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Changes in growth rates of fishes following reduction in population densities by winterkill[1]

[1] Contribution from the Michigan Institute for Fisheries Research

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Abstract

Studies were made on four lakes in southern Michigan to determine the effect of the reduction in numbers of fish by winterkill upon the rate of growth of fishes. Earlier investigations on another body of water had demonstrated that a severe reduction in population density had a marked effect on the rate of growth of the survivors. At the time of the winterkill in 1945 scale samples and counts of dead fish were obtained. Samples were collected each year since the kill. An increase in the rate of growth too great to be accounted for by annual variations followed the winterkill in all but one of the species from one lake. The increase in growth rate was not maintained, however, for longer than one year in most

species. Further studies are suggested to determine possible methods of management which would increase and maintain the greater rate of growth.

Introduction

One of the methods that has been suggested for the improvement of growth rates of populations of stunted fishes is the removal of part of the population by chemical treatment. Beckman (1941, 1943) found an increased growth of rock bass (Ambloplites rupestris) too great to be accounted for by annual variation in growth following the removal of all fish in approximately one-half of Booth (Standard) Lake, Charlevoix and Otsego counties, Michigan. To check further on the value of this method and the extent to which the population must be reduced, several lakes subject to winterkill are being investigated. To date the number of unanswered questions has increased but it is believed that some information of value has been obtained and should be made available.

The lakes and the extent of winterkill

Battease and Goose lakes in Jackson County, Duck Lake in Montcalm County, and Green Lake[1] in Washtenaw County, Michigan, are

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[1] Many lakes other than the four used in this study were visited and counts of dead fish made. Some originally included were dropped for various reasons, such as inadequate scale samples, incomplete counts, etc. Further collections are to be made from

some of these lakes and with the additional material may be incorporated into the study.

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subject to winterkill at relatively frequent intervals. Severe kills occur occasionally with lighter kills interspersed. Prior to the winter of 1944-1945, when a heavy mortality occurred, the last severe mortality was in the winter of 1935-1936.

All of these lakes are shallow; maximum depths are as follows: Batteese Lake, 15 feet (Table 1); Goose Lake, 10 feet; Duck Lake, 9 feet; and Green Lake, 13 feet. Rooted vegetation is abundant over most of the bottoms of these lakes.

In early March, 1945, when the ice cover melted, several members of the Institute staff visited the lakes, made counts of dead fish on measured sections of the shoreline, and took scale samples. At Batteese Lake it was estimated that 179,640 fish were killed (Table 1). No attempts were made at any lake to count all of the small minnows or other small forage fishes. Counts were made, however, of the larger golden shiners (Notemigonus c. crysoleucas), chub suckers (Erimyzon s. kennerlii), suckers (Catostomus c. commersonnii), and other large rough fishes. Legal sized game fish made up 23.5 percent of the kill with the bluegill (Lepomis m. macrochirus) the dominant species. The ratio of bluegills to largemouth black bass (Micropterus salmoides) was 68 to 1 as determined by section counts. From observations made by Dr. G. F. Cooper of the Institute on winterkill lakes it is believed that bluegills and largemouth bass are susceptible to winterkill in the same degree and thus the above ratio is believed to be fairly reliable.

Table 1.--Location, area and depth of the lakes, and numbers of fish destroyed by one winterkill.

Item	Lake			
	Batteese	Goose	Duck	Green
County	Jackson	Jackson	Montcalm	Washtenaw
Area (acres)	100	427	306	78.5
Maximum depth (feet)	15	10	9	13
Total, all species	179,640	81,838	1/ 50,000	65,509
Fish per acre (all species)	1,796	193	163	835
Game fish	177,640	70,958	45,000	59,462
Bluegills	165,000	41,922	18,000	16,852
Largemouth black bass	2,400	13,922	4,500	1,512
Yellow perch	440	6,834	13,500	6,698
Black crappie	500	...	4,500	5,456
Pumpkinseed	2,600	7,378	...	23,452
Other species	8,700	11,782	4,500	11,539
Game fish per acre	1,776	167	147	758
Legal-sized game fish	41,712	24,499	33,750	17,263
Legal-sized game fish per acre	417	58	110	220

1/ No counts made on sample areas

In Goose Lake an estimation based upon sample counts gave a total of 81,823 fish destroyed in the 1944-1945 winterkill. Of this total 24,499 (34.5 percent of the total) were of legal length. The ratio of bluegills to largemouth black bass was 3 to 1.

A total of 50,000 dead fish was estimated to have been killed in Duck Lake, but it is believed that this estimation is much too low. It was based upon sight instead of actual counts of measured shoreline sections. The estimate is believed to be low because of the high percentage of legal length fishes in the data. A population, 75 percent of which is composed of legal sized fishes, is believed to be abnormal. The ratio of bluegills to largemouth bass may also be in error for the same reason, although a ratio of 4 bluegills to 1 bass is not unusual.

In Green Lake where counts led to an estimate of 65,509 fish killed, 29 percent of the total was made up of legal sized fish. The ratio of bluegills to largemouth bass was 11 to 1.

It is interesting to note that the bluegills in Batteese Lake were stunted, while in the other three lakes they were growing at a rate about equal to the established average for Michigan waters (Beckman, 1949).

A slight winterkill occurred in Goose Lake in the winter of 1946-1947 and in Duck Lake in the winter of 1947-1948. The other waters have had no unusual mortality since 1944-1945.

Fluctuations in the rate of growth

Scale samples were taken at the time of the winterkill and subsequent samples were taken by netting and hook and line fishing

in the spring and summer of 1946, 1947 and 1948 (Table 2). Small winterkills added specimens from two lakes. Standard techniques were used in the preparation and study of the scale materials.

In the absence of any data on the body-scale relationships for the species involved, the growth increments for each calendar year of life were derived from direct-proportion calculations. Lee's phenomenon was in slight evidence but was not considered sufficiently great to influence the averages.

The method used is illustrated by Tables 3, 4, 5 and 6. Growth increments calculated for each age group for each year of life are summarized in Table 3. Further combination of the data was necessary and the weighted average of the increments for each year of life were combined by calendar year as shown in Table 4. To obtain data on the annual fluctuation in growth a comparison was made by the successive additions of the growth increments for comparable years of life from the data in Table 4; these comparisons are shown in Table 5. The mean between the growth in the earlier and later years was derived and the change in growth between these years was given in terms of increase or decrease of the later year over the earlier, and the percentage of change in growth was calculated.

From the percentage change in growth the mean deviation of the growth in the different calendar years was calculated from the average of the years prior to the winterkill of 1944-1945. This information is shown in Table 6 and it is from this and similar tabulations for the other species that the data for Figure 1 were

Table 2.--Number of specimens and dates of collection of materials for study of changes in growth rates following winterkill.

Species	Lake	Date of collection	Number of specimens
Bluegill	Batteese	March, 1945	63
		July, 1946	81
		June, 1947	55
Bluegill	Goose	March, 1945	68
		June, 1946	12
		April, 1947	160
		June, 1947	7
Largemouth black bass	Goose	March, 1945	62
		June, 1946	4
		April, 1947	60
		June, 1947	2
Perch	Duck	March, 1945	24
		July, 1947	15
		April, 1948	23
Perch	Green	August, 1944	7
		March, 1945	26
		June, 1946	89
		May, 1947	93
		July, 1948	53
Pumpkinseed	Green	August, 1944	10
		March, 1945	23
		June, 1946	55
		May, 1947	9
		July, 1948	21

Table 3.--Growth increments by calendar years for the bluegill from Batteese Lake, during each year of life, before and after reduction in numbers by winterkill (number of specimens in parenthesis).

Year of life	Age-group	Calculated growth in millimeters of total length for calendar year								
		Before winterkill							After winterkill	
		1938	1939	1940	1941	1942	1943	1944	1945	1946
1	I	...	...	...	...	...	...	...	38(7)	...
	II	...	...	...	...	...	29(8)	...	39(4)	...
	III	...	...	...	...	31(7)	28(4)	26(3)	...	...
	IV	...	...	...	31(16)	29(32)	25(26)	...	...	...
	V	...	...	26(11)	29(26)	28(21)	...	...	...	...
	VI	...	33(9)	24(11)	25(4)	...	...	...	...	...
	VII	35(9)	...	...	...	...	...	...	...	...
2	II	...	...	...	...	...	...	39(8)	...	41(4)
	III	...	...	...	...	...	39(7)	46(4)	48(3)	...
	IV	...	...	...	...	33(16)	37(32)	38(26)	...	...
	V	...	...	...	38(11)	32(26)	36(21)	...	...	...
	VI	...	...	38(9)	36(11)	28(4)	...	...	...	...
	VII	...	42(9)	...	...	...	...	...	...	...
3	III	...	...	...	...	...	...	38(7)	53(4)	35(3)
	IV	...	...	...	...	...	39(16)	33(32)	47(26)	...
	V	...	...	...	...	29(11)	34(26)	33(21)	...	...
	VI	...	...	...	35(9)	28(11)	25(4)	...	...	...
	VII	...	...	32(9)	...	...	...	...	...	...
4	IV	...	...	...	...	...	...	29(16)	46(32)	28(26)
	V	...	...	...	...	...	35(11)	29(26)	39(21)	...
	VI	...	...	...	...	26(9)	31(11)	29(4)	...	...
	VII	...	...	...	24(9)	...	...	...	...	...
5	V	...	...	...	...	...	...	27(11)	34(26)	22(21)
	VI	...	...	...	...	...	26(9)	24(11)	29(4)	...
	VII	...	...	...	...	17(9)	...	...	...	...
6	VI	...	...	...	...	...	...	18(9)	27(11)	19(4)
	VII	...	...	...	...	...	15(9)	...	...	...
7	VII	...	...	...	...	...	...	10(9)	...	...

Table 4.--Calculated annual increments (weighted average) of growth in length of various year classes of the bluegill from Battesse Lake (number of specimens in parenthesis).

Year of life	Increment (millimeters) in growth in calendar year								
	1938	1939	1940	1941	1942	1943	1944	1945	1946
1	35(9)	33(9)	25(22)	29(46)	29(60)	26(38)	26(3)	38(11)	...
2	...	42(9)	38(9)	37(22)	32(46)	37(60)	39(38)	48(3)	41(4)
3	...	...	32(9)	35(9)	29(22)	35(46)	34(60)	48(30)	35(3)
4	...	...	...	24(9)	26(9)	33(22)	29(46)	43(53)	28(26)
5	...	...	...	...	17(9)	26(9)	26(22)	33(30)	22(21)
6	...	...	...	...	...	15(9)	18(9)	27(11)	17(4)

Table 5.--Tabulation of data used in the determination of the annual fluctuations in growth of the bluegill from Batteese Lake.

Years involved in the comparison	Growth in earlier year (in millimeters)	Growth in later year (in millimeters)	Mean	Change in growth	Percentage change in growth
1938 and 1939	35	33	34	-2	-5.9
1939 and 1940	75	63	69	-12	-17.4
1940 and 1941	95	101	98	+6	+6.1
1941 and 1942	125	116	120.5	-9	-7.5
1942 and 1943	133	157	145	+22	+15.2
1943 and 1944	172	172	172	0	0.0
1944 and 1945	172	238	205	+66	+32.2
1945 and 1946	199	145	172	-54	-31.4

Table 6.--Percentage deviation of the growth of the bluegill in Batteese Lake in different calendar years from the average for the 7-year period prior to the winterkill in the winter of 1944-1945.

1938	1939	1940	1941	1942	1943	1944	1945	1946
-12.9	+7.0	-10.4	-4.3	-11.8	+3.4	+3.4	+35.6	+4.2

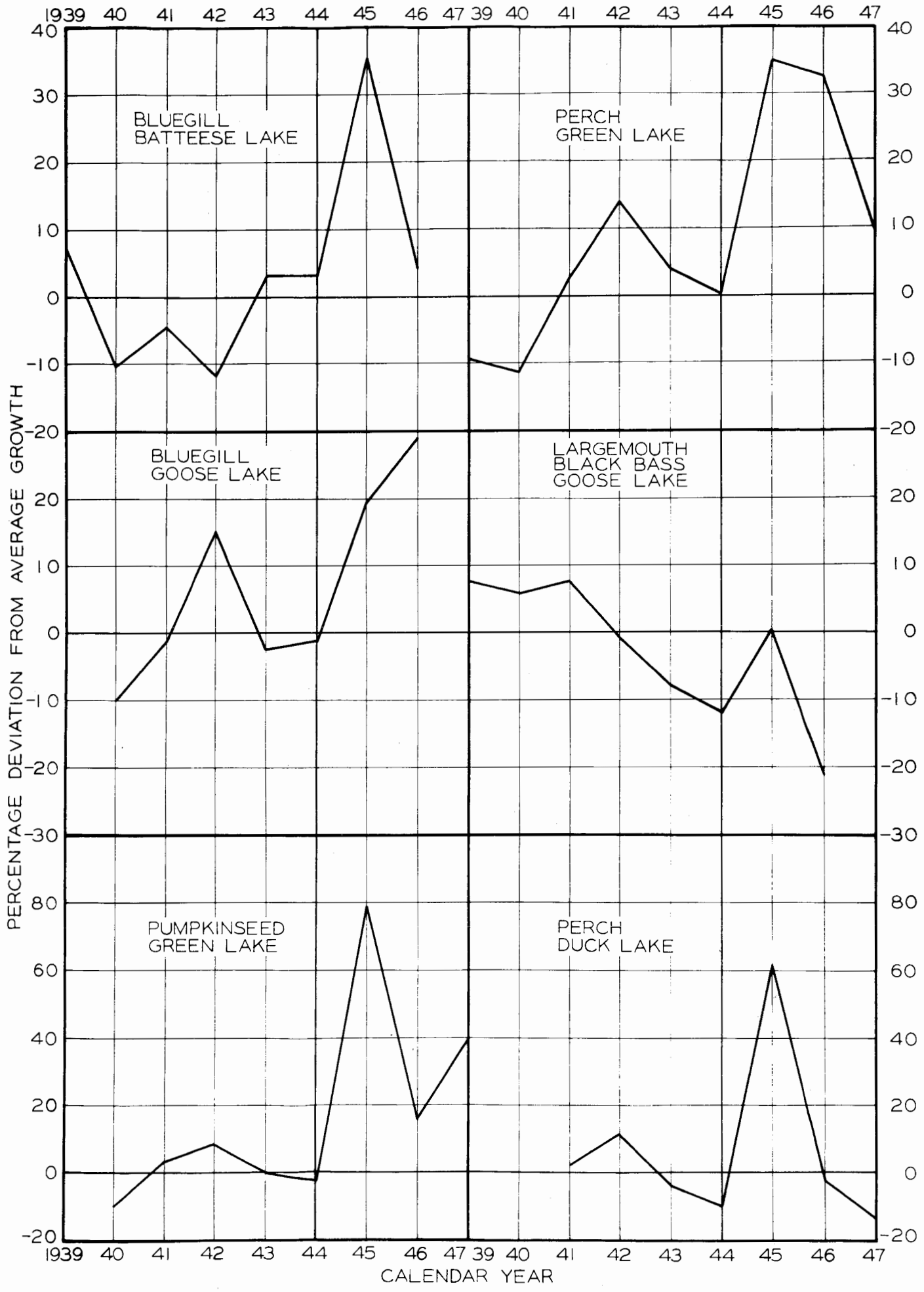

Fig. 1. Annual percentage deviation of the growth of four species of fish from four lakes from the average for the period, 1939-1944. The heavy vertical ruling at 1944 indicates the last year of growth before winterkill.

obtained. This method is more thoroughly explained in the literature (Hile, 1941).

When the growth of the bluegill in Battesse Lake was compared with the average established for the state it was found that they were stunted. In the year following the winterkill the growth improved decidedly, but the fish did not attain the state average, and the following year there was a decline in growth almost to the average of the period before the kill (Fig. 1).

In Goose Lake the growth of the largemouth black bass was following a downward trend before the winterkill (Fig. 1). A slight improvement in growth rate occurred following the kill, but it was no greater than might have been expected through annual variation, and the next year again showed a reduction in the rate. The bluegill in Goose Lake increased in growth rate somewhat following the kill and further increased the ensuing season (Fig. 1). This was the only species to exhibit an accelerated growth rate during the second season after the kill.

The yellow perch (Perca flavescens) in Duck Lake exhibited the change in growth with an improvement of about 70 percent over that for the year previous to the kill (Fig. 1). Again in this lake the growth rate returned, in just one year, to the range of growth established for the years prior to the reduction and continued the decline in the second year following the kill, reaching below the lowest range previously recorded.

The general pattern of the sudden rise following the kill and the decline in succeeding years was also displayed by the yellow perch in Green Lake (Fig. 1). The growth rate of the perch did not drop as suddenly as has been shown for this species in Duck Lake. The major drop occurred two years following the kill. The pumpkinseed (Lepomis gibbosus) in Green Lake gave the sharpest rise, followed by a decline almost to the range of previous years, and then the following year another rise was evidenced (Fig. 1).

The growth rate of all the fishes, excepting the bluegill in Batteese Lake, was approximately average when compared with the established state averages. The increase following the winterkill brought the average size of the fishes to levels exceeding the state average, in the earlier years of life in particular. The fishes of six or seven or more years of age, growing, as they do, such a small amount each year, exhibited little change in average size. Several other species from these lakes and from other lakes which were excluded because of inadequate data, followed the same general trend, but the number of samples does not permit a detailed analysis of the percentage changes that occurred.

From the changes which occurred it would seem that the influence of partial kill on the rate of growth is only temporary. It is possible therefore to question the value of any attempts to relieve stunting of fishes by partial removal of the population. If the effect of the reduction is to last only one or two years it does not seem practicable as a management technique.

The question also arises as to just how many fishes must be removed in order to benefit the growth rate of the remaining fish. In Batteese Lake, the elimination of 165,000 bluegills (1,650 per acre) was inadequate because the subsequent rate of growth, though improved, was still below the average for the state. Yet in Green Lake the loss of 16,852 bluegills (215 per acre) apparently destroyed the entire population, because for two years following the kill no bluegills were taken. A planting of 50 adults has reestablished the species, and the bluegills, at present, are maintaining average growth. Largemouth black bass also were restocked after the loss of 1,512 fish (19 per acre) apparently eliminated this species from the lake. The loss of 41,922 bluegills (98 per acre) in Goose Lake slightly improved the growth rate of the remaining population, but the loss of 13,922 largemouth black bass (33 per acre) did not raise the growth of this species beyond the normal annual variation, and the following year the growth rate dropped farther below the mean than in any previous year.

It therefore appears to be necessary to determine the population within a lake, and the rate of growth of the species, before any consideration can be given as to whether or not an attempt at partial reduction should be undertaken. Experiments must be conducted to determine what percentage of the population must be eliminated to produce an increased growth.

Careful consideration should also be given to the species composition present. While exact figures are not available, it is known that in the lakes checked in this study there was a differential

kill. Many rough fish were not decimated to the extent that the game species were, and thus it may be that they took over the lake, and, having had the advantage of larger numbers, reproduced to such an extent that they now control the lake. The drop in the rate of growth following the large increase immediately after the kill may be due to competition for food, with the rough fish the apparent winners. An example might be cited of the great increase in lake chub suckers in Green Lake. At the time of the kill a count of 5,418 chub suckers was made. When gill nets were operated in the lake during May, 1945, 285 chub suckers were caught, but in May, 1947, 584 were taken in similar gear and netting time. Yellow and brown bullheads (Ameiurus natalis and A. nebulosus) also were taken in numbers exceeding the game species.

It may be that what is needed in many of the waters is not a kill of parts of the whole population, but a differential kill of certain species. If the bluegills, for example, are stunted perhaps the best technique would be to remove as many of them as possible, thus providing the predatory species with a chance to gain control and keep the future generations of bluegills under control. It is planned to conduct some experiments to develop techniques for a differential kill. During the mid-summer period many of the larger fish of some species are in deeper water, while the young-of-the-year and yearling fish are in the shoal areas. By treating the shallows it may be possible to reduce the population sufficiently to bring about a desirable change in growth, and leave the larger fish population intact to control the next brood of young.

Restocking with suitable predatory species following the reduction might prove useful. This technique will be tried in a proposed experiment in the reduction of a population of stunted bluegills in a Michigan lake. Following the reduction, a planting of yearling largemouth black bass will be made to determine whether the addition of this predator can keep the bluegills under control and maintain an average rate of growth.

One of the greatest needs at the present time is an accurate method of determining the existing fish population of a lake. If we are to manage the fishes, we must know how many there are to start with, and also have reliable data on proper species composition within various waters. It is imperative that studies be made to ascertain why certain lakes produce good fishing while others present a stunted population and poor fishing.

Studies of the lakes here reported upon will be continued to detect changes which may occur from year to year, and to learn what effect future light or heavy kills may have on the fish populations and rates of growth.