Original: Fish Division
cc: Education-Game
Inst. for Fish. Res.-2
G. P. Cooper

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

ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

January 23, 1956

Report No. 1465

THE PROBLEM OF SAMPLING A BLUEGILL POPULATION IN A SMALL INLAND LAKE FOR AGE AND GROWTH STUDIES[1]

By Gerald P. Cooper

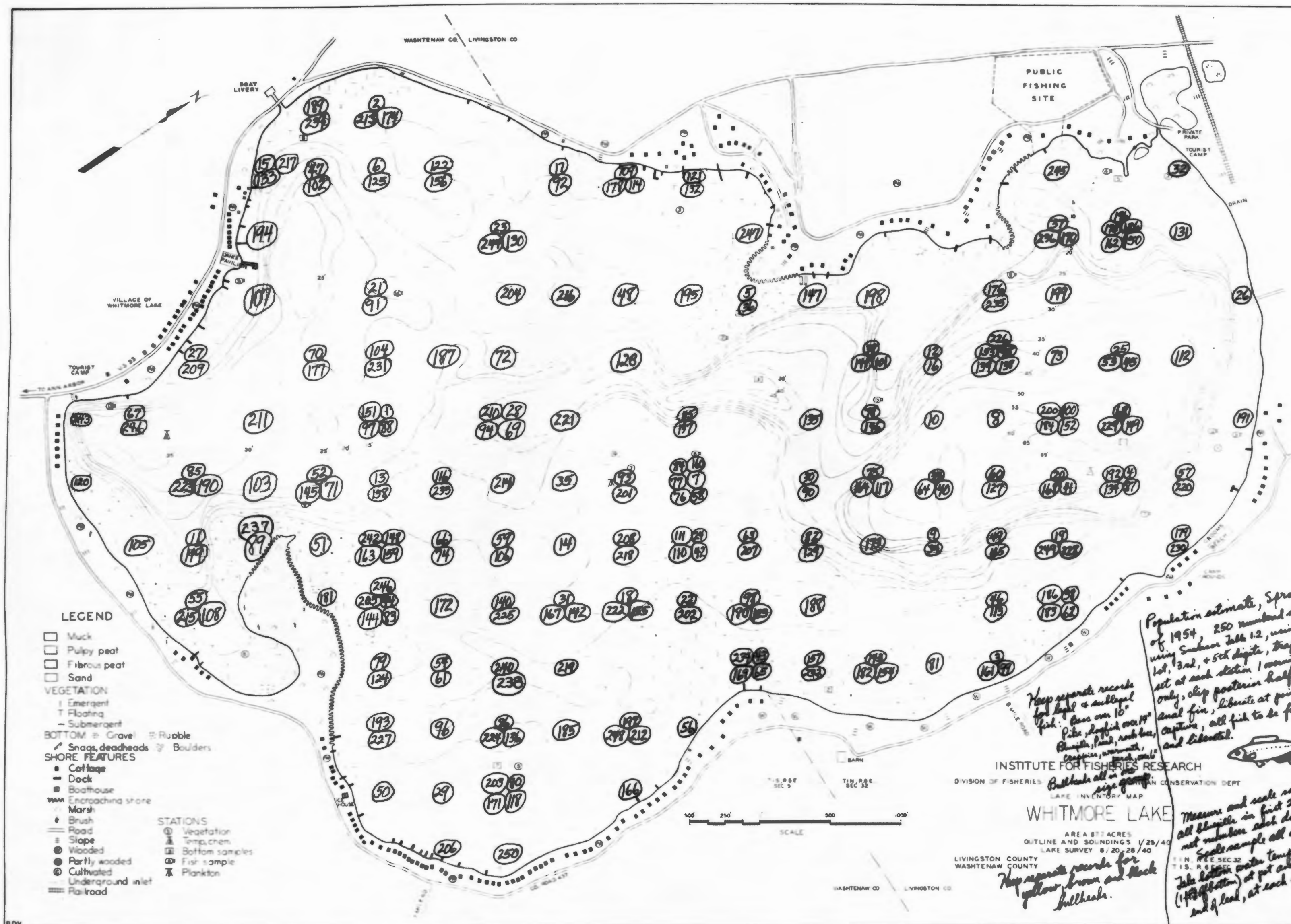
Whitmore Lake is located in the southeast corner of Michigan's Lower Peninsula. It is 667 acres in area. The maximum depth is 69 feet, but 85 percent of the lake area is less than 30 feet deep. In a fish population estimate by trap nets, made on this lake during the period April 17 to May 19, 1953, the standing population of legal-size bluegill (over 6 inches) was found to be about 28,000, or 40 fish to the acre. The netting on which this population estimate was based included the operation of a commercial-type, 6-foot trap net at 168 different stations on the lake. The locations of stations (Fig. 1) had been selected by recourse to random numbers, in order to give a randomized netting pattern over the lake as a whole. Scale samples were taken from all bluegills in 52 of these net sets; the 52 net sets were also selected at random, for the purpose of scale sampling bluegills.

The present discussion deals with problems of assessing average age and rate of growth of the bluegill from analyses of these samples.

---

[1] The data reported upon here were published in part in the Transactions of North American Wildlife Conference for 1954. The present paper was read at the Midwest Wildlife Conference, Purdue University, on December 13, 1955.

Fig. 1. Map of Whitmore Lake showing randomized pattern of netting stations, April—May, 1953. Trap nets were fished at 168 of these stations.



WHITMORE LAKE Livingston Co. T1N, R6E, SEC 32
Washtenaw Co. T1S, R6E, SEC 5

Both the catch per net and the age analyses showed great variability for the different netting stations. Some of these variations were certainly attributable to differences in habitat conditions in different parts of the lake, and some of these differences were not generally evaluated in the present study. Some of the variations were quite unique. For example (Table 1) the number of bluegills caught per one-night net set varied in a strange fashion in relation to depth of water. The catches per net were alternately high and low in consecutive depth intervals, for no obvious reason.

Among the 7 age groups which were represented by those bluegills which were scale sampled, average age (Table 2) showed some correlation with depth of water. Those taken from water up to 15 feet in depth were somewhat older on the average than those taken from water over 15 feet. Among the 4-year-olds, those collected during the last half of April were significantly larger than those collected during the first half of May (presumably a variation due to sampling).

A striking feature of the bluegill population was the great numerical dominance of the 4-year-olds (Table 3). Of 1,877 bluegills scale sampled, 1,698 were in this one age group.

The remainder of the present discussion deals only with these 4-year-old bluegills. For all 4-year-olds collected on the lake as a whole, the size frequency distribution was approximately normal (Fig. 2), with a mean of 6.26 ± 0.014 inch. Where the total distribution was approximately normal, and if one were to assume that the size distribution of 4-year-olds in the lake had been generally homogeneous, then trap net samples drawn from any particular place on the lake should have had approximately the same mean and standard error as

Table 1

Number legal-size bluegills per net set,

by depth of water

April 17 - May 19

Depth in ft.	Number of net sets	Bluegills per set Mean	Bluegills per set Std. dev.
3 - 5	48	32	43
5 - 10	52	7	13
10 - 15	22	29	68
15 - 20	16	3	4
20 - 25	13	18	42
25 - 30	12	3	6
30 - 35	5	36	79

Table 2

Problems in sampling for growth studies.

1,877 bluegills:

627 in 3-5 feet of water, avg. age	4.28 ± 0.04	years
97 in 5-10 " "	4.54 ± 0.14	"
608 in 10-15 " "	4.22 ± 0.03	"
27 in 15-20 " "	4.04 ± 0.08	"
340 in 20-25 " "	4.11 ± 0.03	"
5 in 25-30 " "	4.00 ± 0.0	"
173 in 30-35 " "	4.17 ± 0.04	"

1,698 IV-year-old bluegills:

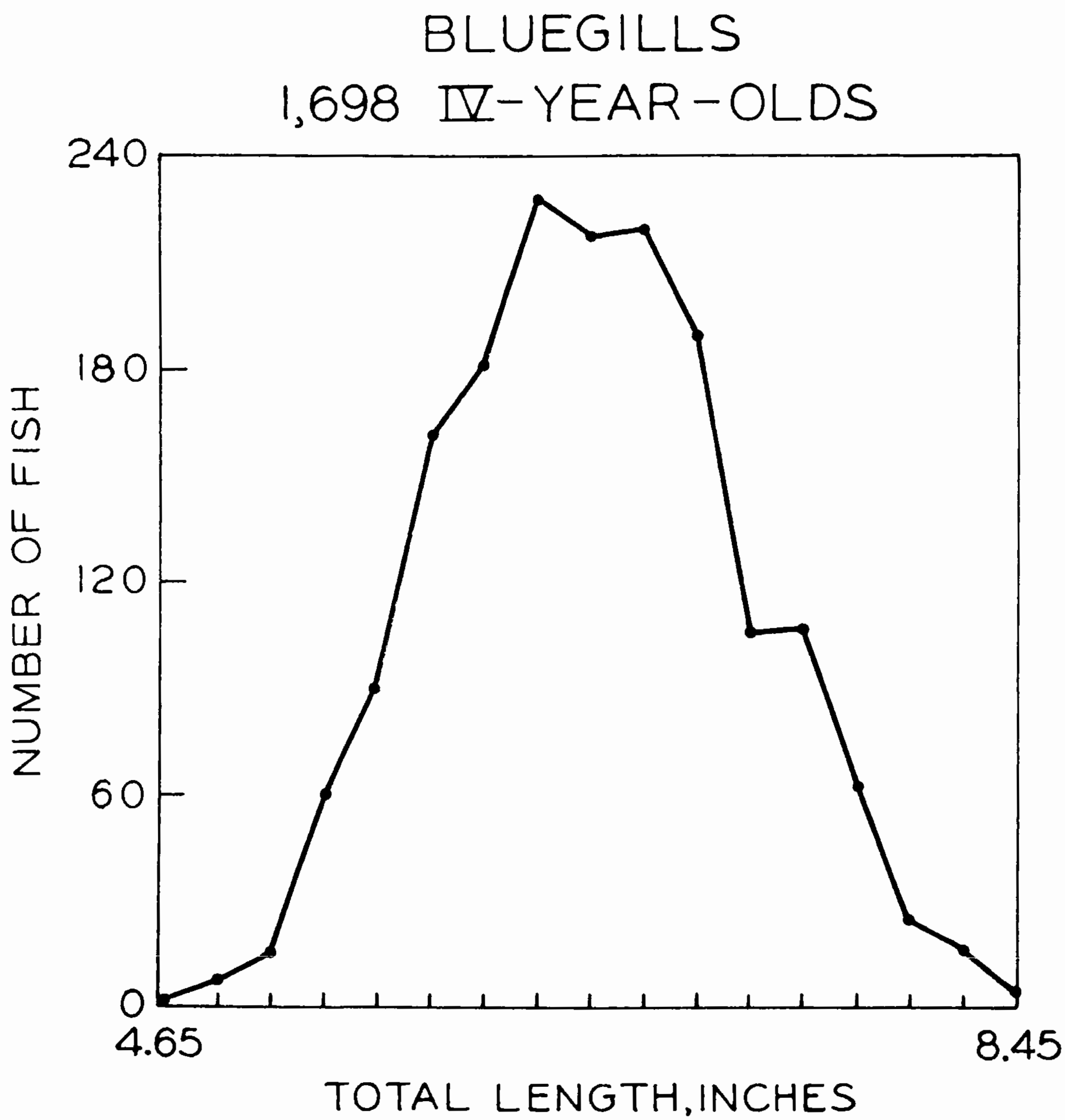
729 in April in 29 net sets, avg. length	6.36 ± 0.021	inches
969 in May in 23 " "	6.18 ± 0.018	"
	(t = 6.7)	

Table ~~4~~ 3. Length- and age-frequency distributions of 1,877 bluegills from Whitmore Lake, Spring of 1953

Total[1] length, inches	Age in completed winters							
	III	IV	V	VI	VII	VIII	IX	X
4.2-4.3	1							
4.4-4.5	1							
4.6-4.7	3	1						
4.8-4.9	3	7						
5.0-5.1	...	16						
5.2-5.3	1	62						
5.4-5.5	...	90						
5.6-5.7	1	162						
5.8-5.9		182						
6.0-6.1		228						
6.2-6.3		215						
6.4-6.5		220	1					
6.6-6.7		190	1					
6.8-6.9		106	2					
7.0-7.1		109	5					
7.2-7.3		63	5					
7.4-7.5		25	7	1				
7.6-7.7		17	8	1				
7.8-7.9		5	8	2				
8.0-8.1			4	5				
8.2-8.3			4	12	1	1		
8.4-8.5			3	9	12	1		
8.6-8.7				8	6	10	1	
8.8-8.9				5	5	8	7	
9.0-9.1				2	2	5	3	1
9.2-9.3					2	2	4	1
9.4-9.5						1	1	
9.6-9.7							1	
9.8-9.9							1	
Total	10	1698	48	45	28	28	18	2
Mean length	4.83	6.26	7.61	8.39	8.65	8.83	9.12	9.15

[1] All lengths of fish were measured to the nearest 0.1 inch; and mean lengths were computed from the original measurements, i.e., not from length-group midpoints.

Fig. 2. Size-frequency distribution of 4-yr.-old bluegills, Whitmore Lake, April—May, 1953.


BLUEGILLS
1,698 IV-YEAR-OLDS
240
180
120
60
0
NUMBER OF FISH
4.65
8.45
TOTAL LENGTH, INCHES

the mean for the whole population, within prescribed confidence limits. But, when the 52 sub-sample means are plotted (Fig. 3), the picture is quite different. In this figure, the 52 sample means are plotted against the value of N for each sample. For samples containing 40 or more specimens, the ranges of ± one standard error are shown. It is immediately obvious that many combinations of these sub-sample means are too far apart to have been drawn from a normal population. For most of the samples with N greater than 40, the mean with its confidence limits would not have correctly approximated the true mean.

The variability in average size among 4-year-olds was not closely related to depth of water (Table 4), as illustrated by the 8 larger samples, each containing over 58 specimens. The slight suggestion that the larger 4-year-olds were in somewhat deeper water is counteracted by the fact, pointed out earlier, that, for all age groups collectively, the bluegills from shallow water were slightly the older.

The obvious conclusion is that 4-year-old bluegills in Whitmore Lake were "schooling" somewhat according to size in different parts of the lake. The question might be raised as to whether or not this schooling by variable size groups might be related to sex and a sex difference in rate of growth. If the sexes tended to school separately, and if one sex had a faster growth than the other, this might explain the present large variability among samples. However, Beckman (1946, Trans. Amer. Fish. Soc., 76: 63-81) found no significant sex difference in rate of growth of the bluegill in Michigan waters.

Fig. 3. Average lengths of 4-yr.-old bluegills in 52 trap-net samples, related to sample size (N), Whitmore Lake, April—May, 1953. Total collection includes 1,698 specimens with average length (represented by vertical mid-line) of 6.26 ± 0.014 inches. For individual collections of over 40 specimens, the ± limits of one unit of standard error are shown.

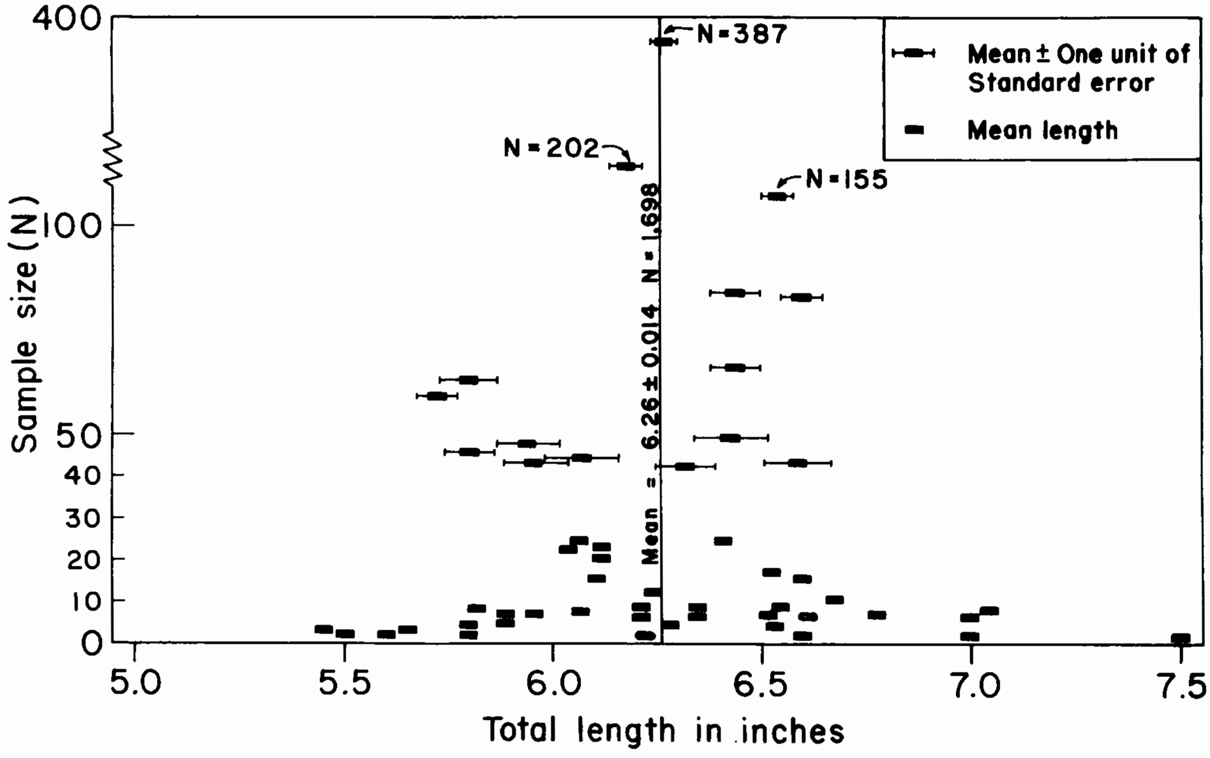

400
100
50
40
30
20
10
0
Sample size (N)
5.0
5.5
6.0
6.5
7.0
7.5
Total length in inches
N = 387
N = 202
N = 155
Mean = 6.26 ± 0.014 N = 1,698
Mean ± One unit of Standard error
Mean length

Table 4

Problems in sampling for growth studies.

1,698 IV-year-old bluegills, from 52 net sets

Total sample, avg. length 6.26 ± 0.014 inches

8 sub-samples with over 58 specimens in each:

Water depth in feet	Number of specimens	Average length	Diff. from total sample, t =
3 - 5	59	5.72 ± 0.05	10.4
3 - 5	63	5.80 ± 0.07	6.5
3 - 5	84	6.44 ± 0.06	2.9
10 - 15	387	6.27 ± 0.03	0.3
10 - 15	83	6.60 ± 0.05	6.5
20 - 25	66	6.44 ± 0.06	2.9
20 - 25	202	6.18 ± 0.04	1.9
30 - 35	155	6.54 ± 0.04	6.7

If one were assessing growth of these 4-yr.-old bluegills, by collecting 2 or 3 large samples, limited to 2 or 3 different places on the lake, quite an erroneous picture as to average size for this year class might be obtained.

If means for the 52 net samples (Table 5) are combined according to the number of fish in each sample, it is found that the 27 net samples which contained from 1 to 10 specimens give a very close approximation of the true mean. This is also true for combining samples with other values of N, but agreement is less good in the combination of the 15 largest samples where N was 40 or more.

If we then compute (Table 6) the minimum, adequate sample size, based on the 52 sample means and the variances of these means, we obtain the following figures. For the lake as a whole, if the assumption were made that size frequency distribution over the lake were uniform, a sample of 128 fish would give an estimate of the true mean within an interval of ± 0.1 inch with a 95 percent probability of being correct. If the prescribed confidence interval is increased to ± 0.4 inch, the required sample size is reduced to 8 fish. But in the present situation, with the fish distribution non-uniform over the lake as a whole, the computation of sample size is concerned with the number of separate collections, scattered at random over the lake, which would be required to give a correct estimate of average length. The approach used here is to average the means for the 52 samples, and compute the variances of these means. For net samples containing from 1 to 10 fish, it would require 108 of these net samples to give 95 percent probability for an interval of ± 0.1 inch; but only 7 of these net samples are

Table 5

Sampling IV-yr.-old bluegills

N = 1,698 fish, $\bar{X}$ = 6.26 ± 0.014

Number of sub-samples = 52

Number of fish in sub-samples	N samples	Mean of sample means	Variance of means
1 - 10	27	6.28	0.280
11 - 39	10	6.25	0.082
40 - 387	15	6.21	0.093
11 - 387	25	6.22	0.086
1 - 387	52	6.25	0.184
Mean: all fish	1,698	6.26	0.333

Table 6

Sampling IV-yr.-old bluegills

Adequate sample size

$$N = \frac{t^2 \quad s^2}{l^2}$$

t = 1.96 for P = 0.05; ± l = confidence limits

Number of fish in sub-samples	N samples	$N = t^2s^2/l^2$, for			
		l = ± 0.1"	l = ± 0.2"	l = ± 0.3"	l = ± 0.4"
1 - 10	27	108	27	12	7
11 - 39	10	32	8	3	2
40 - 387	15	36	9	4	2
11 - 387	25	33	8	4	2
1 - 387	52	71	18	8	4
Mean: all fish	1,698	128	32	14	8

necessary for a confidence interval of ± 0.4 inch. A more realistic confidence interval for the mean in this case might be a value of ± 0.2 inch. For a confidence interval of ± 0.2 inch, and for net catches of something over 10 fish per net, it would require about 8 or 9 net samples to give a reliable estimate of the true mean.

INSTITUTE FOR FISHERIES RESEARCH

By Gerald P. Cooper

Typed by A. D. Waterbury