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Report No. 1125

August 22, 1947

Biological Investigations at Deep Lake,

Oakland County, during 1946

by

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Introduction

The management practices and biological investigations carried on at Deep Lake from 1941, when it was poisoned and restocked, until December, 1945 have been summarized in I.F.R. Report No. 1033. The present report is a continuation of these studies and includes all of the data collected during 1946.

Between January 1 and December 31, 1946, 1,161 bluegills, 30 rainbow trout and 17 king salmon (Oncorhynchus tshawytscha) were removed from the lake by Institute personnel as fish samples. No smallmouth bass were permanently removed from the lake, although four were sampled for scales and length and returned to the water. Analyses of these samples of the fish population are discussed separately for each species present in the lake in the following pages.

Data on the lengths of the smallmouth bass, rainbow trout, and salmon are presented in the decimal English system in conformity with

recently adopted policies. However, length data for the bluegills is recorded in metric measure because of the very small growth increments involved.

We wish to acknowledge the assistance of many members of the Institute staff, and their wives and friends, who cooperated whole heartedly in obtaining the fish samples and preparing the data for analysis. We also wish to acknowledge the cooperation of Mr. Benjamin E. Young, owner of Deep Lake, in permitting us to continue our experiments on the lake.

The Bluegills

During 1946, 1,161 bluegills were collected in Deep Lake by seining and by hook and line fishing. The following numbers were taken on the sampling dates indicated: January 27 and February 3 - 88; May 3 - 264; May 22 - 86; June 16 - 2; July 29 - 163; October 22 and 23 - 558.

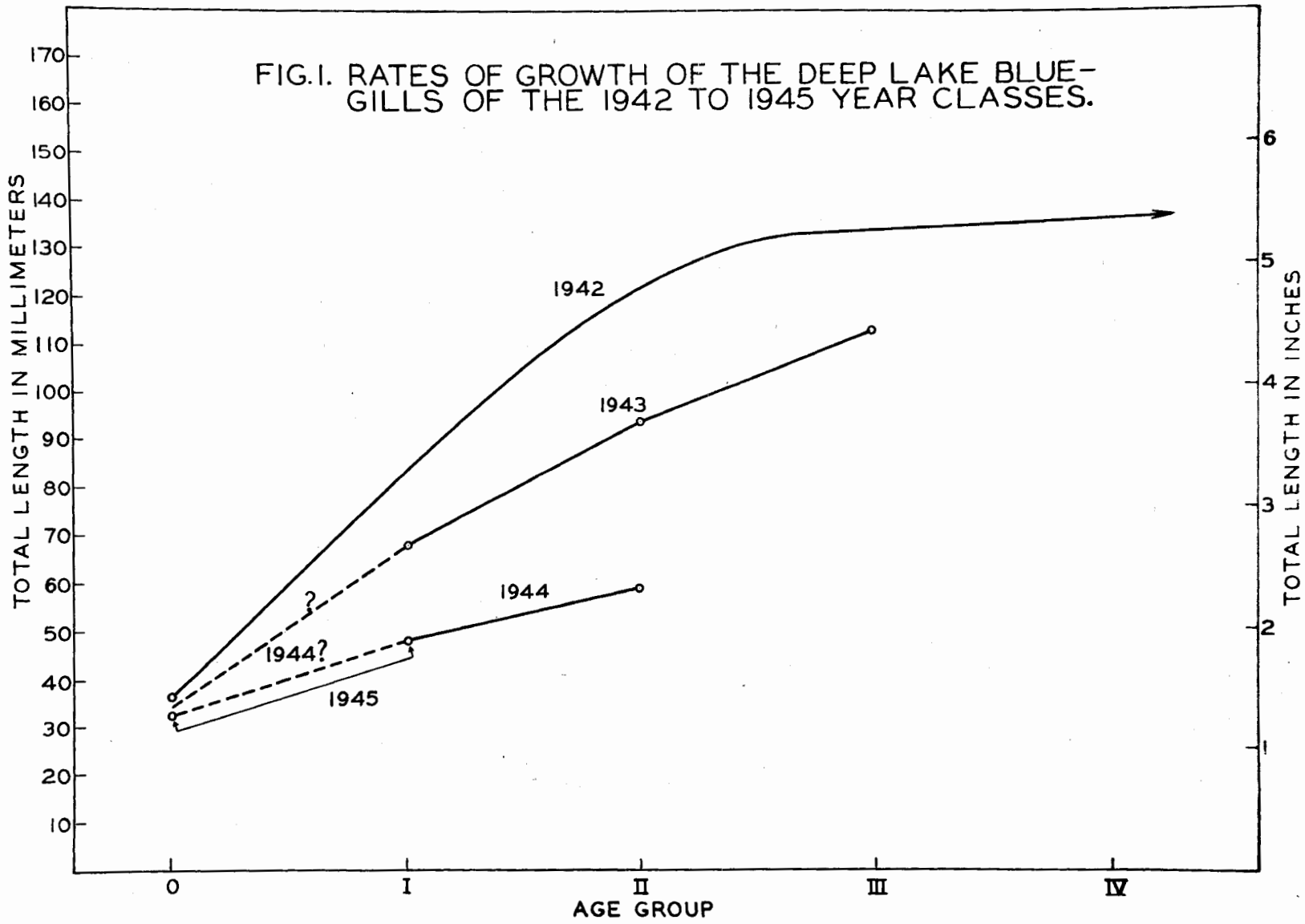
The history of the bluegill population that resulted from the past-poisoning planting of 100 adults has been recorded in I.F.R. Report #1033. As a continuation of this history, the present report is concerned primarily with the samples of bluegills collected during 1946. However, data collected in former years has been drawn upon in the preparation of certain summaries.

The degree of stunting suffered by this population since the lake became over-populated in late 1943 is most apparent when the rates of growth of each year class, through the 1946 season, are examined. In Table 1, the growth of each year class of bluegills from 1942 to 1946 has been summarized. These values are based upon fall collections of fish. Figure 1 is a projection of this growth data upon a graph. The curve representing the rate of growth of the 1942 year class has been fitted to a series of points by inspection. Those lines representing this

Table 1.--Growth of each year class of bluegills based on fall collections
from 1942 to 1946.

Month and year collection	Age group	Number of specimens	Total length in millimeters		
			Minimum	Average	Maximum
1942 year class					
August and October, 1942	0	677	22	36.3	59
September, 1943	I	38	53	83.5	126
August and September, 1944	II	51	86	127.8	152
November, 1945	III	26	93	127.3	168
October, 1946	IV	56	109	138.6	235
1943 year class					
...	0	...	...	...	...
September, 1944	I	8	59	67.1	78
November, 1945	II	29	71	93.0	119
October, 1946	III	55	78	112.8	160
1944 year class					
...	0	...	...	...	...
November and December, 1945	I	105	41	47.3	60
October, 1946	II	326	48	58.0	77
1945 year class					
November and December, 1945	0	68	28	32.2	39
	I	62	42	47.6	53
1946 year class					
October, 1946	0	49	27	32.2	38

FIG. I. RATES OF GROWTH OF THE DEEP LAKE BLUE-GILLS OF THE 1942 TO 1945 YEAR CLASSES.



same function for the other year classes portrayed have been established by connecting, with straight lines, the absolute values of the average lengths recorded.

Table 1 and Figure 1 provide a lucid picture of the progressive stunting of the components of a fish population multiplying too rapidly in an unrestrictive environment. The initial rapid rate of growth of the first hatch of bluegills (1942 year class) was slowed appreciably after the end of their second year by the tremendous production of young-of-the-year (1943 year class) in that season (See Report #1033). Successive hatches held the growth increments of the 1942 year class at a severely reduced level (See Figure 2). Furthermore, the accumulation of each additional year class in the lake had an increasingly depressing effect upon the growth rate of succeeding year classes through the 1946 season.

Although only the youngest age groups of the most recent year classes are now present, there is evidence that the maximum carrying capacity of the lake for bluegills had been reached some time prior to the 1945 growing season. There is further evidence that an apparent static level of stunting in the population may have been established. Figure 1 and Table 1 demonstrate the similarity in the growth rates of the 1944, 1945 and 1946 year classes. Figure 3 further illustrates this by a comparison of the average annual growth increments (before and after poisoning) of young-of-the-year and yearling bluegills. A comparison of the 1945 and 1946 collections of age groups 0 and I reveals almost identical growth increments for those years.

There are several possible explanations of this latent similarity in growth rates: (1) the bluegills may have over-populated the lake to

Figure 2a.--Bluegill, Deep Lake, Oakland County (I.F.R. #89250),
Age IV (1942 year class), T.L. 114 mm. (5.7 in.),
collected October 22, 1946.

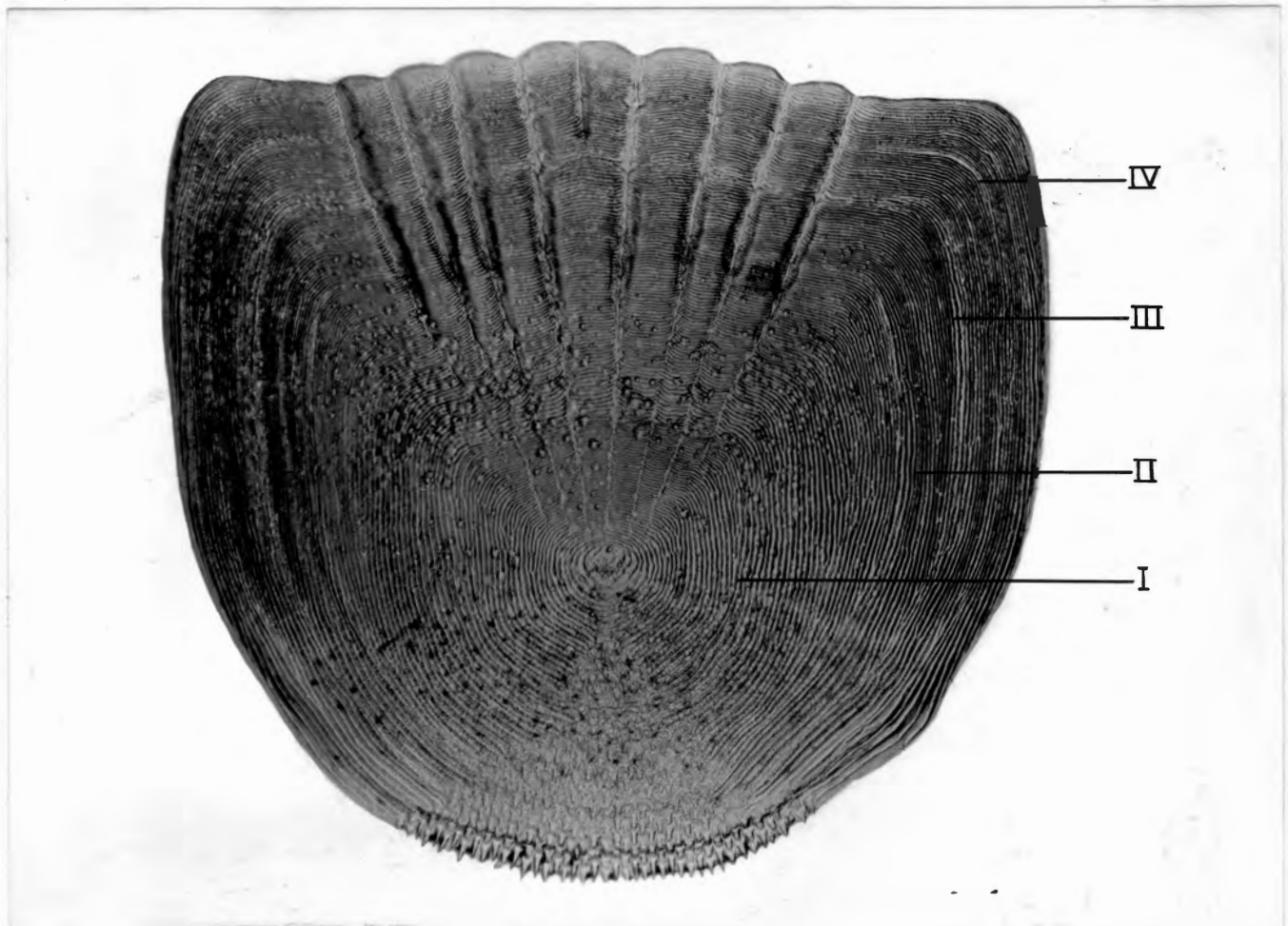


Figure 2b.--Bluegill, Deep Lake, Oakland County (I.F.R. #89259),
Age III (1943 year class), T.L. 160 mm. (6.3 in.),
collected October 22, 1946.

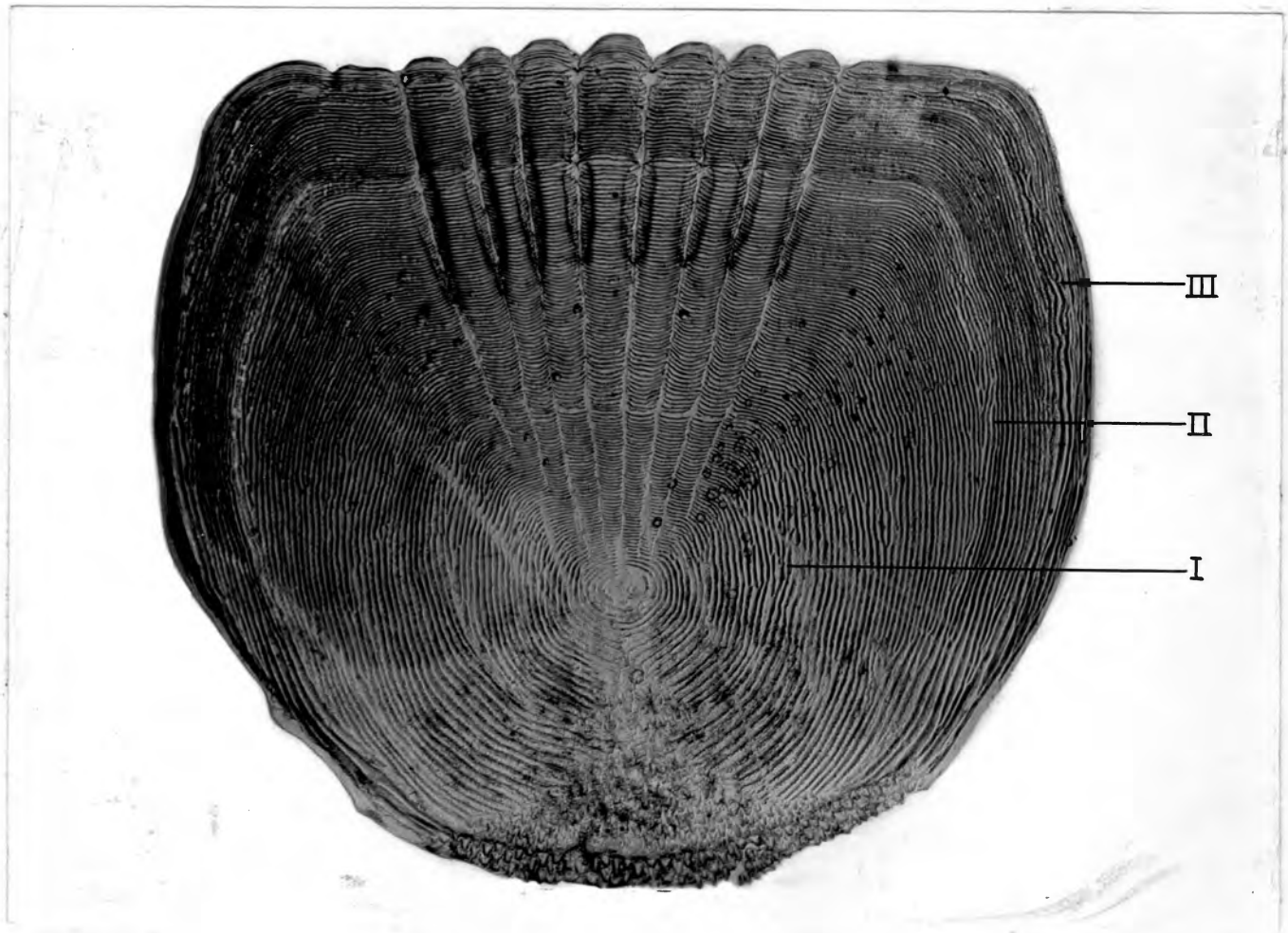
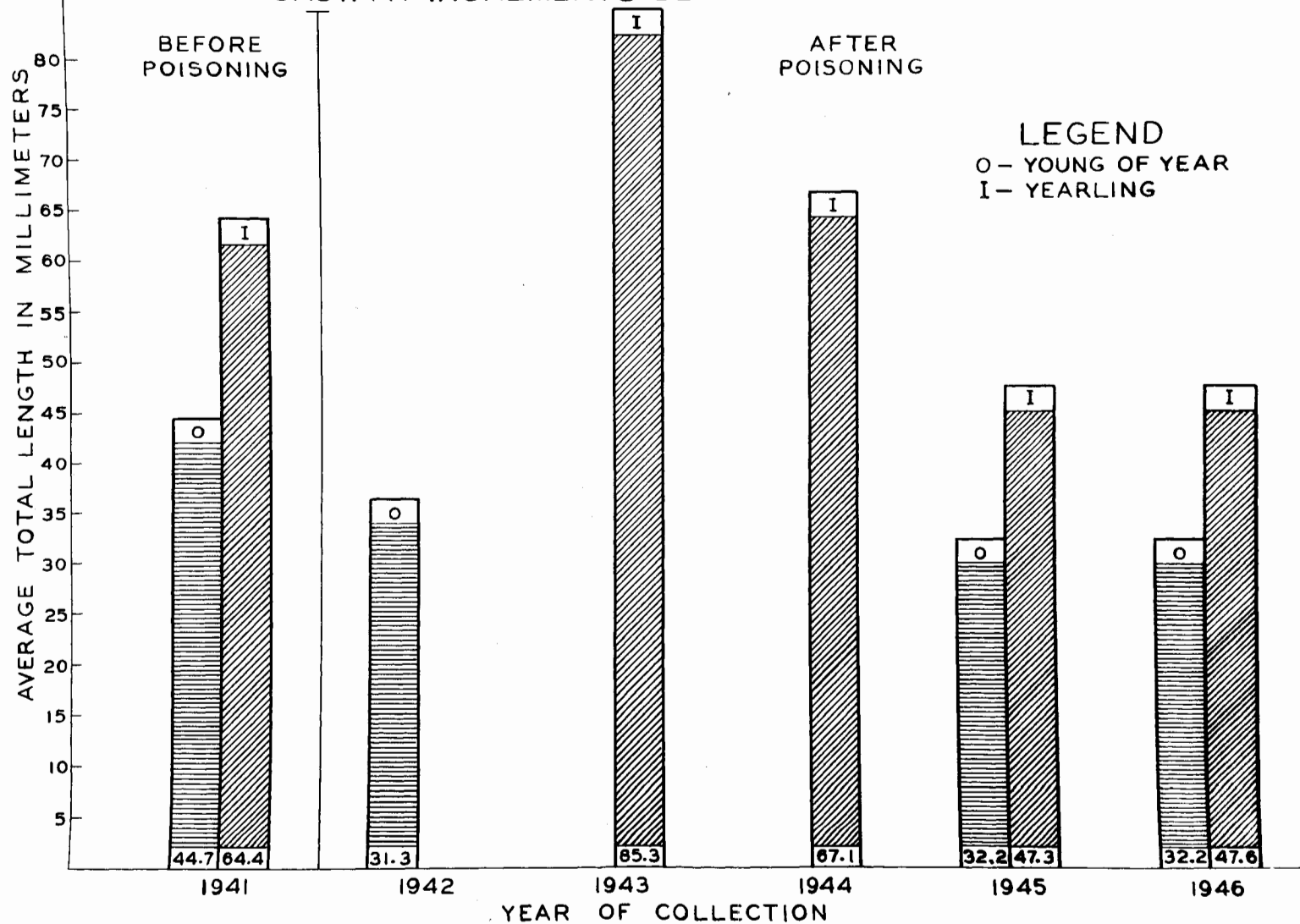


FIG 3-COMPARISON OF YOUNG OF YEAR AND YEARLING DEEP LAKE BLUEGILLS SHOWING COMPARATIVE AVERAGE GROWTH INCREMENTS BEFORE AND AFTER POISONING



such a degree that the resulting competition for food would only permit the survival of a limited number of young-of-the year. Survival and growth would then be related to the total number of bluegills present in the lake and, as long as that number is maintained, the growth rates of the survivors of each succeeding year class would be similar. If this is so, then a heavy cropping and/or a heavy natural mortality among the older and larger fish in the years to follow may result in some compensatory increase in the growth rates of future year classes; or, (2) the bluegills may have begun to exert some natural control upon themselves by cannibalism and in doing so, stabilized the total numbers present in the lake and consequently the growth rates of the younger year classes.

The bluegill collections of July 29 and October 22 taken by seining were assembled to show the number and percentage of each age group in the collection. This is presented in Table 2. The collection of October 22 represents every bluegill taken in a continuous series of seine hauls along more than 40 percent of the lake's shoal areas. It is easily discernible from this table that the 1945 and 1946 year classes (age groups I and 0) are exceedingly weak (14.0 and 11.0 percent of the total sample respectively in the October collection) and that the 1944 year class (age group II) is unquestionably strong. These data are further illustrated in the frequency distribution presented in Figure 4a.

These facts might be interpreted as evidence in favor of either of the preceding hypotheses. However, personal observations made during the bluegill spawning season indicated that the bluegills were exerting some considerable control upon their own numbers. On July 12, a number of nesting bluegill colonies were observed closely by the writers.

Individual nests and colonies of nests containing eggs or from which fry

Table 2.--Number and percentage of each age group of bluegills taken by seining in the 1946 samples.

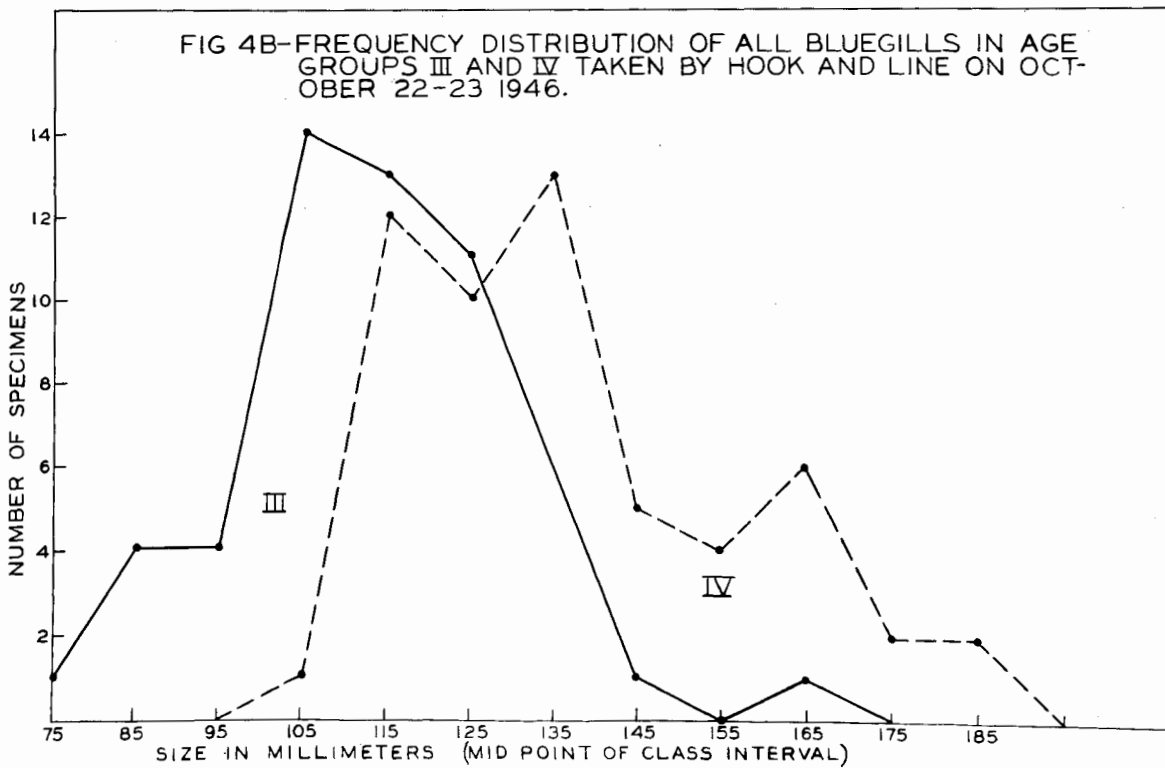
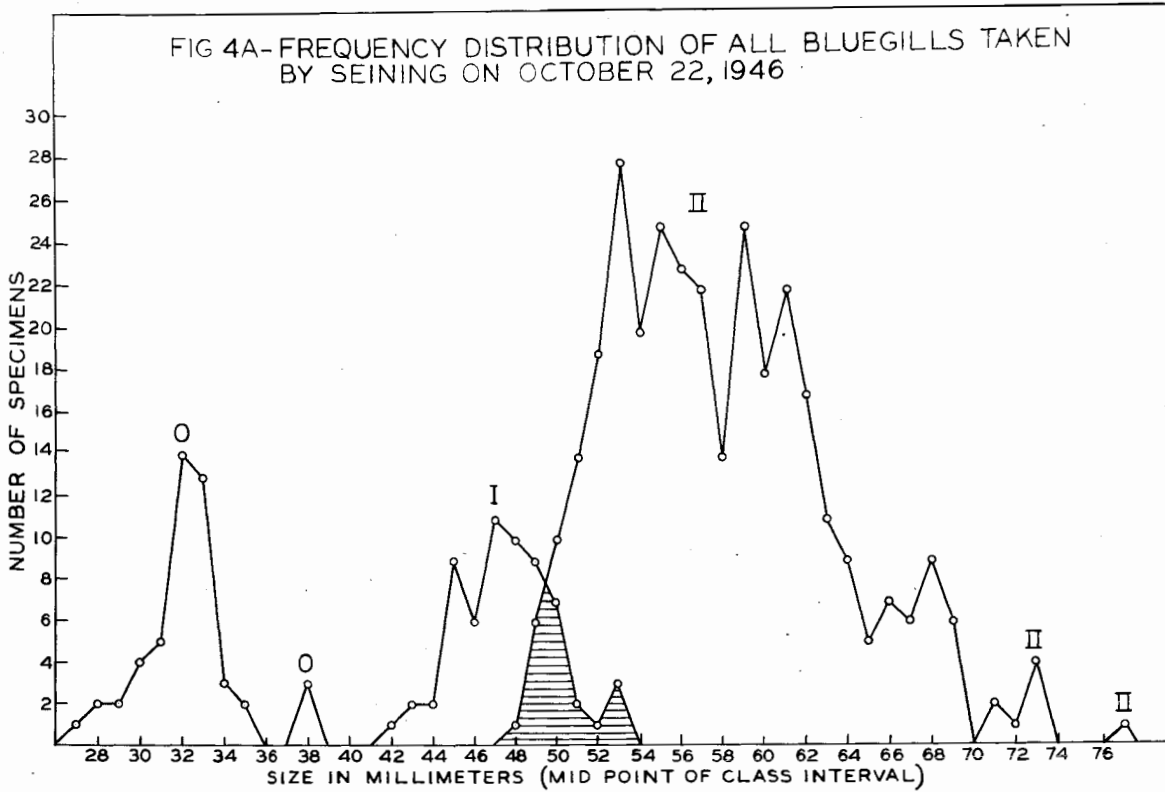
	Age group	Year class	Number taken	Percent of total
Collection of July 29:	0	1946	0	0.0
	I	1945	44	27.0
	II	1944	111	68.1
	III	1943	7	4.3
	IV	1942	<u>1</u>	0.6
Total sample by seining			163	
Collection of October 22:	0	1946	49	11.0
	I	1945	62	14.0
	II	1944	326	73.8
	III	1943	<u>5</u>	1.1
Total sample by seining			442	

rising were completely surrounded or overrun by milling schools of 2- to 3-inch bluegills. It seemed improbable that few, if any, rising bluegill fry could have escaped through the cordons of their own kind that were observed devouring them. It was a simple task on this date to locate all bluegill nesting colonies in the lake, simply by noting the areas where great concentrations of small bluegills were to be found.

We are inclined to believe that the 1945 hatch suffered the same fate as apparently befell the 1946 year class and that any base-leveling of the total numbers of bluegills in the lake and the growth rates of the hatches in those years is the result of natural controls exercised upon the bluegills by their own population.

No prediction is made as to the future growth rate of the bluegill population. The oldest age groups are approaching ages in which a heavy natural mortality may be anticipated. What effect this will have on the various components of the residual population can only be determined by future sampling of the stock.

Few bluegills of legal size were taken in 1946. On May 3, a party of two fishermen caught nothing but sub-legal bluegills during a morning's fishing. Sporadic bluegill fishing during late spring observations on the smallmouth bass spawning yielded nothing but sub-legal fish. On October 22, 116 bluegills were caught by hook and line fishing. Of these, 15 were of legal size. Fourteen varied in total length from 153 to 184 millimeters (6.0 - 7.2 inches). The majority of these were just over 6 inches in length. The fifteenth specimen had a total length of 235 millimeters (8.3 inches). A frequency distribution of the age groups represented in this hook and line sample is presented in Figure 4b.



The average growth of the bluegills, by age groups, during 1946 is summarized in Table 3. It will be noted, that on the average the oldest age group (IV) in the lake had not yet attained the legal length of 6 inches (152.4 mm.).

Some deficiency in the bluegill sampling techniques was evident. The lower limits of the age group III size range were incompletely sampled. These fish were large enough to escape quite easily during seining operations but were generally too small to be taken on the smallest hooks used in the hook and line fishing. One of the smaller, experimental trap nets will be used for obtaining samples in the coming year.

Smallmouth Bass

Observations on the smallmouth bass in Deep Lake were intensified during the 1946 season with the object of ascertaining if successful spawning and fry production would take place. As it has been noted in a previous report (No. 1033), the smallmouth had not spawned successfully in Deep Lake prior to this year. Between April 24 and July 29, thirteen visits were made to the lake to observe the bass spawning activities. During the first two visits on April 24 and May 3, a careful survey was made of the entire lake shoal and no evidence of nest building by the smallmouth (or bluegills) could be found. On May 22, it was apparent that the smallmouth had begun nest-building sometime previous to this visit. However, on this date there was no activity to be noted. The nests appeared recently abandoned--most of them before completion. They appeared not to have been worked for several days as evidenced by small accumulations of algae and vegetable debris that had drifted into the nests. No adult smallmouth were seen in an entire tour of the shoal areas nor were they seen cruising along the drop-off.

Table 3.--Average growth of the bluegills in Deep Lake during 1946.

Date (1946)	Average total length in millimeters				
	Age group 0	Age group I	Age group II	Age group III	Age group IV
January 1, and February 3,7,23	...	↓	↓	14.2 ²	128.3
July 29	↓	41.5	55.8	...	...
October 22,23	32.2	47.6	58.0	112.8	138.6

↓ Age group not represented in sample.

² Hook and line sample. Lower third of size range not sampled rendering this average abnormally high.

The reason for this cessation of nesting activity was most probably the week-long cold and rainy spell which preceded the date of this visit. On the following day, May 23, six adult smallmouth were seen cruising the shoals. This was the second warm day since the end of the aforementioned cold snap. (See Table 4 for air and water temperatures recorded on each visit to the lake).

One week later, on May 30, a complete and careful circuit was made of the lake. Twenty-eight bass nests were observed; sixteen had been built since the last visit and 12 were the same nests noted on May 22. All nests were marked by red-tipped dowels and numbered consecutively around the lake, from the boat dock, in a clockwise fashion. Each of these, and subsequent nests, were followed closely. These observations have been summarized chronologically as follows:

May 30.--Twenty-eight nests were observed - sixteen built since the visit on May 23 and twelve constructed prior to that date. Two nests were being worked by males but no eggs or fry were present in them as yet; eight nests contained live eggs in various stages of development; three nests contained sac-fry in various stages of development; one nest contained advanced fry; one nest too deep to sample (5.5 - 6.5 feet) apparently contained fry when judged by the behavior of the guarding male. Fifteen nests were in active use and spawning had taken place in 13 of them by this date. The remaining 13 nests were not being worked, used or guarded by a male. No successful spawning ever took place in any of these latter nests although several were recleaned later by males in a late and unsuccessful attempt to spawn.

June 5.--Of the two nests that were being worked by males on the previous visit, one now contained sac-fry and the other had been abandoned. This latter nest was later recleaned but never used. Of the 8 nests

Table 4.--Air and water temperatures recorded at Deep Lake, Oakland
County, during April, May and June, 1946.

Date (1946)	Time	Water temperature (Fahrenheit)	Air temperature (Fahrenheit)
April 24	3:00 p.m.	65	68
May 3	3:30 p.m.	57	60
May 22	10:00 a.m.	59	65
May 30	11:30 a.m.	64.4	73.4
June 5	2:30 p.m.	69.8	80.6
June 8	12:00 noon	68	77
June 12	4:00 p.m.	72.5	71.6
June 16	11:00 a.m.	74.3	80.6
June 24	11:00 a.m.	72	78
June 28	2:00 p.m.	84	82

containing live eggs on May 30, 4 now contained advanced fry (pigmented) and in the remainder the fry had evidently become free-swimming and moved away from the vicinity of the nest. In the three nests containing sac-fry on May 30, two now contained advanced fry, and the third contained none. These latter had evidently become free-swimming and moved away from the nest. The one nest that had contained advanced fry (May 30) was now abandoned.

Two new nests had been fanned out. One was still being worked on this date and the other had live eggs in it. Spawning had occurred in 15 nests by this date.

June 8.--Fry found in the nests on the previous visit had become advanced fry, free-swimming fry, or had moved away from the nests. Two new nests had been completed since June 5. One contained live eggs and in the other a pair of smallmouth bass were observed for more than an hour and a half in their spawning act. Two nests had been recleaned and a male was present on one of these nests. Spawning had taken place in 17 nests to date.

June 12.--Fry found in the nests during the preceding visit had developed further or had moved away from the nests. One new nest had been fanned out, but no male was guarding it nor had spawning occurred in it. One old nest was being recleaned by a male. A nest which was first noted on June 5 had been spawned in and now contained well-abandoned eggs and early sac-fry. Spawning had also taken place again in a previously used and abandoned nest which now contained eggs. Spawning had occurred in 19 instances to date in 18 nests (one nest used twice). No further spawning took place after this date.

June 16.--Advanced fry were still present in two nests and free-swimming fry in a third. The eggs and the guarding male had disappeared

from the nest observed spawned in for the second time on June 12. Two nests were observed being recleaned by males. Nine of the previously used and abandoned nests had been taken over by colonies of nesting bluegills.

June 24.--Two nests still contained free-swimming fry. Two old nests were being recleaned and 5 new nests were being fanned out by male smallmouth. Several more abandoned nests had been taken over by bluegills.

June 28.--All of the bass nests had been abandoned and virtually all had been taken over by nesting bluegills.

Nesting activity and spawning of the smallmouth bass may be summarized as follows: 38 nests were constructed by male bass of which 20 were completed but never used. Seventeen nests were used once for spawning and one nest was used twice. This constitutes a total of 19 successful spawning ventures.

Successful fry production may have resulted from these 19 successful spawning acts. However, after the first observation, when eggs were found in five nests, the eggs (or fry) had disappeared by the next visit. In two additional nests, sparse numbers of sac-fry found on one visit had disappeared by the next. There was no reason to assume that development to free-swimming fry and movement from the nests had taken place in the time between observations. Such a rapid development was negated by the rate of development of eggs and fry in adjoining nests.

Stages of development were observed in 11 nests through the advanced fry or free-swimming fry stage. In addition, the large deep nest previously noted is believed to have produced fry based solely on the behavior of the guarding male and the length of time he spent guarding the nest. Of the six nests observed through the free-swimming fry stage, the following numbers over or near the nest were actually counted or estimated:

Number of Nest	Number of free-swimming fry
#2	800 - 1000
#12a	20 - 30
#12b	30 - 35
#25	50 - 60
#25a	35 ±
#28	70 - 80

There is considerable evidence that a heavy mortality of bass eggs and fry took place before the latter ever left the nest. Hoardes of small bluegills were present on the shoals during the entire bass nesting season. Those nests in which the eggs or sac-fry disappeared early were in the areas of greatest bluegill concentration. It was noted, almost without exception, that as each stage of development was attained in a given nest, the numbers of fry in that nest were decreasing rapidly. This was culminated in the free-swimming fry production suggested by the preceding tabulation. On numerous occasions, nests containing eggs or fry were completely encircled by droves of small bluegills, hovering just off the rim of the nest. As the guarding male moved in one direction to drive them away, they advanced from the opposite side of the nest and could be seen devouring the eggs or fry. When the pair of bass were observed spawning on June 8, the male was continually interrupted during the act by bluegills attempting to seize the eggs as fast they were extruded.

It is doubtful if very many of the few survivors from these nests ever lived to escape to deeper water or better cover than the nesting areas provided. On July 12, four long seine hauls were made with a 10-foot bobbinet seine but no smallmouth bass fry were taken. Again

on July 29, 175 feet of the shoal areas were seined with a 50-foot bobbinet seine (1/16 in. mesh) and no bass fingerlings were taken. On October 22, over 40 percent of the shoal areas of the lake were seined with a 50-foot bag seine and no bass fingerlings were captured. We can only conclude from this that relatively few, if any, bass fingerlings were produced by the successful spawning activities observed during this season.

With one unverified exception, the bass observed spawning during the 1946 season were survivors of the second (October 7, 1943) planting. One very large nest, fanned out on the drop-off in over 5-1/2 feet of water was guarded by a male that appeared to exceed 20 inches in total length. This male may very well have been ^a survivor of the first (October 31, 1941) planting. All of the other males observed appeared to approximate each other in size. Two were selected (!) at random while on the nests on May 30 and two on June 8 and caught by fly rod and lure (popper-bug and artificial crawfish). These were scale-sampled and returned to the water where they resumed guarding their nests almost immediately. Examination of the scales indicated they were in age group III which identified them with the second planting of bass. These four male bass averaged 14.9 inches in total length with a range of 14.50 to 15.25 inches. Three specimens taken on May 8 and 25, 1945, averaged 10.2 inches. These few specimens therefore suggest an average gain of 4.7 inches for the 12-month period involved.

Some estimate of the adult bass population remaining in the lake in the summer of 1946 is possible. Since spawning occurred in 19 instances we may assume that at least 19 females are present. By the same token, at least 19 males are present. Furthermore, 20 unsuccessful nests were constructed during the spawning season. Some of these may have been

constructed by previously successful males attempting to spawn a second time as they sometimes do. Indications were, however, that some were built by males that found no mate. Assuming that at least 10 males faced this latter predicament, it seems likely that there were not more than 50 adult bass in Deep Lake, composed of 40 percent females and 60 percent males, by the end of June, 1946.

No bass were permanently removed from the lake by Institute personnel during 1946. Since the owner's fishing records have not yet been received by us we have no measure of the bass cropped during this calendar year.

Deep Lake has little, preferable smallmouth bass spawning areas. Some small scattered areas of mixed sand and small gravel are present and were completely utilized by the bass. In two of these areas nests in use were grouped in colonies, as those of the bluegills sometimes are, with the rims of the nests interlocking.

Many of the nests, as observed in 1945, were fanned out on fine, sandy bottom among the lily roots, and others amid dead leaves, twigs and other rubble. The average depth of the nests constructed in 1946 was 29.9 inches and ranged from 18 inches to an estimated 5.5 feet. This measurement was made midway in a shore-lakeward direction to the highest point on the rim of the nest. The average diameter of these nests was 27.8 inches with a range of 17 to an estimated 57 inches. A description of the nests constructed in both 1945 and 1946 will be found in Appendix I.

Rainbow Trout

Thirty rainbow trout were removed from Deep Lake by Institute personnel during 1946. Twenty-nine of these fish were scale-sampled to provide growth data. These samples were aged and identified with one of the three plantings made in Deep Lake prior to 1946. These data are summarized by plantings in the following tabulation. Average total lengths of the last collection of each planting made in 1945 is inserted for comparison:

Rainbow trout - 1941 planting					
Date	Number of specimens	Minimum	Average	Maximum	Average weight (ounces)
April 23 - May 8, 1945	2	17.5	18.6	20.1	...
October 22-23, 1946	6	15.5	19.2	24.1	47.0

Rainbow trout - 1942 planting					
Date	Number of specimens	Minimum	Average	Maximum	Average weight (ounces)
November 6, 1945	8	10.7	12.6	15.4	12.5
January 1, 27 and February 7, 23, 1946	10	10.5	12.0	16.5	9.9
May 23, 1946	2	12.0	12.8	13.5	11.5
October 22-23, 1946	8	9.2	13.1	14.9	15.2

Rainbow trout - 1944 planting					
Date	Number of specimens	Minimum	Average	Maximum	Average weight (ounces)
November 6, 1945	1	...	9.7	...	4.75
January 27, 1946	1	...	10.7	...	5.0
February 3, 1946	1	...	9.4	...	4.5
February 23, 1946	1	...	8.7	...	3.0

Netting efforts on October 22-23 to secure a large sample of trout were quite successful. Among the 13 trout and 4 king salmon taken in this overnight set, were three exceptionally large recoveries of the 1941 planting. These trout measured 20.3 (♀), 23.0 (♂), and 24.1 (♂) inches and weighed 3 pounds, 4 ounces; 4 pounds, 15 ounces; and 4 pounds, 13 ounces respectively. The scales of these three trout exhibited a severe erosion in the exposed field that may have been the result of an abortive spawning urge or an impaired "condition" due to inadequate preferred foods.

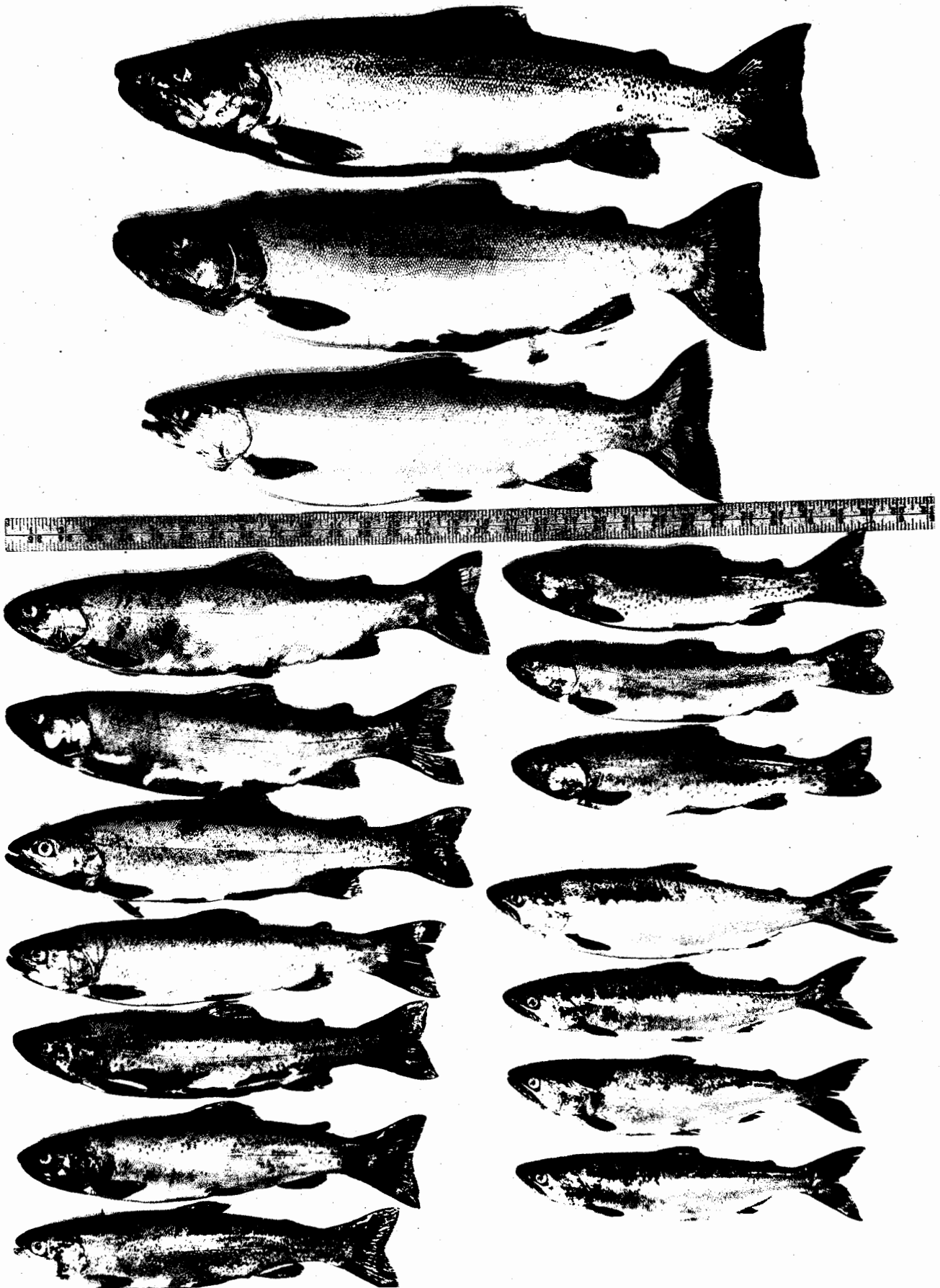
Although the growth increments for the 1946 season shown by the October 22-23 sample are small, the "condition" of all specimens taken was judged as fair. A photograph of the fish of this sample is presented in Figure 5.

Fish of the 1942 planting still dominate the rainbow trout catch in Deep Lake and may now be considered the most successful of the three plantings. Survival of the 1944 planting has evidently been the poorest. To date, only 10 recoveries of this planting have been made (no trout were planted in 1943).

On October 8, 1946, 1,000 rainbow trout fingerlings, provided by the Northville Federal Fish Hatchery, were planted in Deep Lake. These fish were marked by removal of the left pectoral fin. A sample of 100 of these were measured at the time of fin-clipping and averaged 3.8 inches in total length with a range of 2.9 to 4.9 inches.

A second planting of 1,000 fingerlings was inadvertently made on December 3, 1946. These fish were brought from the Drayton Plains State Fish Hatchery after marking by removal of the dorsal fin. This planting averaged 6.4 inches in total length.

Figure 5.--13 rainbow trout and 4 king salmon (lower right hand corner)
taken by gill-netting in Deep Lake on October 22-23, 1946.



It is doubtful if the lake can support both of these plantings and a heavy mortality may be anticipated particularly among the smaller trout of the October 8 stocking.

The Salmon

Because of the interest in the success of these exotic species in Deep Lake, we have reassembled all of the data on this planting. On March 27, 1945, a total of 3,190 salmon was planted in Deep Lake. This planting was made in Deep Lake because it was the only lake near Ann Arbor on which the Institute could obtain accurate records of the catch, growth and survival.

These fish had their origin in a shipment of salmon eggs (5,000 each of three species) that were sent to the Belle Isle Aquarium from the State of Washington. The eggs were received in Detroit on December 20, 1944 and hatched on, or shortly after, December 26, 1944. All of the surplus fingerlings were delivered to the Drayton Plains State Fish Hatchery.

A sample of 103 salmon was preserved for identification at the time of planting in Deep Lake. Dr. Reeve M. Bailey and W. F. Carbine identified these salmon as follows:

6 (5.8 percent) chum salmon (Oncorbynohus heta), average total length 50.3 mm. - 185 estimated planted.

25 (24.3 percent) silver salmon (Oncorbynohus kisutch), average total length 53.5 mm. - 775 estimated planted.

72 (69.9 percent) king salmon (Oncorhynchus tshawytscha), average total length 53.6 mm. - 2,230 estimated planted.

On April 23, 1945, young salmon were observed in shallow water and many were seen jumping out of the water. On May 5, a total of 10 salmon were taken in two seine hauls. Two king salmon, 6.4 and 6.5 inches in

length, were taken with hook and line on November 6, 1945.

During 1946, 17 salmon were taken by hook and line and gill nets by Institute personnel. All of these fish were king salmon (O. tshawytseha).

The dates of capture and the total lengths of these specimens were as follows:

	Gear	Number taken	Total length in millimeters			Total length in inches		
			Minimum	Average	Maximum	Minimum	Average	Maximum
February 3, 1946	H & L	1	...	165.0	...	...	6.5	...
February 7, 1946	H & L	3	164	164.6	165	6.5	6.5	6.5
February 23, 1946	H & L	3	158	164.6	170	6.2	6.5	6.7
May 20, 1946	H & L	1	...	190.0	...	...	7.5	...
July 31 - August 1, 1946	Gill net	5	262	297.0	315	10.3	11.7	12.4
October 22-23, 1946	Gill net	$\frac{4}{17}$	303	323.0	357	11.9	12.7	14.1

The four salmon taken on October 22-23 weighed 9.0, 10.0, 10.5, and 15.0 ounces respectively for an average weight of 11.1 ounces. On the average, these salmon had virtually doubled their length during the 1946 season. A picture of these specimens will be found in the lower right corner of Figure 5.

The stomachs of the five king salmon taken on July 31 and August 1, were examined by Mrs. J. W. Leonard of the Institute staff. Four of the five stomachs contained the identifiable remains of at least three bluegills (1.75 - 2.40 inches in total length) and the fifth stomach held the remains of two bluegills. Formicid wings, a chironomid, and some copepods were each recorded once in these stomachs. It is presumed

from these findings that the salmon are feeding extensively on the abundant supply of small bluegills present in the lake.

Management proposals for 1947.

1. Careful observations should be made during the smallmouth bass spawning season to determine the number of nests, amount of successful spawning, and the escapements and/or production of smallmouth bass fry. Preliminary visits for this purpose should be made at least by May 1, and after spawning has begun, observations should be made at least twice a week.

2. Occasional observations should be made during the bluegill spawning season to determine the extent of destruction of eggs and fry by the bluegills.

3. During early July, the summer sample of all species in the lake should be obtained. A concerted effort should be made to obtain smallmouth bass and bluegill fry with a 50-foot bobbinet seine. It is recommended that a small, experimental trap net be used to obtain a complete series of all other size groups in the lake. It may be necessary to use gill nets again to obtain a sample of the salmon and trout.

This same procedure should be followed again, sometime in October, to obtain an adequate fall sample.

4. It is requested that in the future accurate records of all fish removed from the lake be maintained by all parties concerned.

5. No plantings are recommended for Deep Lake during 1947, nor any alterations in, or controls upon, the present population. It is felt that much valuable biological data may be obtained by allowing the present populations to remain unaltered for at least one more year.

APPENDIX I

- I. Description of nests observed on June 13, 1945 that had been constructed by smallmouth bass in Deep Lake. (Depths were measured to the center of the nest). Water temperature 68° F. at 1:30 p.m.
1. Sand and gravel. 3 boulders. 1-1/2 feet deep by 1-1/2 feet in diameter.
 2. Sand & little gravel. One four foot stick 2 inches in diameter and roots. Depth 2 feet x 2-1/2 feet. Diameter 2 feet.
♂ on nest.
 3. Sand and fine and coarse gravel. Mostly gravel in bottom. Depth 1' 10" x 2-1/4 feet. Diameter 2-1/2 feet. ♂ on nest.
 4. Sand; mostly gravel in bottom (fine to coarse gravel). Orange marble in nest. Depth 2 feet x 2-1/2 feet. Diameter 33 inches.
 5. Four feet from previous nest. Sand with fine to coarse gravel (2 white marbles). Two boulders at side of nest. Depth 1-3/4 feet x 2-1/4 feet. Diameter 2-1/4 feet. ♂ on nest.
 6. Sand. Mostly coarse gravel. No sand in bottom of nest. Depth 1-1/2 feet x 1-3/4 feet. Diameter 2-1/2 x 3 feet.
 7. Two and one-half feet from the last nest. Same type of bottom. Depth 1-1/2 feet x 1-3/4 feet. Diameter 1-1/2 feet.
 8. Sand and black roots. One stone 5 inches long x 2 inches wide. Depth 1-3/4 to 2 feet. Diameter 1-1/2 feet. Bass observed in nest.
 9. Bass on nest but left and stayed within 10 feet of nest as we approached. Sand and gravel. One large boulder and roots. One long water lily root and rootlets. No eggs or fry. Depth 2 feet x 2-1/4 feet. Diameter 2 feet. ♂ observed on nest.

10. Sand and few roots. Depth 1-1/2 to 2 feet. Diameter 2 feet.
♂ observed on nest.
11. Sand and roots. One large water lily root. No eggs. Depth
2-1/2 x 3 feet. ♂ observed on nest.
12. Sand and very few roots. One stick 2 inches in diameter over
nest but not on bottom. Depth 2' x 32". Diameter 2-1/2 feet.
13. Sand and roots. Depth 33" x 39". Diameter 2 feet. Looks like
nest deserted. No bass observed.
14. Sand, several scattered pebbles. One large boulder at side.
Depth 15 inches by 20 inches. Diameter 1-3/4 feet. No eggs;
bass on nest.
15. Bass on nest. Sand and gravel. Depth 22" x 28". Diameter 26".
16. Male on nest. Sand, fine gravel, sticks. Depth 2 x 2-3/4 feet.
Diameter 2 feet.
17. Deserted nest. Sand. Depth 3' x 3-3/4'. Diameter 2 feet.
18. Sand, roots, sticks. Depth 3' x 3-1/2'. Diameter 2 feet. No
fish observed.
19. Sand, little fine gravel, sticks, deserted. Depth 2-1/2 x 3 feet.
Diameter 1-3/4 feet.
20. Sand. Fine gravel. Depth 2 x 2-1/2 feet. Diameter 2 feet.
Within 6 feet of this nest are 3 other nests deserted and filled
with muck, ? have been cleaned this year. Male in nest.
21. Male on nest. No eggs. Sand and fine gravel. Mostly sand.
Stick over corner of nest. Depth 24" x 33". Diameter 2 feet.
22. Sand bottom. Stick through corner. Male on nest. Depth 28" x 33".
Diameter 2 feet.
23. Sand and roots. One rock 4 or 5 inches by 3 inches. Depth
2 x 2-1/2 feet. Diameter 15".

24. Sand; few pebbles; and a stick. Depth 27" x 30". Diameter 26".
25. Sand and few pebbles. Depth 26" x 30". Diameter 1-1/2 feet.
26. Nest observed only by presence of guarding male. Sand, roots, and two large sticks in side. Depth 1 foot x 14 inches.
Diameter 1-1/2 feet.
27. Sand and few roots. Depth 20" x 26". Diameter 2 feet.
28. Sand and few sticks. Depth 30" x 36". Diameter 2 feet.
29. Male on nest. Sand and roots. Depth 15" x 18". Diameter 1-1/2 feet.
30. Male on nest. Sand, fine roots, and sticks. Depth 30" x 32".
Diameter 32 inches.
31. Male on nest. Sand and fine gravel. Depth 20" x 27". Diameter 1-3/4 feet.
32. Male on nest. Sand and roots. One stick. Depth 1 x 1-1/2 feet.
Diameter 1-3/4 feet.
33. Sand and gravel. 3 large rocks in and around nest. Depth 1 x 1-1/2 feet. Diameter 2 feet.
34. Male on nest. Sand, stick, water lily roots. Depth 24" x 29".
Diameter 27".
35. Sand and gravel. One stick. 3 x 3-1/2 feet deep. 2 feet diameter.
36. Male on nest. Sand, roots, 1 rock. Depth 15" x 17". Diameter 15".

II. Description of nests constructed by smallmouth bass during the 1946 spawning season. (Diameters and depths of nests measured to highest point of rim of nest on a line midway on the nest in a shore-lakeward direction).

Nest No.

1. Diameter 24"; depth 36"; mixed sand and small gravel.
- 1a. Diameter 24"; depth 42"; mixed sand and small and large gravel;
one large rock in nest.

2. Diameter 30"; depth 30"; mixed sand and small gravel and some large stones, one of which is 6 x 8 x 4 inches.
3. Diameter 30"; depth 31"; principally small gravel with some sand.
- 3a. Diameter 30" x 36"; depth 32"; marble-sized gravel and sand; shallow nest.
4. Diameter 32"; depth 30"; mostly sand with some scattered small gravel; water-logged barrel stave and dead stick imbedded in nest.
5. Diameter 18"; depth 31"; mostly sand with some rubble including a piece of tile near center of nest.
6. Diameter 24"; depth 30"; small gravel with some sand.
7. Diameter 18"; depth 31"; mixed small gravel and sand.
8. Diameter 48"; depth 26"; entire nest of marble-sized gravel.
9. Diameter 30"; depth 26"; entire nest of small gravel.
10. Diameter 18"; depth 26"; fanned out of sand in tangle of marsh grass roots.
- 10a. Diameter 28"; depth 26"; fanned out in sand; nest criss-crossed with exposed lily roots.
11. Diameter 40"; depth 22"; fanned out in pure sand; a little fine gravel in center of nest; one large stone 12 x 8 x 8 inches in nest; mats of water plant roots scattered through nest.
12. Diameter 18"; depth 18"; large gravel and sand; some plant roots exposed in nest; nest less than six feet from dry shoreline.
- 12x. Diameter 20" x 24"; depth 24"; fanned out in sand, dead leaves and lily roots.
- 12a. Diameter 40"; depth 36"; fanned out of pure sand and pondweed roots; center of nest criss-crossed with latter.
- 12b. Diameter 24" x 15"; depth 32"; fanned out of pure sand with 2 large lily tubers criss-crossing nest.

13. Diameter 17"; depth 22"; fanned out 3" deep in sand.
- 13a. Diameter 24"; depth 24"; fanned out in sand; some mixed gravel in bottom of nests and exposed plant roots in bottom and sides of nest.
14. Diameter 30"; depth 40"; fanned out of sand leaving all but rim of nest a mat of exposed lily roots; rusted tin can in edge of nest.
15. Diameter 30"; depth 30"; fanned out of sand with a little fine gravel in center of nest; baseball-sized rock in edge of nest.
16. Diameter 24"; depth 27"; fanned out of sand leaving bottom of nest a mat of plant roots; one 4" x 4" x 4" rock in nest.
17. Diameter 27"; depth 29"; fanned out of fine gravel and sand; half-dozen pieces of large gravel scattered through nest; nest only 5 feet from dry shore.
18. Diameter 18"; depth 22"; nest bottom of medium and large gravel; one large stone in nest as are some exposed plant roots; about 4 feet from dry shore.
19. Diameter 4-1/2 to 5 feet; depth 5 to 6 feet; (both estimated); very large nest built on the drop-off; rim of nest is sand but entire center, 36" to 40" in diameter, is a solid mat of exposed lily and pondweed roots.
20. Diameter 36"; depth 28"; fanned out 9" deep in sand; odd pieces of gravel in nest; lilies growing out of rim of nest.
21. Diameter 24"; depth 18"; fanned out of sand; several pieces of gravel in nest.
22. Diameter 30"; depth 39"; fanned out in sand and rubble; 12" long dead stick lying in center of nest.

23. Diameter 18"; depth 24"; mixed sand and small gravel.
24. Diameter 30"; depth 27"; fanned out 10" deep in sand and some mixed gravel; one tin can and one piece of dead wood in nest.
- 24a. Diameter 30"; depth 32"; fanned out 8" deep in sand and some small gravel; one tin can, one dead stick and one large rock in nest.
25. Diameter 40"; depth 36"; fanned out in sand; some pea gravel in center of nest; one large tin can and orange-sized rock in center; boulder in edge of nest.
- 25a. Diameter 24" x 30"; depth 28"; fanned out in marble-sized gravel and coarse sand.
26. Diameter 24"; depth 28"; fanned out in mixed sand and small gravel; some plant roots exposed in rim of nest.
27. Diameter 24"; depth 23"; fanned out in sand; some fine gravel in center of nest; large boulder in rim and nest criss-crossed with exposed plant roots.
28. Diameter 25"; depth 26"; fanned out of sand to expose mats of tree roots; located 4 feet from bank, just west of boat deck.
- 28a. Diameter 24"; depth 34"; fanned out of sand; some small gravel in nest; exposed tree roots around margin of nest.

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