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Institute for Fish. Res.
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M. H. Patriarche

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

GERALD P. COOPER PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

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EVALUATION OF POPULATION MANIPULATION ON ANGLING SUCCESS AND FISH GROWTH IN LOON AND DOLLAR LAKES, RIFLE RIVER AREA

By Mercer H. Patriarche

Introduction

Numerous attempts to improve the growth rate of fish by population reduction have met with varying success; results were probably related to the percentage reduction in population. However, population reduction appears to be a logical approach to growth improvement where a large population of fish is dependent on a limited supply of food. Loon Lake contained a large population of pumpkinseeds whose growth rate in 1958 amounted to little more than one inch per year. There were very few fish as long as 6.0 inches. The average size of those caught by anglers was 5.4 inches. Dollar Lake contained a dense population of slow-growing bluegills. The average size of the bluegills caught by anglers in 1958 was 6.2 inches but 89 percent of them were either 5 or 6 years old. In an

attempt to improve growth rates, Loon Lake was treated with toxaphene in 1958, and many bluegills (1,168 weighing 142 pounds) were removed by seining in Dollar Lake in 1959. This report summarizes the effects of these measures in terms of growth rate, population size, and fishing success.

Methods

Complete angling records for each lake were obtained annually by means of a permit-type creel census. Growth data from scales collected from fish caught either by anglers, or in nets, during 1956-1961 were used for calculations of growth rate. Body-scale relationships were computed, and lengths at each annulus were obtained by back-calculation. To compensate for the facts that (1) angler-caught fish are usually faster growing than those captured in nets, and (2) growth increments computed from old bluegills and pumpkinseeds are smaller than those from young fish, the following procedures were used. The mean length at each annulus for each year class was computed separately for fish taken by nets or by anglers. Yearly increments represented the difference in calculated length at annulus x and annulus x + 1. Growth increments for each collection were then combined and weighted by the number of fish in each year of collection. The growth tables in this report were constructed using mean increments taken from the youngest comparable age groups available. As an example, in Table 2, increments for pumpkinseeds during their

second year of life for the years 1955-1960 were taken from age-group-II fish captured in 1956-1961, respectively. For fish in their third year of life, the increments were derived from age-group-III fish captured in 1956-1961, respectively. Because no yearling fish were caught, increments for young of the year were obtained from age-group-II fish captured two years after the year in question.

The body-scale relationship for Dollar Lake bluegills was applied to the bluegills in Loon Lake, and the relationship computed for Loon Lake pumpkinseeds was applied to the pumpkinseeds in Dollar Lake. These formulas were: L (body length) = 0.89 + 0.95 S (anterior scale radius) for the bluegill; L = 0.37 + 0.87 S for the pumpkinseed. These formulas were used interchangeably between populations because Dollar Lake furnished a sizeable sample of bluegills and few pumpkinseeds were available, whereas Loon Lake provided many pumpkinseeds and few bluegills. This procedure introduced a small but consistent error into some of the calculations but this would not affect comparisons between years.

Data for all population estimates, except for Dollar Lake in 1959, were acquired by trapping and marking fish over a period of approximately three weeks. The estimates and their confidence limits were computed by the modified Schumacher formulas proposed by DeLury (1958). In 1959, the Dollar Lake data were obtained by the

marking and recapture of fish on two successive days of seining. Estimates of population size and their confidence limits were computed using the modified Petersen formula used by Bailey (1951).

Loon Lake

This is a 16.8-acre lake with a maximum depth of 16 feet. A small intermittent channel which connects this lake with Devoe Lake allows a two-way movement of small fish in the spring. The height of the outfall from Spring Lake prevents the exodus of fish through the small inlet. Loon Lake contains much natural cover in the form of fallen trees lying in the shallow water and extensive beds of submerged vegetation.

Estimates of the size of the pumpkinseed and bluegill populations in 1957, 1958, and 1960 are shown in Table 1. No estimates could be made for fish shorter than 4.0 inches because few were retained in the nets. The marked difference between the bluegill populations of 1957 and 1958 resulted largely from the disappearance of a strong 1952 year class caused by natural mortality and fishing. Excluding minnows and darters, there were 11 species of fish in the lake. With the possible exception of black bullheads, pumpkinseeds and bluegills were the more abundant species.

To reduce the number of small sunfishes, the lake was treated with toxaphene at the rate of 5 ppb on August 29, 1958. No attempt to estimate the extent of the kill was made. However, a

Table 1.--Estimated populations of pumpkinseeds and bluegills in Loon Lake in June, 1957, 1958, and 1960

Species and inch group	1957 Estimated number	1957 Confidence limits	1958 Number	1958 Confidence limits	1960 Number	1960 Confidence limits
Pumpkinseed						
4.0-4.9	3,947	3,731-4,484	1,961	1,471-2,941	2,737	2,049-4,132
5.0-5.9	1,614	1,420-1,866	1,914	1,526-2,571	485	405- 604
6.0-6.2	10	3-?	20	13- 40	51	30- 157
Totals						
4.0-6.2	5,571		3,895		3,273	
Bluegill						
4.0-4.9	---	---	12,536	8,065-?	667	330-?
5.0-5.9	1,370	1,085-1,859	135	79- 461	178	136- 259
6.0-6.9	1,019	890-1,192	429	251-1,481	48	36- 72
7.0-7.9	190	152- 253	158	85-1,094	8	2- 14
8.0-8.9	---	---	---	---	3	---
Totals						
4.0-7.9	---		13,258		904	

comparison of catches of young fish in small, hardware-cloth traps before and after treatment indicated that the toxaphene was effective. In 28 trap-nights immediately prior to treatment, an average of 6.3 pumpkinseeds and 2.5 bluegills were captured per set. Post-treatment sets (36 trap nights) caught an average of 0.4 pumpkinseed and 0.2 bluegill per set.

Situations arose following the treatment which complicated the interpretation of the data. Winterkills which occurred during the winters of 1958-59 and 1959-60 made it impossible to determine to what extent the treatment alone affected growth rates. However, the combined mortalities permitted some conclusions on the results of population reduction per se.

Annual length increments of pumpkinseeds of several ages during the period 1955-1960 are shown in Table 2. Since the toxaphene was applied in August, 1958, growth during 1959 and 1960 was of especial interest. In 1959, the growth of young-of-the-year fish was not affected but three of four older age groups showed some improvement. The sum of the mean growth increments for fish 2-5 years old was 30 percent greater in 1959 than in 1958 (1.1 inches) and 14 percent better than in 1957. A large fish kill which occurred in the winter of 1955-56 produced a 25-percent improvement in total growth in 1956. The growth rate of first-year fish was not affected. Thus, both thinning processes served to improve the rate of growth by 25-30

Table 2.--The increment of growth (inches) achieved in Loon Lake by pumpkinseeds of several ages during the years 1955-1960. Number of fish in parentheses.

Year of life	Year						Number of fish
	1955	1956	1957	1958	1959	1960	
1	1.7	1.4	1.4	1.5	1.4	---	
	(18)	(26)	(24)	(11)	(7)		86
2	1.5	2.0	1.7	1.2	1.5	1.6	
	(38)	(18)	(26)	(10)	(11)	(7)	110
3	1.4	1.7	1.3	1.0	1.5	1.1	
	(22)	(22)	(12)	(21)	(14)	(9)	100
4	0.9	1.0	0.7	0.9	1.3	1.0	
	(30)	(15)	(22)	(21)	(51)	(36)	175
5	0.6	0.8	0.5	0.6	0.5	0.6	
	(31)	(9)	(8)	(6)	(18)	(13)	85
Sum of increments (2-5)	4.4	5.5	4.2	3.7	4.8	4.3	

percent but this moderate improvement lasted only one year--as shown by the return to an "average" growth rate in 1957 and 1960.

The 1960 estimate (Table 1) of the pumpkinseed population (fish at least 4.0 inches long) indicates that they were almost as numerous as in 1958 (prior to the treatment and winterkills). Seventy-eight percent of these fish belonged to the 1956 year class; they were not involved in the winterkill of 1955-56. Also, most of them seem to have survived the 1958 treatment. More than twice as many 6-inch fish were present in 1960 than in 1957 and 1958.

The bluegill population in 1957 and 1958 was as large or larger than that of the pumpkinseeds but was reduced to a much lower level by 1960 (Table 1). The 1956 year class comprised about 95 percent of the population in 1958 whereas in 1960 the 1957 year class was the dominant group (60 percent). Reducing the size of the population in 1958 did not improve the over-all growth rate (Table 3) but the winterkill of 1955-56 had been beneficial for one year for three of four age groups.

Fishing success was poor after the 1958 treatment (Table 4). In 1959, fishing pressure and success were only one-fourth that of the previous year. The total catch of pumpkinseeds and bluegills amounted to approximately one-tenth that of the previous year. The pumpkinseed and bluegill catch remained low in 1960 and 1961. The pumpkinseeds caught by anglers in 1959 averaged slightly longer than

Table 3.--The increment of growth (inches) achieved in Loon Lake by bluegills of several ages during the years 1955-1960. Number of fish in parentheses.

Year of life	Year						Number of fish
	1955	1956	1957	1958	1959	1960	
1	2.1	1.8	1.8	---	2.1	1.7	
	(30)	(31)	(71)		(4)	(4)	140
2	1.8	2.4	1.9	1.0	---	1.8	
	(26)	(12)	(31)	(19)		(4)	92
3	1.5	2.4	1.7	1.0	1.2	---	
	(51)	(11)	(30)	(25)	(14)		131
4	1.1	2.0	1.3	1.2	1.2	1.5	
	(85)	(24)	(39)	(3)	(62)	(38)	251
5	---	1.2	1.3	1.4	1.1	1.0	
		(23)	(19)	(2)	(6)	(49)	99
Sum of increments (3-5)	---	5.6	4.3	3.6	3.5	---	

Table 4.--The hours of fishing, catch per hour per angler, and total catch of bluegills and pumpkinseeds in Loon Lake, 1957-1961

Year	Hours of fishing	Catch per hour per angler	Number of blue-gills caught	Mean length of bluegills (inches)	Number of pumpkin-seeds caught	Mean length of pumpkin-seeds (inches)
1957	910	2.51	865	6.7	406	5.4
1958	845	1.64	308	6.4	497	5.4
1959	207	0.39	25	6.1	47	5.8
1960	177	0.95	51	6.2	45	5.6
1961	282	0.76	75	6.3	56	5.4

in previous years, but by 1961 there was no difference. The average length of bluegills in the anglers' catch remained unchanged.

Dollar Lake

This is a landlocked lake of 12.9 acres. Most of the lake is less than 15 feet deep. Vegetation is not abundant, and the bottom is covered with a thick layer of soft organic ooze. The bluegill is the most abundant of the eight species of fish in the population. As shown in Table 5, the number of bluegills at least 4.0 inches long in May was estimated to be over 7,000 in 1957, nearly 11,000 in 1958, and almost 5,000 in 1959. In addition, there were numerous smaller bluegills for which no estimate was made. The mean total length of 5-year-old fish caught by anglers or by nets was only 4.9 inches in 1958.

In the hope of improving growth, a fraction of the population was removed by seining. An attempt was made in May, 1959, to take out 75 percent by weight of the bluegills less than 6.0 inches long. Five hauls were made with a 1,600-foot seine on May 13-15 by a crew from the Lake and Stream Improvement Section. The net had a 400-foot bag constructed of 1/2-inch webbing; the rest of the seine consisted of 3/4- and 1-inch webbing. The first two hauls were utilized for a population estimate. It was anticipated that large numbers of 2- to 4-inch fish would be included in the catches. Unfortunately this did not happen--either because of the difficulties

Table 5.--Estimated populations of bluegills in Dollar Lake in May of 1957, 1958, 1959, 1960, and 1962

(P = population estimate; CL = confidence limits)

Inch group	1957		1958		1959		1960		1962	
	P	CL	P	CL	P	CL	P	CL	P	CL
4.0-4.9	2,436	1,617-4,936	7,222	5,694-9,884	3,563	2,836-5,103	2,427	1,128-?	---	---
5.0-5.9	3,155	2,524-4,205	2,442	2,071-2,973	858	793- 940	384	236-1,019	297	181-828
6.0-6.9	1,482	1,204-1,927	1,131	1,028-1,434	465	439- 501	118	76- 273	218	159-347
7.0-7.9	94	54- 377	143	120- 177	62	53- 77	19	13- 32	44	26-131
8.0-8.9	42	20-?	9	7- 31	13	13- 13	14	11- 20	19	16- 23
9.0-9.9	18	12- 41	6	5- 13	0	---	1	1- 1	7	3-?
Totals	7,227		10,953		4,961		2,963		---	

encountered in pulling the seine through the soft ooze, or else they were absent from the area seined. (The hauls were made in two localities.) The lead line had to be lifted occasionally to dump accumulations of bottom material, and this permitted the escape of some fish.

The population estimates computed from the mark-and-recapture procedure used during the first two seine hauls were too low. We know this is true because the number of 4- and 5-inch bluegills was estimated to be about 1,550, whereas we actually removed 1,618 of these fish from the lake. A correction factor[1] devised during earlier work done on this lake was applied to the data. The adjusted estimate of the number of 4- and 5-inch bluegills in the lake was 4,421 (Table 5) having an estimated weight of 192 pounds. A total of 131 pounds of these fish (actual weight) were removed from the lake or 68 percent of this segment of the bluegill population. Only 343 fish (10.7 pounds) under 4.0 inches were caught and discarded. Thus, we fell considerably short of our goal of a 75-percent reduction of the population under 6.0 inches long.

The effect of this reduction on the growth rate should have appeared either in 1959 or 1960. A comparison of growth increments made by bluegills of various ages (Table 6) revealed that 4-year-old fish improved their growth rate in 1959 by 30 percent, but others were virtually unaffected. Improvement occurred only in 1959. Perhaps

[1] Each estimate was divided by the percentage by which the 1958 seining estimates fell short of the "best" estimate obtained in 1958. See I. F. R. Report No. 1631 for further details.

Table 6.--The increment of growth (inches) achieved in Dollar Lake by bluegills of several ages during the years 1955-1960. Number of fish in parentheses.

Year of life	Year						Number of fish
	1955	1956	1957	1958	1959	1960	
1	1.7	1.6	1.7	1.7	1.8	---	
	(15)	(26)	(59)	(22)	(42)		164
2	0.8	0.9	0.8	1.2	1.1	1.0	
	(19)	(15)	(71)	(59)	(22)	(42)	228
3	1.2	0.9	1.0	1.6	1.3	1.9	
	(11)	(19)	(15)	(27)	(42)	(22)	136
4	1.2	1.0	1.3	1.7	1.7	1.9	
	(109)	(67)	(19)	(104)	(45)	(268)	612
5	1.2	1.3	1.3	1.7	2.2	1.4	
	(47)	(44)	(50)	(31)	(14)	(9)	195
Sum of increments (2-5)	4.4	4.1	4.4	6.2	6.3	6.2	

the reason for this increase was that nearly two-thirds of the bluegills removed were 4-year-olds. However, aside from young-of-the-year fish, there also was almost a 50-percent increase in total growth in 1958 (the year before fish were removed) over that of 1957.

Looking at a closely related species, the pumpkinseed, we find that in 1959 there was a 10-percent increase in total growth rate with two out of three age groups affected (Table 7). In 1958 there was also an improvement in growth comparable to that for the bluegill. The population of pumpkinseeds in Dollar Lake, unlike that in Loon Lake, is quite small, numbering perhaps around 100 fish (at least 4.0 inches long) annually in recent years.

Two possibilities are suggested for the sudden spurt in growth rate of these fish in 1958: (1) large catches of bluegills by anglers in 1957 and 1958 may have reduced the population enough to influence the growth rate of the survivors, although the rates of exploitation for bluegills at least 5.0 inches long were not exceptionally high--24 percent in 1957, and 33 percent in 1958; (2) one thousand fingerling redear sunfish were planted in 1954 and in 1956, but this species subsequently disappeared. Redear sunfish and pumpkinseeds compete for similar foods, and this may have depressed the growth rate of the latter species in 1954-1957. Neither of the above explanations, however, is completely satisfactory.

Table 7.--The increment of growth (inches) achieved in Dollar Lake by pumpkinseeds of several ages during the years 1955-1960. Number of fish in parentheses.

Year of life	Year						Number of fish
	1955	1956	1957	1958	1959	1960	
1	1.2 (6)	1.2 (19)	1.2 (28)	1.3 (4)	---	---	57
2	1.1 (16)	1.2 (6)	1.0 (19)	1.7 (28)	1.4 (4)	---	73
3	1.9 (37)	1.4 (11)	1.9 (6)	2.1 (19)	2.7 (28)	2.5 (4)	101
4	2.1 (53)	1.8 (42)	2.1 (16)	2.2 (4)	2.5 (21)	2.2 (13)	136
Sum of increments (2-4)	5.1	4.4	5.0	6.0	6.6	---	

Because fewer bluegills were available in 1959 (Table 5), there was a drastic decline in the number caught by anglers. As shown in Table 8, there were 1,225 fewer bluegills caught in 1959 than in 1958, and only 162 were taken in 1960. The decrease in the 1959 catch doubtless was partly due to the population reduction. Nearly 1,100 of the 1,961 bluegills removed from the lake were estimated to have been in the 5-inch group, together with about 500 4-inch fish. Since the maximum exploitation rate observed for Dollar Lake bluegills was the 33 percent in 1958, we can safely assume that no more than 350 of these 5-inch fish would have been caught by anglers if the population had not been disturbed. Very few of the 4-inch fish would have been caught. Thus, if the catch had been reduced in direct proportion to the number of fish removed by seining, the total harvest probably would not have exceeded about 1,000 bluegills (650 + 350) or 875 fewer fish than were caught in 1958.

Other factors also responsible for the smaller catch of bluegills in 1959 (and the subsequent two years) were: (1) the cumulative mortality of the 1952 year class; (2) relative weakness of succeeding year classes; and (3) reduced fishing pressure. Between 1956-1958 anglers caught 2,550 bluegills from the 1952 year class, or twice as many as from the next most abundant year class (1953). Since few bluegills that were more than six years old have been

Table 8.--The hours of fishing, catch per hour per angler, and total catch of bluegills and largemouth bass in Dollar Lake, 1957-1961

Year	Hours of fishing	Catch per hour per angler	Number of bluegills caught	Mean length of bluegills (inches)	Number of largemouth bass caught
1957	1,107	1.67	1,552	6.3	29
1958	1,484	1.49	1,875	6.2	56
1959	1,156	0.78	650	6.5	44
1960	1,094	0.41	162	6.3	115
1961	1,104	0.57	520	6.6	110

caught in Dollar Lake, a drop in the total catch was inevitable in 1959 unless another strong year class appeared. This did not happen, so the population (Table 5) and harvest (Table 8) declined after 1958.

The main objectives of the thinning operation were to improve both the growth rate and average size of the bluegills in the catch. An increase in the latter was to be expected in 1959 because of the elimination of many of the 5-inch fish, and a small increase did occur. The general similarity in mean lengths of fish caught in 1957-1961 (Table 8) is deceiving. Actually, in 1957 and 1958 the catch was dominated by slow-growing 5- and 6-year-old fish whereas in the later years, faster-growing 4-year-old fish from three year classes comprised the bulk of the catch.

The reduction of the bluegill population (both by seine and natural mortality) apparently encouraged fishing for largemouth bass. Record bass yields (for Dollar Lake) occurred in 1960 and 1961 (Table 8) because of more effort expended in bass fishing and larger populations of legal-size bass. Previous to 1960 most anglers still-fished with angleworms for bluegills. In 1958 and 1959 only 27 and 32 percent of the angling was done with artificial lures but in 1960 and 1961 the percentages rose to 50 and 52,reflecting increased effort for bass. Over the two-year period of 1960-1961, 109 of 138 bass marked in 1960 were caught for an exploitation rate of 79 percent. Undoubtedly there was some natural mortality and the true rate of exploitation on bass was somewhat higher.

The relationship between bluegill reduction and more bass of legal size involves an improvement in the rate of growth of the bass. Three-year-old bass dominated the catch in both years (45 percent of the catch in 1960 and 60 percent in 1961). This is somewhat unusual for Dollar Lake bass since most of them do not reach the minimum legal size of 10 inches until late in their fourth summer of life. Thus a year class generally does not become available until Age IV. Four-year-old bass have outnumbered three-year-olds in the catch in 11 out of 15 years prior to 1960 (also in 1962). A marked improvement in the bass growth rate in 1959 (the year of bluegill reduction) put most of the bass of the 1957 and 1958 year classes over the 10-inch limit one year earlier than usual. For the 1957 year class, there was a 44-percent increase in their growth increment in 1959 (third summer of life) over the average for bass in their third growing season (based on a 3-year mean for the years 1958, 1960, and 1961). Likewise, there was a 36-percent increase in second-year growth for the 1958 brood in 1959. Obviously there is a real numerical advantage when fish become available to anglers one year sooner than usual since mortality constantly whittles at the population. In the spring of 1960 201 bass over 10 inches long were estimated to be present, whereas in 1957-1959 spring estimates of legal-size bass were 105, 122, and 68, respectively. In May, 1962, the estimate of legal bass was 153.

Presumably the principal area of competition between 5-inch bluegills and sublegal bass lies in their mutual predation on bottom

fauna. The supply of these animals, therefore, must be a limiting factor on the growth rate of both species, otherwise the bluegill reduction would not have had such a marked effect on bass growth. One might anticipate an improvement in the survival of the 1959 crop of bass with a reduction in bluegills but apparently this did not occur. There were more survivors of the 1957 year class in 1960 than three-year-olds of the 1959 year class in 1962, despite the fact that the former crop was produced when bluegills were abundant. May estimates of age-group-III bass in 1960 and 1962 were 180 and 131, respectively.

Conclusions

Although interpretation of the results from thinning the fish populations in these two lakes was complicated by natural phenomena, some conclusions as to the effectiveness of such an operation seem plausible. In the first place, it is obvious that a high proportion of a population (at least 75 percent) must be removed to influence growth rates of the survivors. Quite likely a prolific species will be unaffected unless the thinning is repeated frequently. In my opinion, one should not be satisfied with anything less than a 50-percent improvement in growth rate. Probably in most cases where a remedy is required, a doubling of the growth rate would be required to be effective. Any substantial thinning operation will be accompanied by a period of poorer fishing, of

course, until the population regains some of its former abundance. Sometimes the removal or reduction of one species will promote the exploitation of another, as was the case in Dollar Lake for largemouth bass. An alternative to reducing a population is to eliminate it entirely. In a situation where no other species of importance is present, this procedure is preferable.

In some lakes factors other than numbers of fish may be responsible for a slow rate of growth and/or poor fishing. Either the basic productivity is low or there might be a genetic limitation, as suggested by Parker (1958). If either of the above factors is operating, a thinning operation would be of questionable value.

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INSTITUTE FOR FISHERIES RESEARCH

Mercer H. Patriarche

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