The Standing Crop of Fish in Oklahoma Ponds[1]

ROBERT M. JENKINS, Oklahoma Fishery Research Laboratory,
Norman

Current estimates of the total number of ponds in Oklahoma range between 150,000 and 200,000, averaging one acre in surface area, and construction is adding approximately 10,000 new ones per year. They comprise about one-third of the total surface water in the State, and represent a very large sport fishing potential. About 80 percent of the State fish hatchery output is used in pond stocking, and about 30 percent of research and management activities are centered on small bodies of water, which accounts for 60 percent of the entire annual budget of the Fisheries Division. Research efforts directed toward increasing the productivity and sport-fish catch through standing crop, species-combination, fertiliza-

---

[1] Contribution Number 65 of the Oklahoma Fishery Research Laboratory, a cooperative unit of the Oklahoma Department of Wildlife Conservation, and the University of Oklahoma Biological Survey.

tion, and physico-chemical studies, is therefore, of great importance, and should receive increased attention.

The pioneer work of Swingle (1950) in pond fish population research which was begun during the 1930's in Alabama has stimulated much interest in this problem in the past 20 years. Major studies have been conducted by Bennett (1943), Brown (1951), Carlander (1955) and many others. In Oklahoma, pond research results have been reported by Aldrich, Baumgartner, and Irwin (1944), Buck (1956), Burris (1954), Clemens and Martin (1953), Irwin and Stevenson (1951), Jenkins (1956), Kramer (1953) and Wallen (1955). During the past three years biologists at the Fishery Research Laboratory have undertaken detailed studies of the standing crop in ponds, based on the recovery of marked fish following rotenone treatment. A summary of the fish populations in 42 of the ponds studied is presented in this paper.

Methods and Materials

For the purpose of this study, a pond has been defined as any artificially-created body of water less than 10 acres in surface area. This admittedly arbitrary definition includes almost all of the ponds constructed by farm owners privately or through the federal aid program administered by the U. S. Soil Conservation Service, and conforms to the classification system employed by the Oklahoma Planning and Resources Board in describing State waters.

The field procedures used in standing crop determinations were as follows:

(1) Plane table map of pond made.

(2) History of pond obtained from owner, county agent, or local Soil Conservation Service representative.

(3) pH, alkalinity, turbidity, transparency, depth, and temperature of water determined.

(4) Pond sampled with one-half-inch mesh (bar measure) seine, 75 feet long; each fish measured, marked by clipping upper lobe of caudal fin or pectoral fin, and released. Seine hauls were continued until at least 100 fish per acre had been marked. Marked fish which showed any sign of distress were removed. In unseinable ponds, wire traps were used to capture fish for marking.

(5) Pond treated with 1 ppm. rotenone (cube root powder or emulsifiable Pro-Noxfish).

(6) All fish appearing on first day were recovered, total length measurements of at least 20 percent taken, and weights recorded of sufficient number of individuals to calculate length-weight relation. Remainder weighed in groups of 100. Scale samples taken from 30-40 fish of principal species, 10-20 of minor species. All data recorded on standard forms.

(7) On succeeding days, fish were picked up by species, counted and each checked for mark. Large fish were measured individually.

A total of 42 ponds treated with rotenone in the period June, 1954 through August, 1957, were considered to have been studied in sufficient detail, and the recapture of marked fish satisfactorily complete, to warrant statistical analysis and presentation. Although over one-half of the ponds (23) were in Carter County, they were located in various soil and vegetation types, and in combination with the other widely distributed ponds, are considered a fairly representative sample of small bodies of water in the State (Table I.) The ponds varied in size from 0.16 to 9.51 acres, averaging 2.05 acres. Twelve were less than 1 acre in surface area, 17 were between 1 and 2 acres, 5 were between 2 and 3 acres, and 8 exceeded 3 acres. Only 8 of the ponds were muddy, 6 were intermediate in turbidity, and the remaining 28 were clear (less than 25 ppm. turbidity.) Methyl orange alkalinity and pH determinations made near the surface indicated that all the ponds were well within the ranges usually encountered in Oklahoma ponds (Wallen, 1955). The ponds ranged in age from 1 to 55 years, averaging 17.7 years since impoundment at the time of study.

In analyzing the individual pond populations, the following data were computed and tabulated for each species present: number marked, number recaptured, estimated population, number per acre, average weight, pounds per acre, length-frequency, average total length and length range. In order to determine the available yield and relative condition of "balance" as prescribed by Swingle (1950), the numbers of harvestable-size fish were also determined. Harvestable-size fish are defined by minimum weights for each species as follows: sunfishes, 0.1 pounds; crappies, 0.25 pounds; largemouth bass, 0.4 pounds; bullheads, 0.3 pounds; channel catfish and gizzard shad, 0.5 pounds; and carp, buffalo fish and carpsuckers, 1.0 pounds. The percentage of harvestable-size fish in the total standing crop (A_t), and the percentage of the standing crop represented by each species could then be determined.

All computations were made to the nearest 0.1 pound, and rounded to the nearest whole number for presentation. Where appearing in tables, "t" indicates less than 0.5 pounds. The analysis of numbers of fish and length frequency distributions were omitted to save space.

Twenty-two species were collected in the ponds, including: gizzard shad, *Dorosoma cepedianum;* bigmouth buffalofish, *Ictiobus cyprinellus;* black buffalofish, *Ictiobus niger;* river carpsucker, *Carpiodes carpio;* golden redhorse, *Moxostoma erythrurum;* carp, *Cyprinus carpio;* golden shiner, *Notemigonus crysoleucas;* red shiner, *Notropis lutrensis;* channel catfish, *Ictalurus punctatus;* black bullhead, *Ictalurus melas; Gambusia affinis;* white bass, *Roccus chrysops;* spotted bass, *Micropterus punctulatus,* largemouth bass, *M. salmoides;* warmouth, *Chaenobryttus coronarius;* green sunfish, *Lepomis cyanellus;* redear sunfish, *L. microlophus;* longear sunfish, *L. megalotis;* orangespotted sunfish, *L. humilis;* bluegill, *L. macrochirus;* white crappie, *Pomoxis annularis;* black crappie, *P. nigromaculatus.*

Estimated Standing Crop in 42 Ponds

The average standing crop of fish in the 42 ponds studied (Table I) was 341 pounds per acre (Table II.) The standing crop ranged from 57 pounds per acre in a 1.45-acre pond containing only green sunfish to 931 pounds per acre in a 0.16-acre puddle with black bullheads and green sunfish present. Eighty percent of the ponds had standing crops of 120 to 600 pounds per acre, and 50 percent were within the range of 230 to 480 pounds per acre. In comparison, Swingle (1950) found an average standing crop of 236 pounds per acre in 55 "balanced" 1 to 29-acre ponds in Alabama, and an average of 328 pounds per acre in 34 "unbalanced" ponds 1.2-2.6 acres in size, which suggests that Oklahoma ponds are slightly more productive.

Table I. Location and physical and chemical description of 42 Oklahoma ponds studied to determine the standing crop of fish, June, 1954-August, 1957.

Name of pond	No.	County	Section, Township, Range	Date of estimate	Area (acres)	Turbidity (ppm.)	MO alk. (ppm.)	pH	Age of pond (years)
Crowley	1	Atoka	29,2N,12E	12July54	3.00				17
Walton	2	Blaine	35,19N,12W	8Aug57	0.81	25	149	7.5	3
Bridges 1	3	Carter	8,4S,2E	21Jun57	1.45	7	57	8.5	2
Bridges 2	4	Carter	8,4S,2E	19Jun57	2.91	9	57	8.3	6
Bridges 3	5	Carter	8,4S,2E	2July57	1.85	3	98	8.1	8
Colvert 1	6	Carter	29,4S,1E	11Jul57	1.68	18	92	8.1	1
Colvert 2	7	Carter	29,4S,1E	11July57	0.79	20	56	8.6	15
Darbonne	8	Carter	3,4S,1E	16Jul57	1.57	18	84	7.6	22
Ellis	9	Carter	33,2S,1E	27Jul55	4.00			8.2	20
Franklin (A)	10	Carter	18,4S,2E	15Jun54	1.70	20	92	7.5	45
Franklin (B)	11	Carter	18,4S,2E	22May56	0.75	19	92	7.4	2
Goddard 2	12	Carter	10,3S,3E	8Apr57	1.68	7	62	8.0	20
Johnson	13	Carter	18,4S,2E	11Jul56	1.82	8	110	7.3	35
Loughridge	14	Carter	33,4S,2E	18Jul56	3.00	130	36	7.3	55
Mahan	15	Carter	11,4S,2E	17Jul56	4.57	43	95	7.6	17
Moore	16	Carter	34,2S,1E	22Jul55	0.28		58	8.2	19
Muse Strip Pit	17	Carter	21,4S,1E	16Jul57	1.34	8	102	7.6	8
Noble 13	18	Carter	1,4S,1E	24Jun57	3.41	7	80	8.2	16
Noble 14	19	Carter	1,4S,1E	18Jun57	2.75	2	80	8.2	15
North Rod & Gun	20	Carter	18,4S,2E	5Jul56	8.50	19	66	8.0	34
Orr	21	Carter	1,4S,2E	17Jun55	0.47	56	69	7.4	20
Otey	22	Carter	4,4S,2E	2Jul57	1.78	7	52	8.8	15
Taylor	23	Carter	34,2S,1W	24Jul56	0.61	21	88	7.8	42
Van Eaton 1	24	Carter	19,5S,2E	26Jun57	1.09	14	63	7.9	15
Van Eaton 2	25	Carter	19,5S.2E	3Sep57	2.14	18	55	7.2	16
Conklin	26	Cleveland	27,7N,1E	5Jun56	0.75	9	30	8.7	6
McNees	27	Cleveland	35,8N,1W	29Aug57	0.36	10	33	7.3	5
Golf Course	28	Cleveland	32,9N,2W	30Aug56	2.20				29
Smith	29	Cleveland	21,7N,1E	11Mar57	0.58	115	50	7.6	21
Sudik	30	Cleveland	6,10N,3W	7Jun56	1.64				18

Table I. (Cont.). Location and physical and chemical description of 42 Oklahoma ponds studied to determine the standing crop of fish, June, 1954-August, 1957.

Name of pond	No.	County	Section, Township, Range	Date of estimate	Area (acres)	Turbidity (ppm.)	MO alk. (ppm.)	pH	Age of pond (years)
Tubbs	31	Cleveland	33,10N,3W	4Jun57	1.69	96			15
Tull	32	Cleveland	19,9N,2W	22Feb57	0.16	20	80	8.0	6
Woesner	33	Comanche	14,2N,14W	27Jun57	1.82	105		7.0	5
Snedden	34	Craig	30,27N,18E	7Aug56	9.51				21
Clark	35	Major	6,22N,14W	7Aug57	1.14	8	44	7.5	12
Montgomery	36	Nowata	36,26N,15E	8Aug56	3.55				20
Stith	37	Nowata	25,26N,15E	6Aug56	1.93				22
Zoellar	38	Pottawat.	31,7N,5E	21Jun56	2.35	150			16
Jackson	39	Seminole	30,10N,7E	14Jun56	0.71				8
Erwin	40	Woodward	17,23N,20W	30Jul57	0.76	13	154	7.1	40
Agri. Exp. Sta.	41	Woodward	34,23N,21W	31Jul57	1.44	10	115	7.3	21
Henderson	42	Woodward	21,25N,18W	1Aug57	1.47	8	114	7.6	9
				Average	2.05				

Table II. The estimated standing crop of fish in 42 Oklahoma ponds based on recovery of marked fish following rotenone treatment, 1954-57.

Standing crop in pounds per acre

Pond	Total	Harvest-able size	A_t	Largemouth bass	Bluegill	Crappies	Channel catfish	Black bullhead	Other sunfishes	Coarse fishes
1	244	14	6	5	30	78	2		115	14
2	133	17	13			16		117		
3	57	0	0						57	
4	149	91	61	51	59	8	16		57	
5	126	71	57	33	33	60			+	
6	71	27	39	13					58	
7	256	49	13	37				121	97	1
8	332	138	42		41		1	221	69	
9	338	180	53	26	25	33		76	5	173
10	441	322	73	44	390	3			4	
11	346	318	92	41	180	4	1		120	
12	271	162	60			222	10		39	
13	472	27	6	24	407	34			7	
14	327	4	1		3	205		107	12	
15	521	140	27	42	194	77	19		177	12
16	450	140	31	60	171	191			19	9
17	79	25	32							79
18	576	474	82	7	472		41		54	2
19	597	380	64	89	341	+			138	29
20	360	154	43	23	185	57			94	1
21	444	345	78	104	50			250	19	21
22	216	121	56	90	118				8	
23	671	220	33	3	394	42		226	6	
24	317	209	66	31	106	69			109	2
25	237	201	85	7	97	69			64	+
26	470	106	23	76	254				101	39
27	81	66	82	33		15			33	
28	152	26	17					34	97	21
29	650	494	76	320	5	108			71	146
30	191	23	12			62	17	81	31	
31	175	2	1	3		18		126	28	
32	931	0	0					831	100	
33	149	22	15					130	19	
34	502	302	61	17	85	25	7	+	11	357
35	121	15	13	8				25	88	
36	275	160	58	37	155	55			22	6
37	339	106	31	46	130	107			52	4
38	264	91	35	17	96	108	33	+	6	4
39	281	12	4					168	57	56
40	835	55	7	2	30	8	35	533	198	29
41	481	76	15		192	25	46	17	92	109
42	387	142	31	21	255		22	22	65	2
Average	341	132	38	44	161	63	19	162	59	49

The average standing crop of largemouth bass was 44 pounds per acre, ranging from 2 to 320 pounds per acre (Table II.) The average bluegill standing crop was almost four times greater than bass, equalling 161 pounds per acre, and ranging from 3 to 472 pounds per acre. White and black crappies combined averaged 63 pounds per acre, ranging from a trace to 222 pounds per acre. Channel catfish averaged only 19 pounds per acre, the maximum being 46. Black bullheads rivalled bluegill in standing crop, averaging 162 pounds per acre, and ranging up to 831. The other sunfishes, including warmouth, green, redear, longear and orangespotted, averaged 59 pounds per acre, with a maximum of 198. The coarse fishes, including carp, carpsucker, bigmouth and black buffalofish, redhorse, gizzard shad and golden shiner represented an average of 49 pounds per acre, with a maximum of 357.

The average crop of harvestable-size fish equalled 132 pounds per acre, ranging from 0 to 494. Computed A_t values averaged 38, which is barely within the lower limit of Swingle's definition of balanced populations. Within the scope of Swingle's (1950) condition indices, 12 of the ponds were in the highly desirable range of balance, 7 were balanced, 3 were borderline, inefficient populations and 20 represented unbalanced situations.

The most common species was the green sunfish, which occurred in 86 percent of the 42 ponds (Table III.) In descending order of frequency of occurence other species were: largemouth bass, 0.71; bluegill, 0.67; black bullhead, 0.48; golden shiner, 0.45; redear sunfish and white crappie, 0.43; black crappie and orangespotted sunfish, 0.38; warmouth, 0.36; channel catfish, 0.31; carp, 0.26 and river carpsucker, 0.21.

Table III. Standing crop of various species in 42 Oklahoma ponds, including average, maximum, and harvestable-size standing crop in pounds per acre, precent of harvestable-size (A), percent of total standing crop represented by each species (E value), and frequency of occurence in the 42 ponds.

	Pounds per acre					
Species	Average	Maximum	Harvestable size	A	Average E value	Frequency of occurence
Largemouth bass	44	320	36	82	14	0.71
Channel catfish	19	46	19	100	5	0.31
White crappie	72	205	11	15	21	0.43
Black crappie	23	69	7	30	6	0.38
Black bullhead	162	831	34	22	43	0.48
Bluegill	161	472	64	40	39	0.67
Green sunfish	30	198	7	23	9	0.86
Redear sunfish	44	160	23	52	12	0.43
Warmouth	15	120	11	73	4	0.36
Longear sunfish	13	31	0	0	3	0.07
Orangespotted sunfish	14	64	0	0	4	0.38
Gizzard shad	137	172	37	27	28	0.05
Golden shiner	10	56	0	0	2	0.45
River carpsucker	23	125	17	74	6	0.21
Buffaloes	45	73	38	84	15	0.05
Golden redhorse	1	1	1	100	—	0.02
Carp	33	170	28	85	7	0.26

Channel catfish populations were made up of 100 percent harvestable-size individuals (A) in all 13 ponds in which they were present (Table III.) Next in relative harvestable-size fish production was largemouth bass, with an average A value of 82, followed by warmouth with 73. These three species represent the most highly desirable sport fishes for pond production. Of the remaining sunfishes, redear sunfish displayed the highest potential harvestable-size production with an A value of 52, followed by bluegill, 40 and green sunfish, 23.

Only 22 percent of the bullhead populations were of harvestable size, which indicates the tendency of this species to overcrowing and slow growth. White crappie were even more unsatisfactory, displaying an average A of 15. Black crappie populations had an average A of 30, indicating that this species is more desirable in ponds than white crappie, but that neither of the crappies is a recommended pond fish.

Wherever occurring, black bullheads and bluegill tended to dominate the population, with average E values (percent of total standing crop) of 43 and 39, respectively. White crappie constituted an average of 21 percent of the total standing crop when present, followed by largemouth bass with an E value of 14, redear sunfish, 12, green sunfish, 9, black crappie, 6, channel catfish, 5 and warmouth, 4. Of the forage fishes, gizzard shad represented an average of 28 percent of the standing crop, orangespotted sunfish, 4, longear sunfish 3 and golden shiner, 2. In the two ponds, where present, buffalofish had an E value of 15; carp, 7 in 11 ponds; and river carpsucker 6 in 9 ponds. Species combinations were so varied in the 42 ponds that no analysis of their relative merits was attempted.

Interspecific Competition

In order to determine the degree of competition occurring between species in the ponds, regressions of the standing crop of one species with and without another species was computed to determine regression coefficients. Certain precautions should be noted in undertaking such an analysis, however. As stated by Carlander (1955): "The fact that there is a significant decrease in standing crop of one species when another species is present—and that the standing crop further decreases as the other species becomes more abundant—does not indicate that competition is taking place . . . Analysis of the standing crops may not give proof of competion, but may aid in determining where competition may be suspected." The wide range of species combinations and environmental conditions encountered in this study may further tend to mask the effects of interspecific competition.

Populations with channel catfish or black bullheads present had smaller standing crops of largemouth bass than populations without these catfish, but the differences were not significant at the 95 percent confidence level (Table IV.) The presence of crappies had no measurable effect on largemouth bass crops. Bass standing crops appeared to improve with the presence of bluegill and redear sunfish, which is in agreement with conditions in midwest reservoirs analyzed by Carlander (1955). Surprisingly, bass crops were higher with the presence of carp and other rough fishes than without, which is in opposition to findings in other midwest reservoirs (Carlander, 1955).

The presence of redear sunfish had no apparent effect on bluegill standing crops (Table IV.) Although not significant at the 95 percent confidence limit, a decrease in bluegill standing crop in the presence of bullheads was indicated. Green sunfish crops appeared to be decreased in the presence of largemouth bass, bluegill (significant F), and other sunfishes, but significantly increased in the presence of black bullheads.

Table IV. Standing crop of major species, in pounds per acre, with and without the presence of certain other species. F-values or regression coefficients marked with asterisk indicate less than 1 chance in 20 that the observed value would occur if true value is zero.

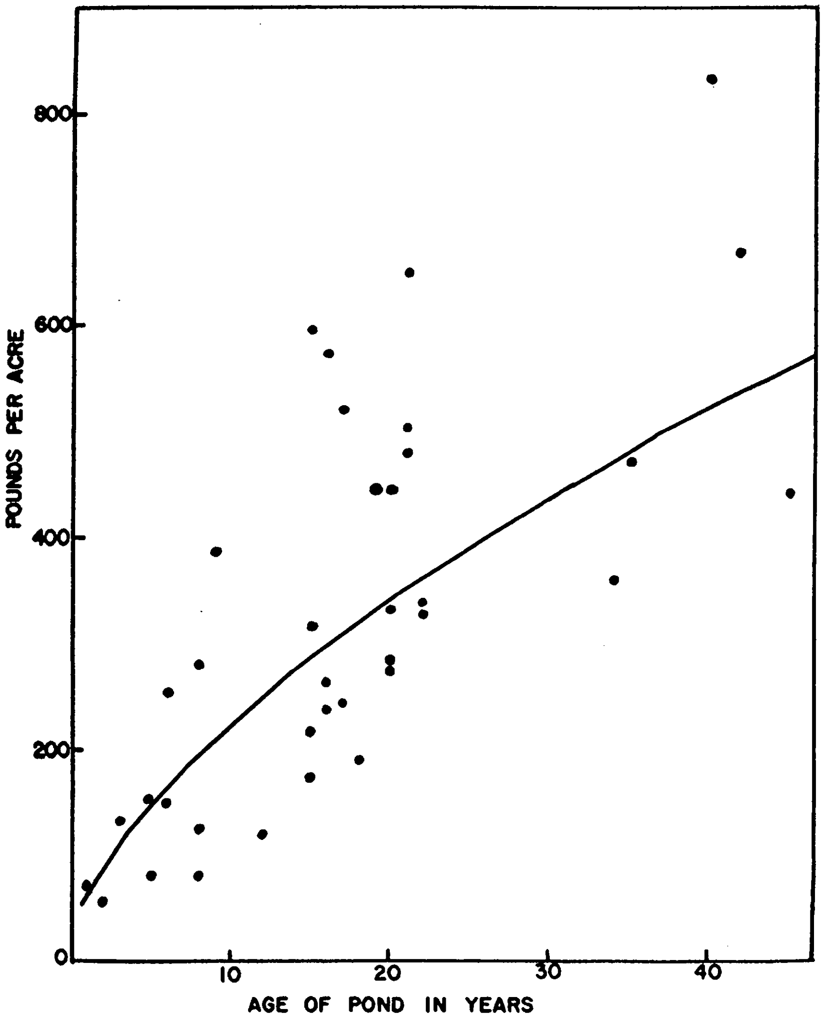
	Number of ponds	Average pounds per acre	F
Largemouth bass			
Without	21	53	
With channel catfish	9	23	1.69
Without	8	45	
With crappies	22	43	0.0002
Without	20	54	
With black bullhead	10	24	1.75
Without	5	19	
With bluegill	25	49	1.07
Without	14	29	
With redear sunfish	16	57	1.75
Without	21	34	
With carp	9	67	2.07
Without	11	31	
With rough fishes	19	51	0.81
			($F_{(.05)} = 4.20$)
Bluegill			
Without	12	158	
With redear sunfish	16	163	0.01
Without	18	185	
With black bullhead	10	117	1.66
			($F_{(.05)} = 4.22$)
Green sunfish			
Without	10	45	
With largemouth bass	26	24	1.98
Without	12	51	
With bluegill	24	20	5.23*
Without	7	56	
With other sunfishes	29	24	3.85
Without	17	16	
With black bullhead	19	43	4.18*
			($F_{(0.05)} = 4.13$)
Black crappie			
Without	9	28	
With white crappie	7	17	1.22

Other differences noted were an increase in largemouth bass crops in the presence of golden shiners and orangespotted and longear sunfishes, a decrease in black crappie in the presence of white crappie, and no appreciable effect of black bullheads on crappies.

Relation of Standing Crop to Age of Pond

In an effort to measure the accumulative effect of the addition of

Figure 1. Regression of logarithm of standing crop upon logarithm of age of pond in 42 Oklahoma ponds.



plant and animal metabolic products on fish production, a regression of standing crop on the age of pond was computed (Figure 1.) Four old ponds which had been treated with rotenone and restocked were omitted.

The regression line for data from 38 ponds is:

$$P = 1.7286 + 0.6161A$$

where P is the logarithm of the standing crop in pounds per acre
and A is the logarithm of the age of the pond in years.

In an effort to find a regression which would better fit the data, a second-degree parabola was computed, resulting in the regression formula

$$P = -18.263 + 28.706A - 0.370 A^2$$

Examination indicated that the logarithmic relationship provided a more reasonable fit, and it is presented in Figure 1. The standard error of the regression equalled 0.1800, and the coefficient of correlation was 0.78 (Table V.) The positive regression of standing crop on pond age strongly suggests that basic productivity increases steadily as organic nutrients accumulate in the pond, and that higher standing crops of fish may be anticipated in Oklahoma waters as the thousands of recently-constructed ponds become older. Barring excessive siltation and floods, pond owners can look forward to increased fish production if modern fish management practices are adopted and vigorously employed.

Relation of Standing Crop to Number of Species

An expected increase in standing crop with increase in number of species was demonstrated by computation of the logarithmic regression relationship of the two variables in 41 ponds (Table V, Figure 2.) The regression line for these data is:

$$P = 1.8200 + 0.8300N$$

Where P is the logarithm of the standing crop in pounds per acre
and N is the logarithm of the number of species in the population.

Carlander (1955) found a similar relationship in his analysis of several pond studies, but the rate of standing crop increase with addition of species (regression = 0.3243) was not as steep as that indicated in the Oklahoma ponds (regression = 0.8300.)

It is apparent that opportunities for additional species introductions by upstream migration during flood, and inadvertant or intentional stocking by fishermen, increase with the age of the pond. This factor may influence the relation of increase of standing crop with increase in age of the pond previously demonstrated. A regression analysis of pond age upon number of species demonstrated a positive value, but with a very high standard error (Table V), and it is not believed that this factor negates the phenomenon of increased productivity accompanying ageing of the pond.

Relation of Standing Crop to Carbonate Content of the Water

The logarithmic relation of standing crop upon methyl orange alkalinity in 26 Oklahoma ponds is expressed by the equation:

$$P = 1.5608 + 0.5087C$$

where P is the logarithm of the standing crop in pounds per acre
and C is the logarithm of methyl orange alkalinity in parts per million

The standing crop showed a significant increase with increased alkalinity, but with a relatively low coefficient of correlation, 0.37. Carlander (1955) demonstrated a similar relationship in warm-water lakes and reservoirs, with higher coefficients of correlation (0.64 and 0.83, respectively). More data are needed from Oklahoma waters to clearly define this important relationship.

Figure 2. Regression of logarithm of standing crop upon logarithm of number of species in 42 Oklahoma ponds.

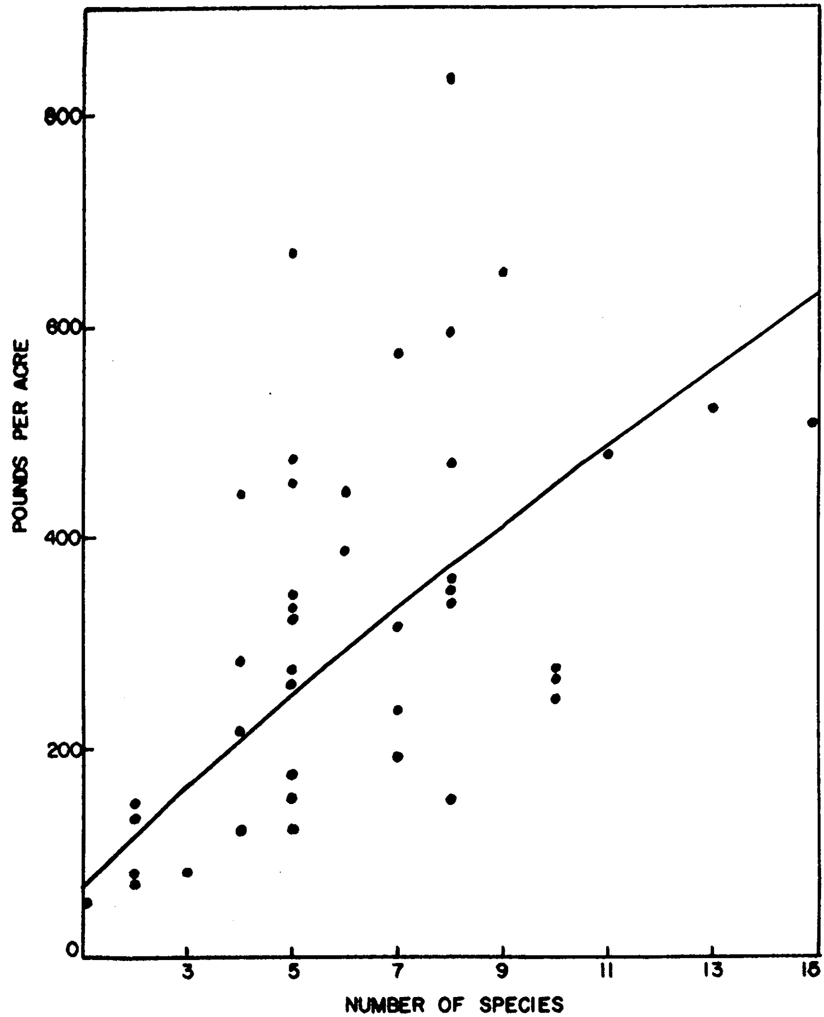
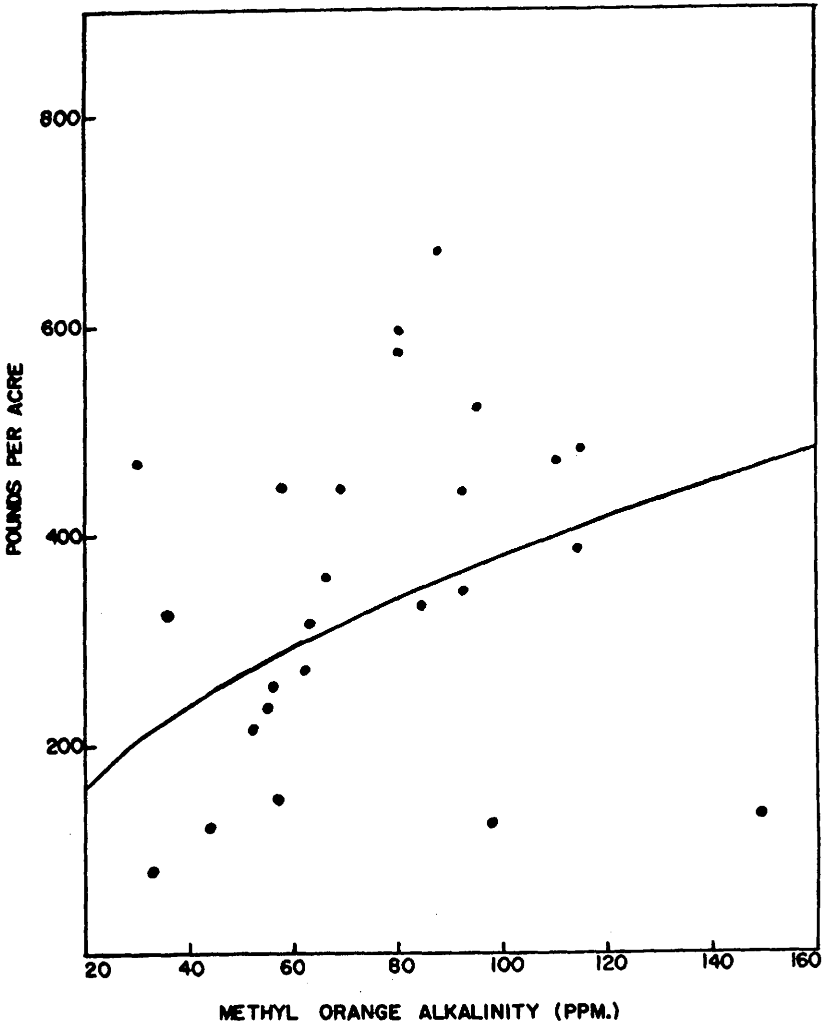


Table V. Relationship of the standing crop in pounds per acre to age of pond, number of species, methyl orange alkalinity, and surface area, and age of pond to number of species in Oklahoma ponds.

Relationship	Number of ponds	Regression b	Standard error S_b	Coefficient of correlation r
Standing crop — age of pond in years	38	0.6161	0.1800	0.780
Standing crop — number of species	41	0.8300	0.1998	0.708
Standing crop — methyl orange alkalinity (ppm.)	26	0.5087	0.2331	0.372
Age of pond — number of species	42	0.8735	0.4670	0.621
Standing crop — surface area in 0.01 acres	41	0.0164	0.2827	0.022

Figure 3. Regression of logarithm of standing crop upon logarithm of methyl orange alkalinity (ppm.) in 26 Oklahoma ponds.



The logarithmic relation of standing crop to surface area of Oklahoma ponds disclosed no relationship (P = 2.3980 + 0.0164 area in 0.01 acres) (Table V), which is in agreement with the analysis of available data from U. S. water (Carlander, 1955).

Pond Management Suggestions

The foregoing analyses have provided no evaluation of controlled species combinations to serve as a basis for establishing stocking ratios. However, certain basic facts are outlined which should be considered in any pond stocking, population manipulation, or environmental improvement program. It has been shown that largemouth bass, channel catfish, warmouth and redear sunfish produced more harvestable-size fish in comparison with their total standing crop than any of the other fishes, indicating that these 4 species are less prone to slow growth and overcrowding in ponds. Any program of rearing fish for public stocking should, therefore, be directed towards greater high quality production of these species.

Until better methods of controlling the access of "wild" fish to ponds is developed, concern over the presence of adequate numbers of forage fishes should be greatly lessened. There were an average of 5.3 species in the 42 ponds studied, many of them containing forage fishes not reared in State hatcheries. In the 30 ponds containing largemouth bass there were an average of 7.0 species, and only 2 of these ponds did not have at least one "wild" forage species. It would seem wisest, therefore, to restrict stocking to only the most desirable species, and curtail the costly effort of providing bluegill as a forage fish. White crappie were represented by an adequate number of harvestable-size fish in only 2 ponds out of 18, and black crappie in only 3 out of 16. The average A values of these two species were only 15 and 30, respectively. They are not, therefore, desirable species for waters under 10 acres in size, and their introduction into ponds should be discouraged.

If siltation and water exchange are limited by proper pond construction, an increase in standing crop of 10 to 30 pounds per acre per year following impoundment may be anticipated. It is, therefore, imperative that dam sites be chosen carefully, and that soil erosion prevention measures be taken if optimum fish production is the goal.

An examiantion of standing crop, length-frequency distribution, growth-rate and longevity data from these ponds indicates that the fish populations are unharvested and that owners could fish them intensively with traps and seines at intervals without harmful effect.

Summary

Analyses of the estimated standing crop of fish in 42 Oklahoma ponds indicate:

1. An average standing crop of 341 pounds per acre, ranging from 57 to 931 pounds per acre.
2. A harvestable-size average standing crop of 132 pounds per acre, ranging from 0 to 494 pounds per acre.
3. High average A values (percent harvestable) for channel catfish (100), largemouth bass (82), and warmouth (73).
4. High average E values (percent of total standing crop) for black bullhead (43) and bluegill (39).
5. Tendency for largemouth bass crops to increase in presence of sunfishes, golden shiners, carp, and buffalo fishes, and to decrease in presence of black bullhead and channel catfish.
6. Tendency for green sunfish crops to increase in presence of black bullheads, and to decrease in presence of other sunfishes and largemouth bass.
7. A positive regression of standing crop on age of the pond, number of species, and carbonate content of the water.
8. No relation of standing crop to surface area of the pond.

LITERATURE CITED

Aldrich, A. D., F. M. Baumgartner, and W. H. Irwin. 1944. Fish production in farm ponds. Okla. Agri. and Mech. Coll. Exp. Sta. Circ. C-115: 1-8.

Bennett, George W. 1943. Management of small artificial lakes, a summary of fisheries investigations, 1938-42. Bull. Illinois Nat. Hist. Survey, 22(3): 356-376.

Brown, William H. 1951. Results of stocking largemouth black bass and channel catfish in experimental Texas farm ponds. Trans. Amer. Fish. Soc., 80: 210-217.

Buck, D. Homer. 1956. Effects of turbidity on fish and fishing. Okla. Fish. Res. Lab. Rep., 56: 1-62, (multilith.)

Burris, W. E. 1954. The bottom fauna development of a newly constructed pond in central Oklahoma. Proc. Okla. Acad. Sci. 33: 129-136.

Clemens, Howard P., and Mayo Martin. 1953. Effectiveness of rotenone in pond reclamation. Trans. Amer. Fish. Soc. 82: 167-177.

Carlander, Kenneth D. 1955. The standing crop of fish in lakes. Jour. Fish. Res. Bd. Canada, 12(4): 543-570.

Irwin, W. H., and J. H. Stevenson. 1951. Physicochemical nature of clay turbidity with special reference to clarification and productivity of impounded water. Bull. Okla. Agri. and Mech. Coll., 48(4): 1-54.

Jenkins, Robert M. 1956. An estimate of the fish population in a forty-five year old Oklahoma pond. Proc. Okla. Acad. Sci. 35(1954): 69-76.

Kramer, C. M. 1953. Farm pond investigation — Atoka County. D-J Federal Aid to Fisheries job completion report. Okla. Game and Fish Dept.: 1-39. (mimeo.)

Swingle, Homer S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Alabama Polytechnic Inst., Agri. Exp. Sta. Bull., 274: 1-74.

Wallen, I. E. 1955. Some limnological considerations in the productivity of Oklahoma farm ponds. Jour. Wildl. Manag. 19(4): 450-462.