8. Data summarized from Angler's Report Cards show a definite upward trend of 9, 10, 11, and 12 inch smallmouth bass caught following the establishment of the 12-inch size limit.

LITERATURE CITED

Kapustka, S. F. 1957. Chemical and Physical Characteristics of Surface Waters of Virginia. Commonwealth of Virginia, Department of Conservation and Development, Division of Water Resources, Bulletin Number 22.

Surber, Eugene W. 1943. Observations on the Natural and Artificial Propagation of the Smallmouth Black Bass, *Micropterus dolomleu,* Trans. Amer. Fisheries Society, Vol. 72, pp. 233-245.

SOME EFFECTS OF SUPPLEMENTAL FEEDING AND CONTROLLED FISHING IN LARGEMOUTH BASS-BLUEGILL POPULATIONS

By H. R. Schmittou
Agricultural Experiment Station
Auburn University, Auburn, Alabama

ABSTRACT

The effects of supplemental feeding and controlled fishing in supplementally fed largemouth bass-bluegill populations were studied in one control pond and two treatment ponds. The ponds were stocked in March and April, 1963. One treatment and the control pond were drained in October, 1964. The objective of this phase of the study was to determine the effects of supplemental feeding on growth rate, condition index, and survival of bluegill, and on population balance and total production. A second phase of the experiment, restricting the harvest in a given time interval on a 3.5-acre pond, was begun in 1964 and terminated in October, 1967.

Bluegill in all ponds grew at comparable rates for the first 6 months after stocking. Seven months after stocking, bluegill in the treatment ponds were significantly heavier than those in the control pond. However, length-weight computations indicated that differences in condition indices between treatment and control ponds began to develop in the fifth month when the bluegill were in the 4-inch group. The two treatment pond populations were still expanding when the first phase of this study was terminated after 19 months of culture, but the control pond population had become static (i.e., no reproduction) by that time. When the control pond and treatment pond were drained in 1964, no significant difference between survivals of originally stocked bluegill in these ponds was found. The difference between total bluegill productions in those two ponds was 308 pounds per acre after 19 months. The difference between standing crops in the control pond at draining in 1964 and in the treatment pond drained in 1967 was 768 pounds. This difference was considered to be approximately equal to difference in carrying capacity between these two ponds since both populations were static when the ponds were drained.

Total production per acre in the fished treatment pond for the 4-year period was 2307 pounds including 2194 pounds of forage fish. The pond had a standing crop of 1129 pounds when drained. Conversion (S) of the 8766 pounds of feed used to produce the 2194 pounds of forage fish was 4.0 at a cost of $0.22 per pound. Fishing success for the 4-year period averaged approximately 60 percent better than in 20 Alabama state-owned fertilized lakes over a 14-year period.

INTRODUCTION

The bluegill, *Lepomis macrochirus* Rafinesque, has been used extensively in ponds of the Southeast in combination with largemouth bass, *Micropterus salmoides* Lacepede, as recommended by Swingle and Smith (1940 and 1942) and Smith and

Swingle (1943). Swingle (1949) reported that a combination of these species would produce an annual catch of less than 50 pounds per acre in unfertilized ponds and from 175 to 200 pounds per acre in ponds receiving fertilizer. Byrd and Crance (1965) reported that 20 state-owned fertilized lakes in Alabama produced an annual average harvest of 173 pounds per acre over a 14-year period. The carrying capacity for fertilized ponds in the Southeast is from 300 to 500 pounds per acre and averages about 400 (Swingle, 1951). However, as the demand for sport fishing increases there is a need to increase carrying capacity further. Supplemental feeding has been shown to be effective in increasing production of channel catfish in ponds (Swingle,1959), but to the present time there has been little work concerning use of feed in supplementing the bluegill diet in order to increase carrying capacity of largemouth bass-bluegill populations above that in fertilized ponds. Results of preliminary experiments using various feeds and rates of feeding bass-bluegill populations have been recorded by the Agricultural Experiment Station, Auburn University, in their unpublished Fisheries Research Annual Reports from 1943 to 1953. One such record (1947) states that 671.2 pounds per acre of bluegill and largemouth bass were produced in a pond that received 2938 pounds of pelleted turkey growing mash per acre from 24 January through 12 October.

A two-phase study was conducted in 3 ponds to study the effects of supplemental feeding and controlled fishing on supplementally fed largemouth bass-bluegill populations. The first phase (Phase I) was to determine the effects of supplemental feeding on growth rate, condition index, and survival of bluegill, and on population balance and on total production. This phase utilized all 3 ponds, and, except for total production in one treatment pond, was terminated in October, 1964, upon draining of one treatment pond and the control pond. Phase II, the controlled fishing phase, was terminated in October, 1967.

Phase I

MATERIALS AND METHODS

The study was conducted in three ponds of the Agricultural Experiment Station, Auburn University, Auburn, Alabama. The ponds were a 3.5-acre pond (S-9) and two rectangular 1-acre ponds (E-7 and E-8). Each pond averaged approximately 4 feet in depth. Ponds E-8 and S-9 were treatment ponds and in this paper are designated as ponds T-1 and T-2, respectively: E-7 served as a control and is designated as pond C. Pond T-2 was also used in Phase II and will be discussed in greater detail under that section.

Ponds C and T-1 were each stocked per acre in March 1963, with 1000 fathead minnows, *Pimephales promelas* Rafinesque, that weighed approximately 3.0 pounds; and 2000 bluegill that averaged 1.7 inches in total length and 0.005 pound each. Pond T-2 was stocked with 1143 fathead minnows and 2286 bluegill per acre in March, 1963. One-inch largemouth bass fingerlings were stocked at 150 per acre into each pond in April, 1963.

Populations in T-1 and T-2 were fed from March to October-November of each year using Auburn No. 2 pelleted fish feed (Prather, 1959). The populations were fed once each day 6 days per week. Feed was cast 20 to 30 feet out into the ponds at approximately 30 yard intervals around the shoreline excluding the dams. Feeding was begun in both treatment ponds on 25 March, 1963, at a rate of 1 pound per acre per day. Rate of feeding was increased monthly to equal 3% of the estimated total weight of bluegill until the maximum amount of 10 pounds per acre per day was being fed in September. Previous studies at Auburn (U.F.R.A.R., 1950 and 1951) demonstrated that feed in excess of 10 pounds per acre per day in bluegill ponds was not utilized. Some accumulated and decomposed, thus depleting the supply of dissolved oxygen which resulted in fish kills. Those studies also showed that 10 pounds per acre per day was not adequately utilized by bluegill when water temperatures were below 55°F - a period from November to March at Auburn.

Triple superphosphate fertilizer was used in all ponds as recommended by Byrd and Swingle (1964). The weight and cost of fertilizer and feed per acre are presented in Table 1.

TABLE 1

Total weight and cost of fertilizer and feed used in ponds C, T-1, and T-2 from March, 1963 to October, 1964 or 1967.

	Fertilizer		*Feed*		*Total*
Pond	*Pounds*	Cost ($)	*Pounds*	Cost ($)	*Cost ($)*
C	240	7.92	--	--	7.92
T-1	240	7.92	2896	159.28	167.20
T-2	256	8.45	8766	482.13	490.58

Cost of fertilizer at 3.3 cents/pound: cost of feed at 5.5 cents/pound.

From April, 1963, until draining of ponds C and T-1 in October, 1964, each pond was seined at bi-weekly intervals to obtain a sample of approximately 20 bluegill for length-weight and growth rate studies. These samples were preserved and stored not longer than 7 days in 10 percent formalin solution. In addition to the fish preserved at each bi-weekly sampling, a sample of 50 bluegill was obtained from the lot of fish used in stocking all ponds. At each sampling period population analysis checks for balance (Swingle, 1950) were made using 15 and 50 foot seines.

In the laboratory each fish was measured to nearest 0.1 inch and weighed to nearest 0.01 pound. Fish less than approximately 4.5 inches in total length were measured in millimeters, weighed in grams, and the resulting measurements converted into inches and pounds. All fish were sexed by dissection.

Ponds C and T-1 were drained in October, 1964, and T-2 was drained in October, 1967. At draining all fish from each pond were separated to species, counted, separated to inch groups and weighed. A random sample of 100 bluegill of each sex was taken from pond C and T-1 to aid in length-weight studies. Fish of these samples were measured to nearest 0.1 inch and 0.01 pound.

Length-weight data representing each fish collected in all samples were punched on IBM cards to a format slightly modified from that presented by Swingle (1964a). These data consisted of total length and total weight of each fish and two identification numbers - one referring to sex and the other to sampling date. Treatment of these data consisted of calculating the standard weight for each inch group representative of each sex. The computations were made with the IBM 1620 Data Processing System using a computer program developed by Swingle (1964a and 1964b).

RESULTS AND DISCUSSIONS

Bluegill in all ponds grew at comparable rates for the first six months after stocking, i.e., during the period when all populations were expanding (Figs. 1-2). The effect of supplemental feeding on bluegill growth did not become evident until September of the first year. Growth was greatly accelerated in both treatment ponds in mid-September and rapid growth continued through late November. Bluegill in the control pond grew only slightly during this period, and by the end of October both male and female bluegill of this pond weighed significantly less (P=.05), respectively, than their counterparts in the treatment ponds. Due to the high stocking density and lack of fishing, growth of bluegill in the control pond population practically ceased at the end of the first year - 7 to 8 months after stocking - and the originally stocked bluegill remained in the 6- and 7-inch groups thereafter. Bluegill in both treatment ponds continued to grow throughout this phase of the experiment, and at draining of ponds C and T-1 in October of the second year, originally stocked bluegill averaged 0.33 pound in T-1 but only 0.14 pound in the control pond (pond C).

Calculated length-weight relationships (Fig. 3) illustrate the better condition indices of both male and female bluegill, 4-inch group and larger, in the treatment ponds than in the control pond.

The 4-inch group was attained in all ponds in the fifth month (July, 1963), and, according to the calculated length-weights, the differences in condition between

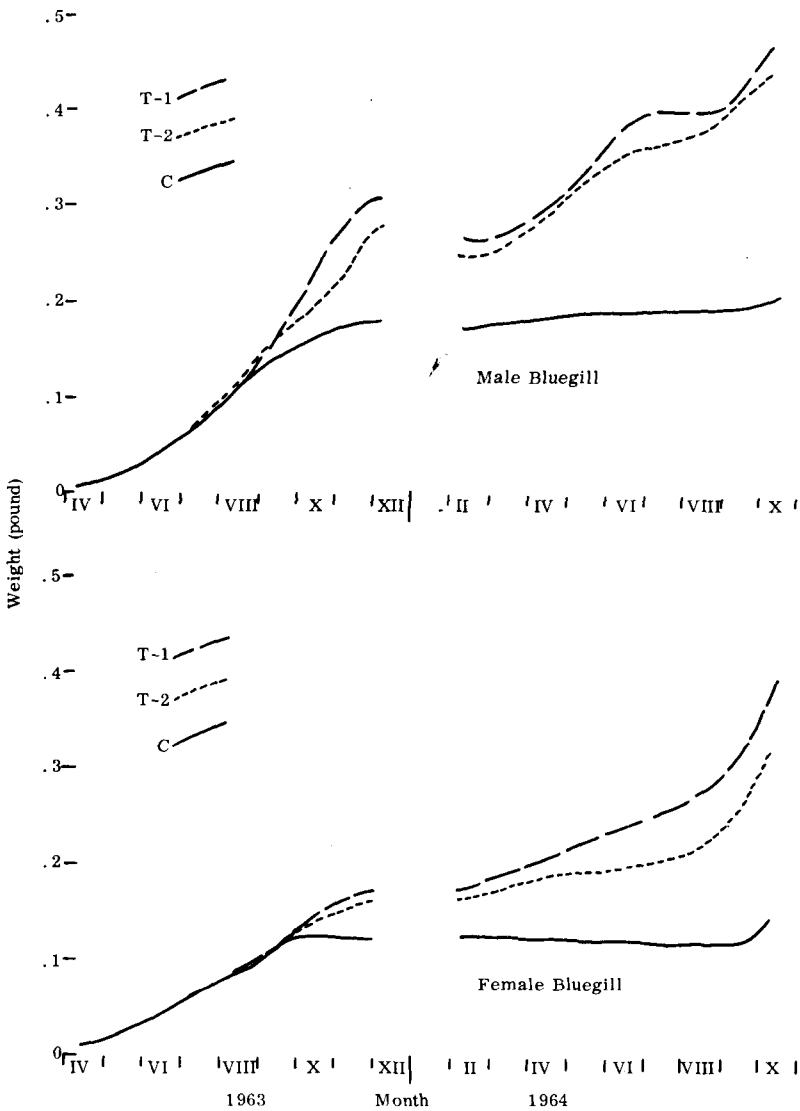

Fig. 1. Weight-time growth curves of male and female bluegill from ponds C, T-1 and T-2 based on bi-weekly samples taken from March, 1963 to October, 1964.

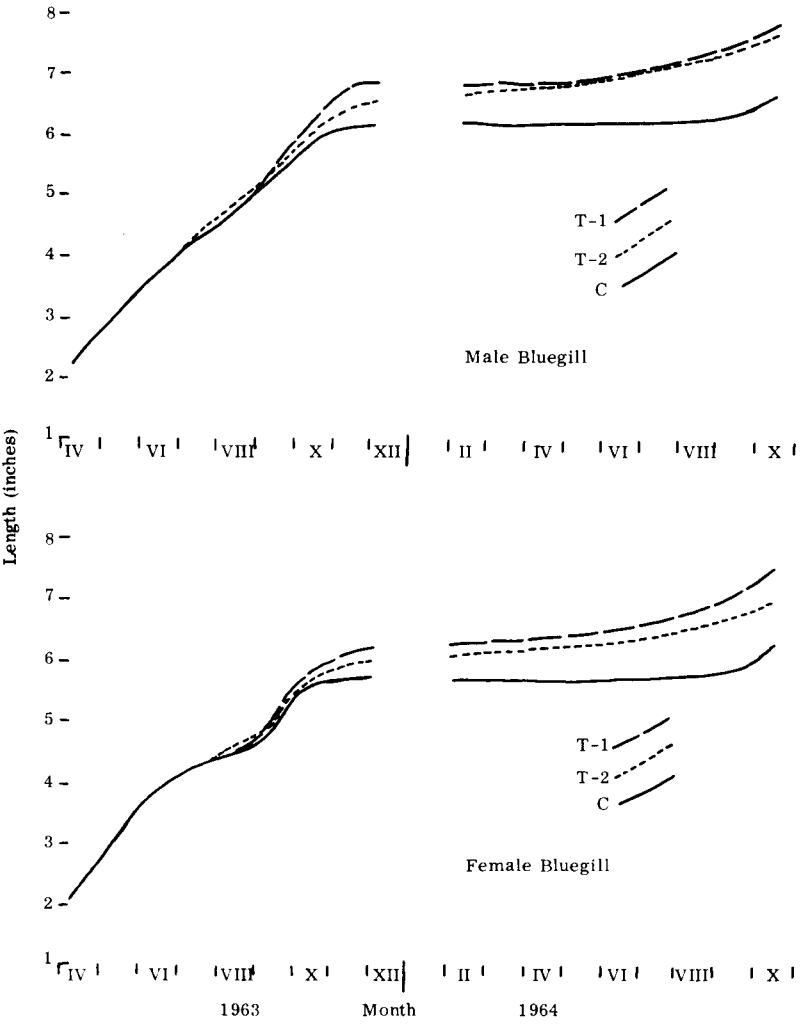

Fig. 2. Length-time growth curves of male and female bluegill from ponds C, T-1 and T-2 based on bi-weekly samples taken from March, 1963 to October, 1964.

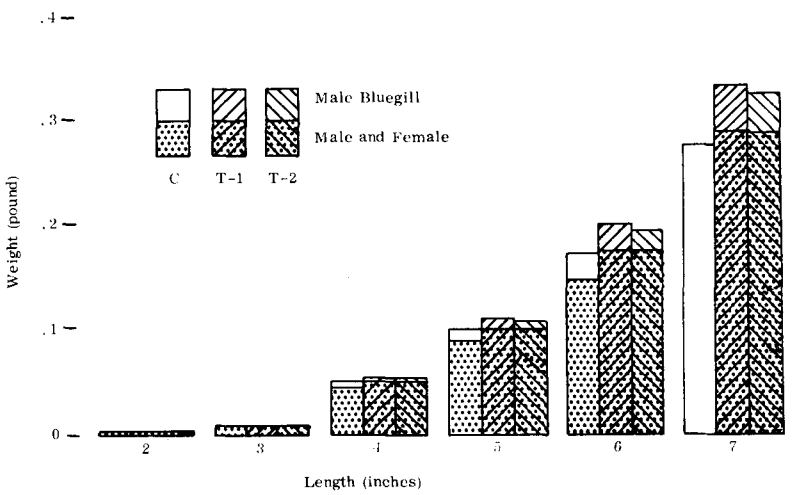

Fig. 3. Length-weights of male and female bluegill of ponds C, T-1 and T-2 calculated from data taken in bi-weekly samples from March, 1963 to October, 1964.

supplementally fed and control populations began to occur at this time although it was not visibly evident in the samples until the seventh month (September). The slightly lower condition index of bluegill in T-2 than in T-1, the two supplementally fed populations, may be attributed to the stocking of 286 more bluegill per acre into T-2 than in T-1, which resulted in greater competition for less food per fish. Also, the T-2 population experienced a mild parasite (*Trichodina*) epizootic resulting in insignificant mortality, in the fall of 1963 that probably adversely affected condition of those fish.

Seining results indicated that all ponds were becoming crowded with 4- and 5-inch bluegill by late May and June of the second year - about 14 months after stocking. However, spawning had occurred in all ponds by May 18, and some fry were found in all ponds throughout the spawning season from mid-May through September. The number of intermediate bluegill per 50-foot seine haul declined steadily during the summer and both treatment ponds remained in proper balance (Swingle, 1950). The control pond population was considered out-of-balance since a static condition was present, however, 63% of the bluegill were of harvestable size (0.1 pound or larger).

Upon draining ponds T-1 and C, totals of 1694 (84.7%) and 1744 (87.2%) bluegill, respectively, were recovered from 2000 stocked into each pond. The numbers recovered include those bluegill removed in samples during the experiment. *Survival of the original stock of bluegill was considered not different (P=.05) between* treatment (T-1) and control ponds. It was concluded that feeding had no effect on bluegill survival through 19 months after stocking.

Total production per acre in pond C, the control pond, during the 19-month period was 429 pounds of fish. The standing crop at draining was 361 pounds and 68 pounds had been removed in sampling during the experiment. Of that total 386 pounds (90.0%) were fish of harvestable size. The bluegill alone totaled 374 pounds of which 235 pounds (62.8%) were harvestable (0.1 pound or larger). A total of 54 pounds of largemouth bass were produced of which 51 pounds were harvestable (0.4 pound or larger).

Total production per acre in T-1 during the 19-month period was 749 pounds. The standing crop at draining was 621 pounds and 128 pounds had been removed in samples during the experiment. Of the total production, 602 pounds (80.4%) were

fish of harvestable size. The bluegill alone totaled 682 pounds of which 551 pounds (80.8%) were harvestable. A total of 66 pounds of largemouth bass were produced in this pond, of which 52 pounds were harvestable.

When drained, the difference in total fish production between T-1 and the control pond was 320 pounds (74.6%). The difference in total production of bluegill between ponds was 308 pounds (82.4%). These results indicate that total fish production and production of bluegill were each increased approximately 75 to 80% by supplemental feeding in 19 months after stocking.

Corrected conversion factors (Swingle, 1959) using differences in weights between the control bluegill population and that of T-1, were obtained using the formula C = F/W, where F equals total weight of feed used (2896 pounds) and W equals difference in harvestable or total weight of bluegill between ponds C and T-1. Values of "C" for harvestable bluegill weight and total bluegill weight for T-1 were 9.2 and 9.4, respectively.

A reduction in conversion factor could probably be accomplished with adjustments in the rate of feeding for different seasons of the year. Not feeding during population expansion, i.e., until September of the first year, would have saved 550 pounds of feed and probably would not have significantly affected bluegill growth rate or total production. A 550 pound reduction in feed would lower the above C values to 7.4 and 7.6, respectively. Increasing the rate of feeding during the spring and fall growing seasons - March through May and September through November - and decreasing the feeding rate during the summer months could possibly have given better efficiency and consequently reduced the conversion values.

Standing crop in each pond at draining may be used as an expression of productivity in this experiment, and pond T-2, the treatment pond drained in 1967 and discussed in detail in Phase II, may be used in comparisons of this parameter. Based on the bluegill growth curves, condition indices, and/or seining results, it appears that standing crop in the control pond and in T-2 were equal to or approximately equal to maximum productivity for conditions in those respective ponds, but that the standing crop of T-1 was less than maximum production. Standing crop in the control pond was 361 pounds after 19 months as compared to 621 pounds standing crop in T-1 for the same period. Standing crop was 1129 pounds in pond T-2 after 55 months. The difference of 768 pounds in standing crop between the control pond and T-2 is considered the approximate difference in carrying capacity between conditions of these two fed and non fed populations.

Phase II

MATERIALS AND METHODS

This phase of the experiment was conducted exclusively in T-2, the 3.5-acre pond discussed in Phase I. The pond was stocked per acre in March and April, 1963, with 1143 fathead minnows, 2286 2-inch bluegill and 150 1-inch largemouth bass. In addition to the original stocking of bass, 100 2- and 3-inch bass fingerlings were stocked into this pond on 25 May, 1967, and another 15 bass averaging 0.3 pound each were stocked per acre on 9 June 1967. Wild fish, redear sunfish, *Lepomis microlophus* (Gunther), green sunfish, *Lepomis cyanellus* Rafinesque, brown bullhead, *Ictalurus nebulosus* (Le Sueur), and golden shiners, *Notemigonus crysoleucas* (Mitchill), entered the pond in early summer, 1963.

Fertilization and feeding was conducted as discussed in Phase I, except fertilization was discontinued after 1964 (Table 1). Population analysis checks (Swingle, 1950) were made using 15- and 50-foot seines at bi-weekly or monthly intervals throughout the study.

Controlled fishing - restricting the weight of each species removed during a specific time interval - was begun in 1964 with intentions of removing 10 pounds of bluegill and 3 pounds of bass per acre per week. Necessary manpower required to handle fishing activities was not available, so fishing was carried-out as manpower permitted. The pond was opened to public fishing on restricted basis during March to October of each year 1964 through 1967. Fishing records kept included number and weight of each species caught and time fished by each fisherman.

This phase of the experiment was terminated with the draining of T-2 on 16 October 1967.

RESULTS AND DISCUSSION

Population balance appeared to be the major factor in the results obtained in the fishing phase of the study. Seining analysis indicated the population to be in balance through 1965, for reproduction of both base and bluegill were found throughout each summer. Bass and bluegill reproduction was found in 1966 but the number of bluegill fry was low. No evidence of bass or bluegill reproduction was found in 1967. It appears from this information that the out-of-balance condition was developing in 1966 and possibly in 1965, although some bluegill fry were found throughout the summer of 1965.

The reason for population unbalance was due to lack of sufficient bass to keep the bluegill reproduction in-check. At draining only 33 bass weighing 34 pounds (3% by weight of the total population) were recovered per acre from the pond. These bass include the 100 fingerlings and 15 adult bass stocked in May and June, 1967. A total of 265 bass were stocked per acre and bass reproduced every year except 1967. However, only 153 bass were recovered per acre during and at termination of the experiment. The largest number and weight of bass removed per acre from the pond in any one year was in 1966 when 59 bass weighing 32 pounds were taken by angling. Byrd and Crance (1965) reported the annual average bass catch in Alabama state-owned lakes to be 29 pounds per acre. The annual catch of bass in T-2 averaged 19 pounds and only 5 pounds in 1967 after the peak catch of 32 pounds in 1966. The reason(s) for the insufficient bass population is not known, but is not considered to be associated with supplemental feeding or a result of excessive fishing pressure. This is verified by the population relationship (analysis) values using the standing crop (Table 2).

The A and S values are indicative of fished but balanced populations; however, the Y/C and F/C ratios verify the out-of-balance condition. Since the population was deficient in bass, the above values suggest that the population had not been excessively fished, and that supplemental feeding had replaced the effects of predation since expansion of the population continued in spite of the high F/C ratio.

Fishing success in T-2 during the 4-year period of fishing is presented in Table 3. Some of these data are compared to the 14-year averages in per acre fishing success in 20 Alabama state-owned lakes given by Byrd and Crance (1965) as follows:

Item	*State lake*	*T-2*	*% Difference*
Fishing trips	135	114	--
Catch/trip (pounds)	1.29	2.31	56
Annual catch (pounds)	173	274	63
Forage fish	144	255	56
Bass	29	19	66
Most weight caught in given year	281	502	56

These data show that catch per trip and total per acre catch were about 60 percent greater from the fed population than from the state lakes.

Total per acre production in T-2, including weight removed by fishing, was 2307 pounds - 113 pounds of bass, 2007 pounds of bluegill, and 187 pounds of other forage species. Total weight of all forage fish was 2194 pounds and was produced with 8766 pounds of feed - an S conversion of 4.0 where S is equal to 8766/2194. Considering only fertilizer and feed used, the cost of forage fish production was $0.22 per pound.

SUMMARY

1. Bluegill in the treatment and control ponds grew at comparable rates for the first 6 months after stocking. This indicates that growth rate was not effectively increased by supplemental feeding during this period.

TABLE 2
Population analysis values of T-2 standing crop at draining in October, 1967.

Species	*Analysis Value* E	H	A	I	S	F/C	Y/C
Largemouth bass	3.03	32.5	95.2	--	--	--	--
Bluegill	81.90	557.9	56.5	14.2	29.3	--	--
Brown bullhead	4.06	35.6	77.6	20.4	2.0	--	--
Golden shiner	11.01	0.0	0.0	99.7	0.3	--	--
Total forage	96.97	593.5	51.0	24.1	24.9	--	--
Total all species	100.00	626.0	52.3	--	-	32.0	8.0

Average size bass was 11.7 inches total length
Analysis values:

E = percent by weight of entire population
H = total weight of harvestable fish/acre
A = percent by weight of harvestable fish
I = percent by weight of intermediate sized fish
S = percent by weight of small fish
F/C = ratio of total weight of forage fishes to total weight of laregmouth bass
Y/C = ratio of "S" weight to total weight of bass

TABLE 3
Fishing success per acre in T-2 from 1964 through 1967.

Item	*1964*	*1965*	*1966*	*1967*	*Total*
Fishing trips	29.1	76.8	203.7	147.7	457.3
Fishing hours	104.8	374.2	949.3	702.1	2130.4
Catch/fisherman (pounds)	2.92	3.20	2.65	1.53	2.31
Catch/fishing hour (pounds)	0.81	0.66	0.57	0.32	0.52
Total catch (pounds)					
Bluegill	69.1	217.6	501.7	216.6	1005.0
Bass	13.7	27.1	31.6	4.8	77.2
Other species	2.3	1.2	7.1	4.7	15.3
Total	85.1*	245.9	540.4	226.1	1097.5
Percent catch (pounds)					
Bluegill	81.2	88.5	92.9	95.8	91.6
Bass	16.1	11.0	5.8	2.1	7.0
Other species	2.7	0.5	1.3	2.1	1.4
Average size caught (pound)					
Bluegill	0.30	0.39	0.32	0.28	0.32
Bass	0.72	0.97	0.54	0.41	0.66

*An additional 54.2 pounds of fish were removed by seining in 1964.

2. Eight months after stocking there was a significant difference between the weight of bluegill in the control pond and those in the treatment pond.
3. Calculated length-weight relations indicate that differences in condition indices began to occur in the fifth month (July, 1963) when bluegill in all ponds were in the 4-inch group. This difference was not visibly evident in the samples until the seventh month (September).
4. It was determined that the control population had become static by the time of draining - 19 months after stocking. The two treatment populations were considered to be in balance at that time.
5. Supplemental feeding had no effect on bluegill survival through 19 months after stocking.
6. The difference in total production of bluegill between one treatment pond (T-1) and the control pond after 19 months was 308 pounds (82.4%).
7. Corrected feed conversion factors for weight of harvestable bluegill and for total weight of bluegill for the treatment pond drained in 1964 were 9.2 and 9.4, respectively.

8. When drained, the control pond and the treatment pond (T-2) drained in 1967 were considered to have standing crops that were approximately equal to carrying capacity under conditions of those respective ponds. The difference in standing crops between those ponds was 768 pounds.
9. An unexplained loss in the bass population of T-2 created an out-of-balance condition during the controlled fishing phase of the study.
10. Population analysis values indicate that the effect of predation was replaced by supplemental feeding in the fished population.
11. Fishing success for the 4-year period in T-2 averaged about 60 percent better than in 20 Alabama state-owned fertilized lakes over a 14-year period.
12. Total production per acre in T-2 during the 4-year study was 2307 pounds including 2194 pounds of forage fish.
13. Conversion (S) of the 8766 pounds of feed used to produce the 2194 pounds of forage fish was 4.0, and cost, including cost of feed and fertilizer, $0.22 per pound.

LITERATURE CITED

Auburn University, Agricultural Experiment Station. Unpublished Fisheries Research Annual Reports 1947, 1950, and 1951.

Byrd, I.B., and J. H. Crance. 1965. Fourteen years of management and fishing success in Alabama's state-owned public fishing lakes. Trans. Am. Fish. Soc., 94(2):129-134.

Byrd, I. B., and H. S. Swingle. 1964. Pond fertilization cost can be reduced by 66 percent. Alabama Conservation, 34(3):4-6.

Prather, E. E. 1959. Further experiments on feeds for fathead minnows. Proc. 12th Ann. Conf. S. E. Assoc. Game and Fish Comm. (1958) 12:176-178.

Smith, E. V., and H. S. Swingle. 1943. Results of further experiments on the stocking of fish ponds. Trans. N. Am. Wildl. Conf. 8:168-179.

Swingle, H. S. 1949. Experiments with combinations of largemouth black bass, bluegills, and minnows in ponds. Trans. Am. Fish. Soc. (1946), 76:46-62.

_____. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Auburn Univ. Ag. Exp. St. Bull. No. 274, 74 pp.

_____. 1951. Experiments with various rates of stocking bluegills and largemouth bass in ponds. Trans. Am. Fish. Soc. (1950), 80:218-230.

_____. 1959. Experiments on growing fingerling channel catfish to marketable size in ponds. Proc. 12th Ann. Conf. S. E. Assoc. Game and Fish Comm. (1958), 12:63-72.

Swingle, H. S., and E. V. Smith. 1940. Experiments on the stocking of fish ponds. Trans. N. Am. Wildl. Conf., 5:267-276.

_____. 1942. Management of farm fish ponds. Ala. Ag. Exp. St. Bull. No. 254, 33 pp.

Swingle, W. E. 1964a. Length-weight relationships of fishes from Alabama rivers and river impoundments. Unpublished M.S. Thesis, Auburn Univ., Auburn, Alabama, 169 pp.

_____. 1964b. Length-weight relationships I. IBM 1620, Fortran/Format. Trans. Am. Fish. Soc., 93(3):318-319.