalanced populations	4 (40%)	13 (81%)	20 (91%)
	Total No. Ponds (140)	54	42	44

*Includes only ponds containing green sunfish, bullheads or crappie (the principal species of wild fishes in Table 7) in addition to the listed stocking of bass and bluegill.

Occurrence of manageable, marginal and unmanageable ponds - The occurence of manageable, marginal, and unmanageable ponds by soils regions is given in Table 9 for a random sample of 238 ponds investigated during the summer of 1952. The highest percentage of manageable ponds (37%) occurred in the Eastern Coalfields while the lowest percentage (15%) occurred in the Pennyroyal. The highest percentage of marginal ponds (32%) occurred in the Pennyroyal while the lowest percentage (14%) occurred in the Western Coalfields. The highest percentage of unmanageable ponds (62%) occurred in the Inner Bluegrass while the lowest percentage 33% occurred in the Eastern Coalfields.

Table 9. OCCURRENCE OF MANAGEABLE, MARGINAL AND UNMANAGEABLE PONDS BY SOILS REGIONS

Soils Region	Manageable ponds	Marginal ponds	Unmanageable Ponds
Pennyroyal	5 (15%)	11 (32%)	18 (53%)
Jackson Purchase	10 (18%)	12 (21%)	35 (61%)
Eastern Coalfields	10 (37%)	8 (30%)	9 (33%)
Western Coalfields	20 (35%)	8 (14%)	29 (51%)
Outer Bluegrass	10 (29%)	7 (21%)	17 (50%)
Inner Bluegrass	5 (17%)	6 (21%)	18 (62%)
Total	60 (25%)	52 (22%)	126 (53%)

As shown in Table 9, 53% of the ponds included in the sampling were unmanageable and 22% marginal. Excessive siltation and/or turbidity resulting from unrestricted livestock usage were the factors of greatest importance in both unmanageable and marginal ponds. While more than one factor was usually involved in limiting ponds to an unmanageable or marginal category, it was possible to determine the primary limiting factors in almost all cases. The primary limiting factors for 147 unmanageable and 50 marginal ponds were as follows:

Unmanageable

1.	Extensive siltation and/or turbidity from livestock usage	55 ponds (37%)
2.	Inadequate depth	46 " (31%)
3.	Extreme water level fluctuation	16 " (11%)
4.	Dam failure	12 " (8%)
5.	Extensive siltation from watershed	6 " (4%)
6.	Excessive watershed	6 " (4%)
7.	Acid mine water	4 " (3%)
8.	Overflowed by stream	2 " (2%)

Marginal

1.	Excessive siltation and/or turbidity from livestock usage	13 ponds	(26%)
2.	Excessive water level fluctuation	10 "	(20%)
3.	Severe weed problem associated with extensive areas of shallow water	9 "	(18%)
4.	Excessive siltation from watershed	7 "	(14%)
5.	Inadequate depth	5 "	(10%)
6.	Excessive watershed	4 "	(8%)
7.	Extensive shallow areas without weed problem	2 "	(4%)

Determination of approximate carrying capacities - The use of the bluegill (or other similar species) carrying capacity of ponds in a given area is suggested by Swingle (1950) in determining the stocking rates of bass and bluegill needed to produce balanced populations in the same area. Swingle states that " ... the approximate carrying capacity in pounds of fish per acre ... can be determined by poisoning and weighing established populations or by stocking new waters with 1000 or more bluegill per acre and determining the total production in pounds per acre at the end of one year."

Krumholz (1948), following up the earlier work of Clarke (1946), in attempting to further delineate and standardize some of the terminology relating to fish populations, proposed that the total weight of all the fishes present in the area at the time of observation be referred to as the standing crop. He points out that the standing crop is not necessarily a measurement of the carrying capacity; however, "If the body of water in question is supporting its maximum weight then the standing crop is a measurement of the carrying capacity ...", carrying capacity being defined as "the upper limit of the weight of a species or combination of species that can be supported by a body of water over an extended period of time."

Ostensibily, the standing crop would be near the upper limit of the weight of fish which could be supported on a sustained basis in the populations described by Swingle (op.cit.) and would, therefore, be indicative of the carrying capacity under the prevailing conditions.

Draining or poisoning with rotenone are the most widely-used methods in obtaining the fish populations of ponds for total censusing. Where draining is not feasible, poisoning with rotenone will apparently result in a reasonable recovery, in most instances, if the fish are collected over a period of several days. Various investigators, Krunholz (1950), Ferdin (1950), and Jenkins (1951) recovered an average of 80% or more of the fish which had been marked and returned to the ponds prior to poisoning. However, Ball (1948) recovered only 59% of marked bluegill and 44% of marked trout which had been planted in a Michigan lake 4 and 3 days, respectively, prior to poisoning. He notes the possibilities that many of the fish may have become entangled in the dense, compact mat of Chara carpeting the lake, or sank into deep water and disintegrated without coming to the surface. It is expected that recovery would be less from the cold, deep waters of trout lakes than from the warmer and somewhat shallower waters characteristic of ponds in southern areas.

Eight ponds were treated with rotenone and as many of the fishes as practicable recovered and weighed. It was desired to poison only ponds containing bluegill and/or green sunfish; however, only 3 such populations available for poisoning could be located at the time the work was undertaken. Consequently, it was necessary to poison populations which included a small percentage of fish of other species. Although bluegill and/or green sunfish comprised the major portion of the total weight recovered from the 5 ponds which were subsequently poisoned, bass and/or bullheads - and in one instance golden shiners and crappie - made up a small percentage of this weight.

Snags and the absence of sizeable areas of shallow water prevented the capture of adequate numbers of fish by seining for marking and recovery studies in the majority of these ponds. A high rate of recovery was obtained, however, on a small number of marked fish in a one-acre pond.

Inasmuch as no appreciable amounts of fish were observed floating on the fifth day following poisoning, no attempt was made to recover fish after the fourth day. In view of the foregoing and other observations, it was surmised that a relatively good recovery of fish was obtained from the majority of these ponds.

The recoverable portion of the standing crop, as an indication of the approximate bluegill carrying capacity, of 7 ponds was as follows (a dense growth of submerged aquatic weeds prevented a satisfactory recovery of fish from the eighth pond):

Outer Bluegrass:	509, 406, 384 and 278	pounds per acre.
Western Coalfields	237	" " "
Pennyroyal:	243 and 100	" " "

Determination of age and growth - During the summers of 1952 and 1953 scale samples were taken from 1608 bluegill from 91 ponds, from 274 large-mouth bass from 58 ponds, and from 68 Kentucky bass from 27 ponds. Sampling was state-wide and only those populations occuring in manageable and marginal ponds were sampled. Corrected growth rates were used in all studies.

Age and growth of bluegill

The body-scale relationship for bluegill in Kentucky farm ponds as determined by Kirkwood (1952) placed the Y intercept at 0.74 inch.

The following equation was used for the back calculation of total length at time of annulus formation:

$$Lx = 0.74 + \frac{Sx\ (Lt - 0.74)}{St}$$

Lx = Length of fish at time of annulus (x) formation

Lt = Total length of fish

Sx = Scale radius at annulus (x)

St = Total scale radius

0.74 = Length of fish at time of scale formation

Table 10 shows that bluegill occurring in the populations sampled had not reached an average length of 6 inches at the end of their third year of life.

Table 10. GROWTH RATES OF 1608 BLUEGILL COLLECTED FROM 91 FARM PONDS

Age	Total	Average total length (inches)	Calculated total length (inches) at time of annulus formation				
			I	II	III	IV	V
0	216	2.8					
I	517	4.5	3.2				
II	580	5.6	3.1	4.7			
III	271	6.3	3.0	4.6	5.7		
IV	25	6.8	3.2	4.7	5.6	6.3	
V	3	7.8	3.8	4.7	6.0	7.0	7.3
Average length			3.1	4.7	5.7	6.4	7.3
Increment of growth.			3.1	1.6	1.0	0.7	0.9
Total number			1396	879	299	28	3

The following two tables, 11 and 12, show the growth rates of bluegill in 46 ponds with balanced populations and 30 ponds with overcrowded bluegill populations.

Average growth rates of bluegill in balanced populations do not at first appear to be markedly greater than growth rates of bluegill in populations overcrowded with this species; however, a comparison of weights (Table 13) reveals that bluegill of the younger year classes from the balanced populations weigh considerably more than those of the same year classes from populations overcrowded with bluegill. Older age groups tend to show a less pronounced weight difference which may be partially explained by the lack of scale samples from populations which appeared to have been badly overcrowded with bluegill for more than one or two growing seasons.

Table 11. GROWTH RATES OF 821 BLUEGILL COLLECTED FROM 46 FARM PONDS WITH BALANCED POPULATIONS

Age Group	Total Number	Average total length (inches)	Calculated total length (inches) at time of annulus formation				
			I	II	III	IV	V
0	147	2.7					
I	247	4.9	3.4				
II	288	6.0	3.5	5.0			
III	129	6.6	3.2	4.8	5.9		
IV	14	7.0	3.5	4.7	5.8	6.5	
V	2	8.0	4.0	4.9	6.2	6.9	7.4
Average length			3.4	5.0	5.9	6.5	7.4
Increment of growth			3.4	1.6	0.9	0.6	0.9
Total Number			674	433	145	16	2

Table 12. GROWTH RATES OF 594 BLUEGILL COLLECTED FROM 30 PONDS WITH OVERCROWDED BLUEGILL POPULATIONS

Age Group	Total Number	Average total length (inches)	Calculated total length (inches) at time of annulus formation				
			I	II	III	IV	V
0	47	3.1					
I	206	4.0	2.9				
II	226	5.1	2.9	4.3			
III	109	6.2	2.9	4.5	5.5		
IV	5	6.5	3.0	4.6	5.3	6.0	
V	1	7.5	3.3	4.2	6.2	6.7	7.1
Average length			2.9	4.4	5.5	6.1	7.1
Increment of growth			2.9	1.5	1.1	0.7	1.0
Total Number			547	341	115	6	1

Table 13. GROWTH RATES AND AVERAGE WEIGHTS OF 674 BLUEGILL FROM 46 FARM PONDS WITH BALANCED POPULATIONS AND 574 BLUEGILL FROM 30 PONDS WITH POPULATIONS OVERCROWDED WITH BLUEGILL

Age Group		I	II	III	IV	V
Balanced Populations	Length (inches)	3.4	5.0	5.9	6.5	7.4
	Weight (Pounds)	0.03	0.08	0.14	0.19	0.29
Populations overcrowded with Bluegill	Length (inches)	2.9	4.4	5.5	6.1	7.1
	Weight (pounds)	0.01	0.05	0.11	0.16	0.27
Weight differential between balanced populations and populations overcrowded with bluegill		67%	38%	20%	16%	7%

Some of the more pertinent findings resulting from this incidental study of the growth rates and age of bluegill in Kentucky farm ponds are presented in abbreviated form in Table 14.

Table 14. AVERAGE GROWTH RATES OF BLUEGILL FROM SELECT POPULATIONS

No. Ponds	No. blg.		Length (inches) at time of annulus formation I	II	III	IV	V
91	1608	All ratios combined	3.1	4.7	5.7	6.4	7.3
30	594	Overcrowded bluegill	2.9	4.4	5.5	6.1	7.1
46	821	Balanced	3.4	5.0	5.9	6.5	7.4
9	70	Balanced - fertilized	3.7	5.0	5.3	6.4	
6	205	Outer Bluegrass balanced	2.9	4.6	5.8	6.4	
2	56	Inner Bluegrass - balanced	2.7	5.0	5.8	7.2	
9	89	Eastern Coalfields - balanced	3.6	5.2	5.6		
12	221	Western Coalfields - balanced	3.6	5.0	6.2	6.1	
8	104	Jackson Purchase - balanced	3.3	5.1	6.0	6.9	7.4
5	90	Pennyroyal - balanced	3.7	4.8	6.0	6.4	
8	63	120 : 1000 - fingerling	3.6	4.9	5.2		
5	102	100 : 1000 - "	3.7	4.8	7.0		
3	70	100 : 500 - "	3.0	4.8	5.7	7.0	
14	267	80 : 500 - "	3.0	4.3	5.0		
10	150	50 : 500 - "	3.1	5.0	5.1	6.1	
13	354	100 : 30 - adult	3.0	4.9	5.9	6.6	
7	117	80 : 30 - "	2.8	4.1	5.2	6.0	7.4

Age and growth of bass

As stated previously, both Kentucky and largemouth bass are produced by the state hatcheries for stocking farm ponds; consequently, information relative to the growth rates and longevity of each of the two species in farm ponds is highly desirable.

Table 15 shows that an average of 2 years was required for largemouth bass to reach a length of 10 inches in the populations sampled; however this growth may not be indicative of that in newly-stocked ponds.

Stroud (1948) determined that Kentucky bass grew at a slower rate than largemouth bass and were subject to earlier mortality in Norris Reservoir. Similar trends are indicated for this species in Kentucky farm ponds (Table 16).

It was found that largemouth bass grew less rapidly in the farm pond populations sampled than they did in the lakes sampled by Tompkins and Carter (1951); however, comparative growth rates of Kentucky bass did not differ significantly.

Table 15. GROWTH RATES OF 274 LARGEMOUTH BASS COLLECTED FROM 58 FARM PONDS

Age Group	Total Number	Average total length (inches)	Calculated total length (inches at time of annulus formation							
			I	II	III	IV	V	VI	VII	VIII
0	26	5.5								
I	130	8.2	5.1							
II	85	11.2	5.7	9.7						
III	25	15.8	6.0	11.2	14.1					
IV	3	16.5	7.1	10.7	13.9	15.8				
V	1	20.5	5.0	13.2	16.7	18.3	19.5			
VI	3	19.7	4.9	8.9	12.3	14.4	16.7	18.8		
VII	0	----	---	---	---	----	----	----		
VIII	1	22.5	6.4	10.0	13.6	16.4	17.6	19.4	20.7	21.9
Average length			5.8	10.0	14.0	15.7	17.4	18.9	20.7	21.9
Increment of growth			5.8	4.2	4.0	1.7	1.8	1.5	1.8	1.2
Total Number			248	118	33	8	5	4	1	1

Table 16. GROWTH RATES OF 68 KENTUCKY BASS COLLECTED FROM 27 FARM PONDS

Age Group	Total Number	Average total length (inches)	Calculated total length (inches) at time of annulus formation	
			I	II
0	2	5.9		
I	36	8.4	6.0	
II	30	11.0	5.0	9.4
Average length			5.6	9.4
Increment of growth			5.6	3.8
Total Number			66	30

Summary and Conclusions

Data were obtained as to the relative success of various stocking rates and ratios of fingerling or fry bass to fingerling bluegill from 63 ponds and for fingerling or fry bass and adult bluegill from 50 ponds. Six hundred eighty-six of the ponds selected for survey purposes were not usable in an evaluation of the success of stocking rates and ratios.

The highest percentage (87%) of balanced populations was produced by a fingerling ratio of one bass to eight bluegill. The highest significant percentage (46%) of balanced populations resulting from adult bluegill stocking was produced by a ratio of three bass to one bluegill.

Some trends are indicated for both adult and fingerling stocking, although ratios other than 2:1 (bass : bluegill) and 3:1 in adult bluegill stocking and 1:10, 1:8, and 1:6 in fingerling bluegill stocking appear to be insignificantly represented. The most useful ratios of adult stocking appear to lie between 2:1 and 6:1. The most useful fingerling ratios appear to be greater than 1:12; the best range appears to be 1:10 to 1:6, inclusive.

In adult stocking, the tendency for overcrowding by bluegill appears to increase as the ratio of bass to bluegill is increased. Conversely, the tendency for overcrowding by bass appears to increase as the ratio of bass to bluegill is decreased.

In fingerling stocking, the ratio of one bass to eight fingerling bluegill produced a maximum number of balanced populations; either increasing or decreasing this ratio seemed to result in an increasing tendency for overcrowding by bluegill.

One hundred thirteen ponds were used in determining the relative success of various stocking rates and ratios. Forty-one of these ponds had populations

which were four to eight years old. Fingerling ratios had been used in stocking 10 of these ponds and adult ratios in stocking the remainder. Sixty percent of the ponds stocked with fingerling ratios and 42% of those stocked with adult ratios contained balanced populations.

Unfertilized ponds of 1/2 acre or larger contained balanced populations twice as often as did unfertilized ponds of less than 1/2 acre.

Approximately 50% of the ponds, from which survey ponds were selected, were less than 1/2 acre; however, only 27% of the ponds used for survey purposes were this small. Selection of such ponds in proportion to their actual occurrence would have undoubtedly reduced the number of ponds suitable for evaluation of stocking ratio success and also the overall percentage of ponds with balanced populations.

Twenty-five percent of the ponds in a random sample of 239 ponds were reportedly fertilized the first year following stocking. Thirty-eight ponds (16%) received some fertilization during the year in which the ponds were investigated. Fourteen ponds (6%) were being fertilized adequately to maintain at least a light plankton growth.

Fertilization of the ponds investigated was largely ineffective due to inadequate and irregular application of fertilizer materials. Many uninformed pond owners were wasting fertilizer materials by applying them to unmanageable ponds or ponds which contained hopelessly unbalanced populations.

The effects and proper role of fertilization in relation to Kentucky farm ponds are yet to be determined. However, it appears that judicious use of fertilizer materials may be highly beneficial to ponds in such areas as the Eastern Coalfields.

A random sample of 272 ponds was investigated during the summer of 1952. Twenty-seven percent of these ponds contained bass and bluegill only, 41% contained other species (usually in addition to bass and bluegill), 5% were devoid of fish, 14% were dry when investigated, 2% could not be seined, and 11% did not warrant seining (hog or cattle wallows, etc.).

A total of 184 ponds from the preceding sample were seined as completely as practicable and the species composition determined. One hundred eleven ponds (60%) contained species other than bass and/or bluegill. The green sunfish was the most common extraneous species, occurring in 28% of the 184 ponds. Bullheads were found in 19% of these ponds and crappies in 14%.

The presence of wild fish in manageable ponds resulted in a decrease of 14% of the relative number of balanced populations compared with ponds in the same classification containing bass and bluegill only; in marginal ponds their presence resulted in a decrease of 46%, and in unmanageable ponds, a decrease of 50%.

For ponds containing bass and bluegill only, the relative number of balanced populations was four times greater in manageable ponds than in unmanageable ponds and twice as great in marginal as in unmanageable ponds. For ponds containing wild fish in addition to bass and bluegill, the relative number of balanced populations was six times greater in manageable than in unmanageable ponds.

Fifty-three percent of the ponds in a random sample of 238 ponds were unmamageable and 22% were marginal. Excessive siltation and/or turbidity resulting from unrestricted livestock usage were limiting factors of primary importance for both unmanageable and marginal ponds. Factors of secondary importance were inadequate depth for unmanageable ponds and excessive water level fluctuation for marginal ponds.

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 the ponds investigated.

The approximate bluegill carrying capacities for seven ponds varied from 100 pounds per acre in the Pennyroyal to 509 pounds per acre in the Outer Bluegrass. The results from such a limited number of determinations, obviously, can not be interpreted as either average, maxima or minima.

Scale samples were taken from 1608 bluegill from 91 ponds, from 274 largemouth bass from 58 ponds, and from 68 Kentucky bass from 27 ponds. Sampling was state-wide and only manageable and marginal ponds were sampled.

Bluegill spawned in established populations did not reach an average length of six inches until their fourth summer of life. Bluegill of the younger year classes from the balanced populations weighed considerably more than those of the same year classes from populations overcrowded with this species. Older age groups tended to show a less pronounced weight difference which may be partially explained by the lack of scale samples from populations which appeared to have been badly overcrowded with bluegill for more than one or two growing seasons. There are indications that the longevity of bluegill in Kentucky farm ponds rarely exceeds five years. It would appear that natural mortality is the chief factor limiting longevity since fishing pressure on bluegill was extremely light to nonexistent for the majority of ponds investigated.

An average of two years was required for largemouth bass to attain a length of 10 inches in the populations sampled. The average Kentucky bass grew at a somewhat slower rate than did the largemouth. Also, Kentucky bass were apparently subject to earlier mortality than largemouth bass in the

populations examined. Similar growth and mortality trends have been reported for Kentucky bass in Norris Reservoir, Tennessee. For these reasons, Kentucky bass appear less desirable than largemouth bass for use in the bass-bluegill stocking combination for Kentucky farm ponds. It was also noted that while largemouth bass appeared to be growing more rapidly in the lakes of Kentucky than in the majority of the better farm ponds, comparative growth rates of Kentucky bass did not appear to differ significantly.

Data

All original data pertaining to this report are filed in the offices of the Department of Fish and Wildlife Resources, Frankfort, Kentucky.

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