Original: Fish Division
cc: ~~Education-Game~~
Inst. for Fish. Res. (2)
G.P. Cooper
R. N. Schafer
D. S. Shetter

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

April 1, 1954

Report No. 1415

STUDIES ON THE POPULATION OF LEGAL-SIZE FISH IN WHITMORE LAKE, WASHTENAW AND LIVINGSTON COUNTIES, MICHIGAN[1]

By

Gerald P. Cooper and Robert N. Schafer

Abstract

Whitmore Lake is one of several lakes in southern Michigan on which liberalized fishing regulations are being tested by creel census and by trap-net estimates of the number of legal-sized game fish present. The lake is 1-1/2 miles long, 677 acres in area, and 69 feet in depth (3/4 of area is less than 20 feet deep). Six commercial trap nets, plus several wire pots and gill nets, were fished at 223 netting sites (locations selected at random) during the period of April 17 to May 19,1953, one over-night set per station. Fish were "marked" by fin-clipping and were released at the point of capture. Population estimates were made by use of the Schumacher and Eschmeyer formula.

By netting, 7,419 fish were caught and most of them were marked and released, and 509 marked fish were recaptured. Population estimates for legal-size game and pan fish were: bluegill 28,692, largemouth bass 4,532, black crappie 567, pumpkinseed 1,274, rock bass 713, pike 539, yellow bullhead 2,258, brown bullhead 15,916; total 54,491 or 80.5 (35.3 pounds) per acre.

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[1] Revised copy of paper presented to the North American Wildlife Conference, Chicago, March 8, 1954.

Age determinations on 3,914 fish of principal scaled species showed a marked year-class dominance of bluegills (IV-yr.-olds), black crappie (III's), rock bass (IV's), pumpkinseed (IV's), but no marked year-class dominance among largemouth bass. Rate of exploitation by angling, computed only for largemouth bass, for 1952 was 22 per cent.

With 1,204 marked bass in the lake on the opening weekend of the bass season, a check on anglers gave records of 47 marked bass in their creels. Bass taken by anglers were of the same average and range in size as legal-sized bass present in the lake.

Analysis, by species, of numbers of fish caught per net set, and of their age- and size-frequency distributions, showed that there was little homogeneity in distribution of legal-size fish throughout the lake with respect to geographical areas, depth of water, or time within the 33-day netting period. Abundance varied with areas and with depths, and varied with time within areas; average age varied with depth; average size within a given age group varied with netting sites, etc. An allowance for these sources of variability must be made in sampling fish populations of lakes for studies of such questions as population density, and age and growth.

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An estimate of the population of legal-size game fish in Whitmore Lake was made during the spring of 1953 using a commercial type of trap net (described by Cooper and Latta, 1954) for collecting fish, and using the Schumacher and Eschmeyer (1943) and Schnabel (1938) formulas in the mark-and-recapture procedure of estimating population size. The extensive net collections also provided data for analyses of age and growth, total mortality rate, distribution of fish within the lake, and adequacy of sample size in connection with growth studies.

Whitmore is one of a dozen lakes which have been under intensive study during the past eight years for an evaluation of the effect of liberalized fishing regulations (Christensen, 1953). An intensive creel census is conducted on these lakes to determine the annual yield to anglers, and trap-net population estimates on certain of the lakes are being made to determine what the lakes contain in the way of legal-size fish for a comparison with angler yields. Thus far, trap-net population estimates have been made on Sugarloaf Lake (five consecutive years), Fife Lake (one year), Big Portage Lake (one year), and Whitmore Lake (one year--present study).

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[1] Paper presented to the North American Wildlife Conference, Chicago, March 8, 1954, and submitted (not including Tables 10 and 11, and Figure 2) for publication in the Transactions of the Nineteenth North American Wildlife Conference.

On Whitmore Lake six trap nets were fished for 33 consecutive days during the spring of 1953. This netting provided the primary basis for the fish population estimates. In the case of the largemouth bass, the population was also estimated from records on marked (fish captured in the trap nets and marked) and unmarked fish captured by anglers on the opening week end of the bass fishing season in June. The records of fish caught by trap nets were also analyzed in terms of catch per unit of netting effort for different intervals of the netting period, for different depths of water, and for four geographic divisions of the lake. The purposes of this detailed analysis of trap-netting records were (1) to obtain a general understanding of the distribution of legal-size fish within the lake, and (2) to investigate the possibility of using trap-net catch records, on a per-unit-of-effort basis, as indices to population density.

In the present study of Whitmore Lake, large series of scale samples were taken at random from trap-netted fish for a study of age and growth and for the computation of total annual mortality rates.

Acknowledgments

Assistance in the field netting party was provided by Michigan prison inmates. Mr. C. A. Pfitzmaier, a department employee, also gave some assistance on the field party. Messrs. R. W. Phillips and J. E. Williams made age determinations on the fish scale samples. Mr. K. G. Fukano verified many of the statistical calculations. For the opening week-end bass census, field help was given by Dr. F. F. Hooper and Messrs. H. D. Tait, R. O. Anderson and Mr. Phillips. Dr. Hooper supplied certain morphometric data for the lake. Mr. K. E. Christensen

generously supplied unpublished data on the 1952 and 1953 creel census on Whitmore Lake. Dr. A. S. Hazzard offered many valuable suggestions.

Description of Whitmore Lake

A morphometric map of the lake was prepared by a field party from the Institute for Fisheries Research in January, 1940, and that field map is the basis for available data on physical features. The shore line and depth contours are shown in Figure 1. The lake is 677 acres in area. It is generally oval in shape. Its greatest length is about 1-1/2 miles. The maximum depth is 69 feet, and deep water in the lake (i.e., over 25 feet) is largely confined to the northern half. Data on distribution of lake-bottom area in relation to depth contours are included in Table 1.

Bottom soils in the lake are largely sand, gravel, and organic muck. There are some extensive areas of rubble and boulder bottom, especially on shoal areas off points, in water less than two feet deep. Submerged aquatic vegetation is abundant during summer months over about one-half of the lake area, at depths of less than 25 feet.

Fish Population of the lake

Whitmore Lake has a population of warm-water game and coarse fishes which is quite typical of lakes of southern Michigan. The bluegill (Lepomis macrochirus) is by far the predominant fish in the lake, among species which exceed a length of six inches. Other abundant species include the pumpkinseed (Lepomis gibbosus), black crappie (Pomoxis nigromaculatus), rock bass (Ambloplites rupestris), largemouth bass (Micropterus salmoides), yellow perch (Perca flavescens), northern pike (Esox lucius), yellow bullhead (Ameiurus natalis), brown bullhead

(Ameiurus nebulosus), bowfin (Amia calva), and lake chubsucker (Erimyzon sucetta). Less abundant species include the smallmouth bass (Micropterus dolomieu), warmouth (Chaenobryttus coronarius), white sucker (Catostomus commersoni), grass pickerel (Esox vermiculatus), carp (Cyprinus carpio), redhorse (Moxostoma sp.), and golden shiner (Notemigonus crysoleucas).

Whereas the present report is concerned primarily with legal-size game fish and with pan fish over six inches in length, some information on smaller fishes in the lake is available in Institute files. The lake has a variety of small forage species. The green sunfish (Lepomis cyanellus) is especially abundant in shallow water; it seldom exceeds a length of 5-6 inches, and none was taken by the trap nets.

Trautman (1941) kept extensive records of angling on Whitmore Lake done by himself and friends during the five-year period, 1934-1938, and made observations on fish reproduction and survival of young fish. He concluded that there were important differences in survival of young from different year classes, and that these differences were reflected in the size distribution and numerical abundance of legal-size fish caught in subsequent years. The four species recorded by Trautman in his creel records (bluegill, largemouth bass, yellow and brown bullheads) were likewise the four most abundant species found to be present in 1953, and the 1953 studies have shown a dominance of year classes similar to that reported by Trautman.

Christensen (1953) recorded the fishing intensity on Whitmore Lake for the years 1946-1950 as 22 to 101 thousand angling hours per year, the total catch as 18 to 96 thousand fish per year, and the average catch per hour as 0.7 to 1.0. Percentage composition of anglers' creels for selected species was: 43 to 71 per cent bluegills, 10 to 25 per cent

yellow perch, 1.6 to 4.2 per cent largemouth bass, and 1.0 to 3.5 per cent bullheads.

Procedure

A randomized schedule of trap-netting stations was developed by recourse to the table of "ten thousand randomly assorted digits" in Snedecor (1946). Use was made of a copy of the Institute map of Whitmore Lake on which the lake outline encompassed a map area of 345 square inches. This map was superimposed over a grid in which the individual squares were 1-1/2 by 1-1/2 inches and in which the grid squares were numbered 1 to 330, in sequence. Snedecor's table was used (by one of the procedures recommended by that author) to select a series of three-digit numbers (001 to 999), and such of these numbers which were contained within the outline of the lake (while superimposed over the grid) were reassigned, in sequence, to become netting station numbers 1 to 236.

It was apparent at the start that the 5-foot commercial trap nets could not be fished effectively in water much less than three feet in depth, and it was regarded as impractical to attempt to fish these trap nets in water over 30 to 35 feet in depth. With respect to very shallow water, it was anticipated that fish of legal-size (generally over 6 inches) would not be regularly present in shallow water near shore, except as they would migrate into the shallow water for feeding at night. The minimum depth at which the trap nets were fished was about 3 feet, and those netting stations which were located at depths of less than 3 feet were fished by a wire funnel pot. These wire pots were far less effective in catching fish than were the trap nets. The distribution of the netting stations over the lake as a whole was designed to give uniform coverage according to lake area, and the fact that the wire pots caught

few fish means that uniform netting coverage did not include the shoreline shoals of depth less than 3 feet. Direct observations indicated that larger fish were not present on these shoals during the daytime. Fish moving onto the shoals presumably at night were, however, subject to capture by trap nets set in somewhat deeper water.

At depths greater than 30 to 35 feet the stations were fished by experimental gill nets, each net being 125 feet by 6 feet and made up of five experimental sections of the following mesh sizes: 1-1/2", 2", 2-1/2", 3" and 4", stretched measure. The gill nets in deep water caught far fewer fish per net-day than did the trap nets, due in part to differences in effectiveness of gear and due no doubt in large part to a much lower concentration of fish in the very deep water. Since only 10 per cent of the lake area is over 35 feet in depth, the lesser efficiency of gill nets in the very deep water was of minor significance in the netting effort on the lake as a whole.

The present system of employing random numbers for the selection of netting sites on the lake proved to be very effective in obtaining uniform netting coverage throughout the lake, from the point of view of both geographical distribution and depth of water. This fact is illustrated by a comparison of the percentage of all net sets made in a particular geographical "quarter" (Fig. 1) of the lake, with the percentage of lake area contained within the same "quarter"; and by a similar comparison of percentages of net sets and lake areas within various depth contours (Table 1). For examples: 25 per cent of the 236 stations were located in the northwest "quarter" of the lake, and this part of the lake has 28 per cent of the total area; and 22 per cent of the 236 stations were between the 5- and 10-foot depth contours, and this part of the lake has 24 per cent of the area.

The 236 netting sites, selected by random numbers are located on Figure 1. Whereas the number of stations selected for netting was 236, fishing with wire pots in very shallow water was so ineffective that 13 of the 43 wire-pot stations were dropped from the netting schedule. This reduced the netting stations from 236 to 223. At each netting station, a single net (either trap, wire pot, or gill net) was fished for one night only. In the selection of netting locations, by the grid system as described above, a considerable number of locations on the lake were repeat stations where from two to six net-station numbers fell on the same point. At these locations a net was fished from two to six times. A total of six commercial trap nets, two wire pots, and two experimental gill nets were used, with from six to 10 nets in operation at a time, to fish through 223 stations in 33 days. With minor exceptions the 223 stations were fished in numerical sequence.

The netting party on the lake located each netting site by general orientation with shoreline features, and to a lesser degree by actual depth soundings. Thus the actual depths and locations at which the nets were fished were not always precisely those indicated on the map (Fig. 1). However, in the analysis of catch records by depths, results from numerous stations are combined into averages, so that minor errors in individual depth records should be compensatory.

The compass direction in which each net was set was varied on a systematic pattern, with the net at Station No. 1 fishing north, No. 2 fishing east, No. 3 south, No. 4 west, No. 5 north, and so forth. This was done in order to eliminate possible bias in collecting fishes of different species, or fishes of different sizes, assuming that a species or size difference might be related to the movements of fish and therefore to the probability of capture by nets.

Fig. 1. Map of Whitmore Lake showing depth contours, division of the lake into geographic "quarters," and the locations of 236 randomly selected netting stations.

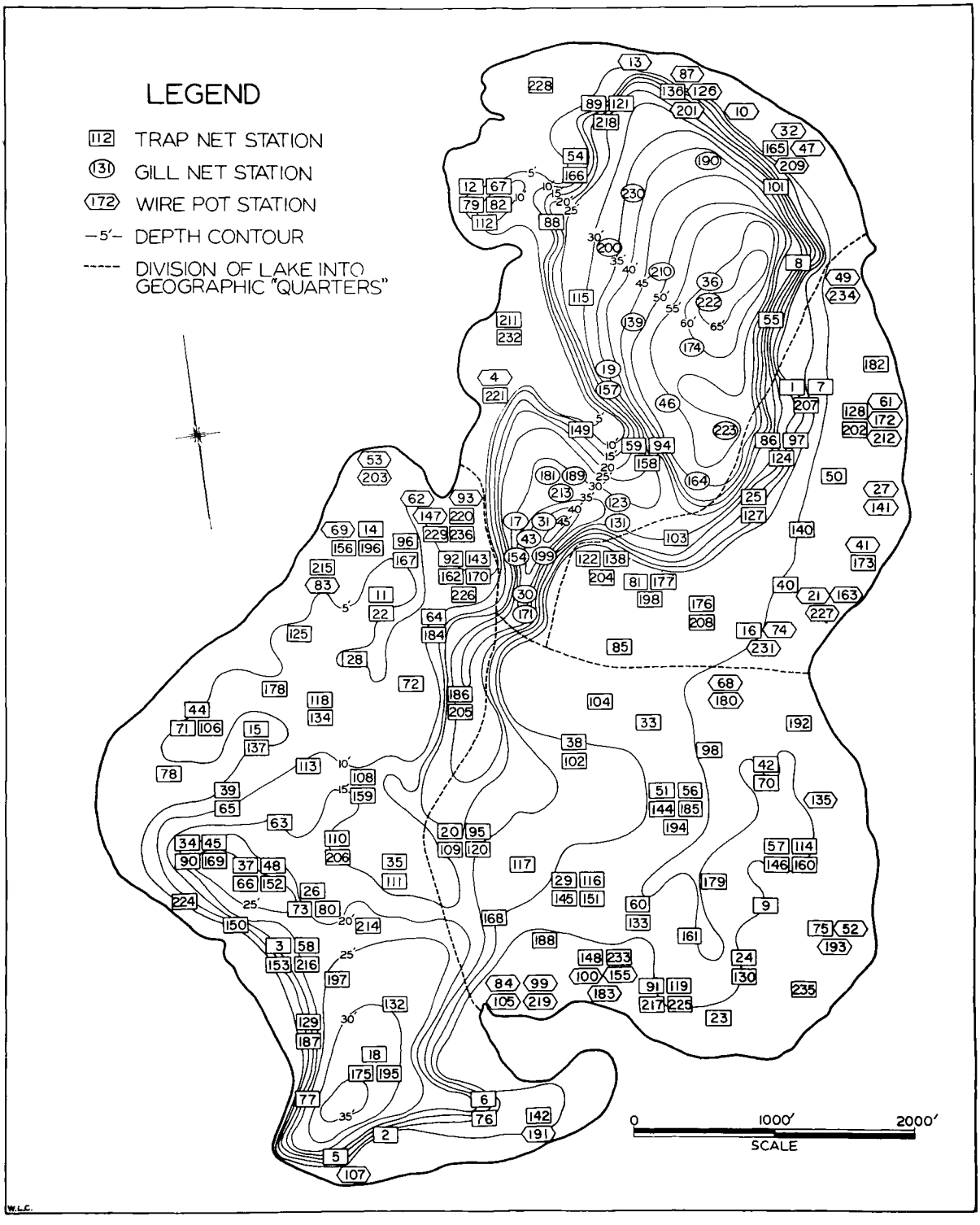

LEGEND
112 TRAP NET STATION
131 GILL NET STATION
172 WIRE POT STATION
—5'— DEPTH CONTOUR
----- DIVISION OF LAKE INTO GEOGRAPHIC "QUARTERS"
0
1000'
2000'
SCALE
W.L.C.

Table 1.--Distribution, by geographic area and by water depth, of 236 netting stations on Whitmore Lake, selected by recourse to random numbers

Lake divisions: geographical and contour interval in feet	Number of stations fished by			All nets		Lake area within divisions	
	Trap nets	Gill nets	Wire pots	Number	Per cent	Acres	Per cent
NW 1/4	25	25	9	59	25	190	28
NE 1/4	26	...	13	39	16	88	13
SW 1/4	73	...	9	82	35	230	34
SE 1/4	44	...	12	56	24	169	25
Total	168	25	43[1]	236	100	677	100
0- 5	48	...	43[1]	91	39	240	35
5-10	52	...	...	52	22	161	24
10-15	22	...	...	22	9	59	9
15-20	16	...	...	16	7	42	6
20-25	13	...	...	13	5	35	5
25-30	12	...	...	12	5	45	7
30-35	5	...	...	...	...	...	...
30-40	...	10	...	15	6	39	6
40-50	...	7	...	7	3	22	3
50-60	...	6	...	6	3	27	4
60-69	...	2	...	2	1	7	1
Total	168	25	43[1]	236	100	677	100

[1] Of the 43 wire-pot stations, only 30 were fished; these 30 sets caught practically nothing, so that there was little point in making the remaining 13 sets.

All fish captured by nets were marked by fin clipping for later identification, scale samples and length measurements were taken, and the fish were liberated at the point of capture. Each net was then moved to a new location. Scale samples and individual length measurements were taken on all fish when first captured, but not on fish when captured a second time. Scale samples were taken on all bluegills in the first two trap-net lifts each day throughout the netting period; for all other scaled species, samples were taken from practically all fish.

Catch records were recorded daily, by netting station number, and separately for "legal-size" fish as contrasted with fish of "sub-legal" size. Legal-size fish include bass over 10 inches, pike, gar and bowfin over 14 inches, and all other fish over 6 inches. Whereas the 6-inch limit on pan fish has been dropped as a state-wide regulation, the legal and sub-legal categories are here retained as a means of separating the larger fish (those prized by anglers) from the smaller ones.

During the 33 days of netting, periodic examinations were made of the shoreline of Whitmore Lake to check on the presence of dead fish, since the netting and marking of fish might be expected to cause some mortality, and since the daily allowance for any mortality of marked fish is an essential part of the method used in the population estimate. Daily mortality records were kept on any marked and unmarked fish encountered. The extent of this mortality was low, due no doubt to the cool water temperatures (44° to 64° F.) prevailing during the period. The greatest mortality occurred during the first week in May, and a careful inspection of the entire shoreline on May 9 resulted in the recovery of 110 dead fish; of these, 26 were fish which had been captured by trap nets and marked by fin-clipping, while 84 were unmarked fish, i.e., fish

which had not been previously caught in our trap nets and for which the mortality could not be attributed to netting. During the entire netting period only 34 dead, marked fish were found out of a total of 7,373 which were marked and released.

The estimate of the population of fish is based on the total catch of fish in trap nets, gill nets, and wire pots. Certain of the analyses on the catch per unit of netting effort are based on only the catch of the trap nets, because the numbers of fish taken by gill nets and wire pots were too few to allow significant statistical treatment. The unit of catch-effort analysis is the catch by one net in each over-night set; in each instance the time interval amounted to approximately 24 hours, with some variation depending upon the particular daylight hour on which the net was set and the particular hour on which it was lifted. The small variation in length in hours of the net sets is judged to be of very minor importance, especially for nets set in relatively shallow water (under 15 or 20 feet), because it is believed that the nets caught almost all of their fish during hours of darkness.

For the detailed analysis of netting records, one basis was by dividing the lake into northwest, northeast, southwest, and southeast geographic areas (approximately into quarters); another basis was the division of the lake into 5-foot contour intervals (0'-5', 5'-10', etc.) according to the water depth at the netting station; and the third basis was by dividing the 33-day netting period into three sub-periods: April 17-27, April 28-May 8, and May 9-19.

Population Estimates

The netting on Whitmore Lake took 7,928 fish (7,419 initial captures plus 509 recaptures) of 18 species. Of the 7,928 fish, 6,187 were legal-size game fish, pan fish and bullheads; 1,538 were sub-legal pan fish; and 203 were suckers, bowfin, carp, and other coarse fishes. The trap nets took 7,859 fish (99 per cent of the total); gill nets took 41 fish; and wire pots, 28. Of the 7,419 fish initially caught, 7,373 were fin-clipped and released; 509 marked fish were recaptured.

The numbers of fish caught, marked, and recaptured, and the population estimates and their confidence limits computed by the Schumacher and Eschmeyer formula are listed for certain species in Table 2. Species for which the numbers marked and recaptured were inadequate for a population estimate were as follows:

	Caught	Marked	Recaptured
Warmouth	20	20	0
Yellow perch	10	10	0
Grass pickerel	3	3	0
Chubsucker	71	71	0
Smallmouth bass	2	2	0
Redhorse sp.	5	5	1
Carp	8	8	0
Golden shiner	1	1	0

The estimates on sub-legal fish (in Table 2) are small as compared to estimates for legal-size fish, because the sub-legal groups include a very limited size range of fish, due in turn to the fact that the nets did not catch fish much smaller than legal size. In other words, the present population estimates involve primarily only the legal-size fish. Population estimates, based on the Schnabel formula, were very similar to the Schumacher and Eschmeyer estimates recorded here.

The bluegill population estimate for the spring of 1953 was 28,692; the brown bullhead was second in abundance, with 15,916; and the largemouth

Table 2.--Numbers of fish caught, marked and released, and recaptured, and population estimates (with confidence limits) computed by the Schumacher and Eschmeyer formula

Species and size	Total[1] catch	Marked and released	Recaptures	Schumacher and Eschmeyer estimates		
				Population	± one standard error	
					Lower limit	Upper limit
Bluegill						
Legal size (6"+)	3,036	2,886	145	28,692	25,674	31,710
Sub-legal (4-1/2-6")	1,271	1,238	29	26,624	20,149	33,099
Largemouth bass						
Legal size (10"+)	1,381	1,204	176	4,532	4,079	4,985
Sub-legal (7-1/2-10")	138	135	3	3,921	1,688	6,154
Black crappie						
Legal size (6"+)	246	203	42	567	505	629
Sub-legal (5-1/2-6"	17	15	1	...	...	...
Pumpkinseed						
Legal size (6"+)	72	56	0	[2]1,274	914	1,634
Sub-legal (4-1/2-6")	82	78	3	1,451	1,040	1,862
Rock bass						
Legal size (6"+)	140	127	13	713	541	885
Sub-legal (5-6")	23	23	0	...	...	...
Northern pike (14"+)	84	73	5	539	445	633
Yellow bullhead (6"+)	598	529	69	2,258	2,025	2,491
Brown bullhead (6"+)	605	592	12	15,916	12,816	19,016
Bowfin (14"+)	56	50	4	324	227	421
White sucker (8"+)	59	44	6	199	127	271

[1] Includes recaptures.

[2] Estimate for pumpkinseeds based on all fish, subdivided by size according to ratio in total catch.

bass third, with 4,532. Total population of legal-size game and pan fish, exclusive of rare species, was 54,491. This amounted to 80 fish per acre (Table 3).

Whereas the trap net estimate of legal-size largemouth bass was 4,532 fish, the independent estimate of legal-size largemouth bass, based on angler returns during the opening week-end (June 20 and 21) of the bass season, was 3,397 fish. This latter estimate was based on 123 angler-caught bass of which 47 were fish which had been marked during the trap netting four to eight weeks earlier; and on the assumption that the 1,204 marked legal-size bass (plus the 94 bass which were slightly under legal size, but which should have attained legal size by June 20) which were liberated in the lake during April and May were still present on June 20 to 21. (There was no legal bass fishing in the lake prior to June 20.) The estimate from angler-caught bass is 2.5 units of standard error below the trap-net estimate, which strongly suggests that there is some unrecognized source of bias in either, or both, of the methods. An average of the trap-net and angler-record estimates would put the population of legal-size largemouth bass at about 4,000.

Fish netted on Whitmore Lake were not weighed. However, a large and random series of each species was measured for total length (Tables 4 to 8), and using these length frequencies of legal-size fish, average weights were computed from length-weight data given by Beckman (1946) for the bluegill, largemouth bass, pumpkinseed, rock bass, and northern pike, and similar data recorded by Carlander (1950) for the black crappie, yellow bullhead, and brown bullhead. Average weights were applied to the population estimates for individual species to give total weights--which are given on a per-acre basis in Table 3. Total weight of

Table 3.--Population estimate and total angler harvest of legal-size fish of principal game and pan fish species[1] in Whitmore Lake

Species	Population estimate, spring, 1953			Angler harvest	
	Total number	Per acre			
		Number	Pounds	1952	[2]1953
Bluegill	28,692	42.38	9.91	13,818	38,405
Largemouth bass	4,532	6.69	8.09	707	2,831
Black crappie	567	0.84	0.34	430	922
Pumpkinseed	1,274	1.88	0.57	1,599	4,265
Rock bass	713	1.05	0.30	462	581
Northern pike	539	0.80	2.25	502	344
Yellow bullhead	2,258	3.34	1.64)	127	464
Brown bullhead	15,916	23.51	12.19)		
Total	54,491	80.49	35.29	17,645	52,934

[1]Yellow perch not included, because a population estimate was not possible.

[2]Not including data for the winter of 1953-1954.

legal-size game and pan fish was 35 pounds per acre, made up largely by the brown bullhead, bluegill and largemouth bass.

The claim is sometimes made that large fish in a lake become too smart to be caught by anglers, and that anglers therefore catch off only the smaller fish. The present records on largemouth bass throw some light on this question. The 1,204 marked legal-size bass in the lake at the end of the netting period on May 19 had an average length of 13.29 ± 0.06 inches while the 47 marked bass found in anglers' creels on June 20-21 had an average length of 13.55 ± 0.26 inches; the difference is not statistically significant. The percentage distributions of the two groups of fish by length groups were:

Length in inches:	10-11.9	12-13.9	14-15.9	16-17.9	18-19.9	20-21.9
47 angler-caught bass:	19	43	32	4	2	...
1,204 marked bass present:	27	40	20	9	3	1

The numerical distributions, from which the above percentages were derived, are not significantly different at the 5 per cent level; analyses by Chi-square ($X^2 = 6.85$, d.f. = 5, P = 0.24) reveal a 24 per cent chance that the difference is due to sampling variation. The present data do not support the claim that big bass are too smart for the angler.

Age determinations from scales were made on 3,914 fish--1,877 bluegills, 1,293 largemouth bass, 216 black crappies, 148 pumpkinseeds, 147 rock bass, 80 northern pike, and 153 of other species. The age and growth analyses are summarized in Tables 4 to 8. The few scale samples which were unreadable because of scale regenerations are not included in these tables. Age determinations from bones were not attempted on the bullheads. Growth of game fishes in Whitmore Lake is about the same as Michigan state-wide averages (cf. Beckman, 1949).

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

Total length, inches [1]	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	1,698	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.

Table 5.--Length- and age-frequency distributions of 1,293 largemouth bass from Whitmore Lake, spring of 1953

Total length in inches[1]	Age in completed winters													
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
6.0 - 6.4	1													
6.5 - 6.9	...													
7.0 - 7.4	1													
7.5 - 7.9		4												
8.0 - 8.4		6	1											
8.5 - 8.9		25	1											
9.0 - 9.4		41	3											
9.5 - 9.9		43	6	1										
10.0 - 10.4		31	10	...										
10.5 - 10.9		16	54	1										
11.0 - 11.4		1	97	2										
11.5 - 11.9			95	11										
12.0 - 12.4			119	26	3									
12.5 - 12.9			55	74	7									
13.0 - 13.4			17	82	7	1								
13.5 - 13.9			10	59	14	4								
14.0 - 14.4			...	18	41	18	2							
14.5 - 14.9			...	7	31	16	2							
15.0-15.4			1	3	22	22	11	1						
15.5 - 15.9				...	10	14	4	...						
16.0 - 16.4				1	3	20	8	...	1					
16.5 - 16.9					1	12	10	5	...					
17.0 - 17.4						5	10	4	2	1				
17.5 - 17.9							6	8	3	2	...			
18.0 - 18.4							3	6	2	1	...	...		
18.5 - 18.9							1	6	1	...	...	...	...	
19.0 - 19.4							1	4	1	3	...	...	...	...
19.5 - 19.9									...	1	...	1	...	1
20.0 - 20.4									1	2	...	...	1	2
20.5 - 20.9											...	...	...	...
21.0 - 21.4											1	...	...	...
Number	2	167	469	285	139	112	58	34	11	10	1	1	1	3
Mean length	6.60	9.54	11.73	13.12	14.41	15.39	16.46	17.86	18.03	18.81	21.0	19.5	20.0	19.93

[1] All lengths of fish were measured to the nearest 0.1 inch; and mean lengths were computed from the original measurements.

Table 6.--Length- and age-frequency distributions of 216 black crappies, and length-frequency distributions of yellow and brown bullheads, from Whitmore Lake, spring of 1953

Total length, inches	Black crappie					Yellow bullhead	Brown bullhead
	Age in completed winters						
	II	III	IV	V	VI		
4.9 - 5.1	2						
5.2 - 5.4	4						
5.5 - 5.7	4						
5.8 - 6.0	5					1	1
6.1 - 6.3	4					...	...
6.4 - 6.6	3					1	3
6.7 - 6.9	2					1	2
7.0 - 7.2	1					4	4
7.3 - 7.5	1	2				4	4
7.6 - 7.8		6				11	3
7.9 - 8.1		16				32	2
8.2 - 8.4		25				21	9
8.5 - 8.7		31				43	11
8.8 - 9.0		41				61	29
9.1 - 9.3		28				57	33
9.4 - 9.6		16				51	77
9.7 - 9.9		7	1			38	76
10.0 - 10.2		5	...			59	101
10.3 - 10.5		1	...			37	82
10.6 - 10.8		1	1			41	61
10.9 - 11.1			1			25	39
11.2 - 11.4			1	1		12	17
11.5 - 11.7				...		10	19
11.8 - 12.0				...		7	10
12.1 - 12.3				3		3	8
12.4 - 12.6				...	1	3	...
12.7 - 12.9				1	1	...	...
13.0 - 13.2						4	2
Total	26	179	4	5	2	526	593
Mean length	5.98	8.81	10.7	12.2	12.6	9.6	10.0

Table 7.--Length- and age-frequency distributions of 148 pumpkinseeds and 147 rock bass from Whitmore Lake, spring of 1953

Total length, inches	Age in completed winters								
	Rock bass					Pumpkinseed			
	III	IV	V	VI	VII,VIII, IX,X[1]	IV	V	VI	VII
4.2-4.3						4			
4.4-4.5	2					7			
4.6-4.7	...					12			
4.8-4.9	...					13			
5.0-5.1	3					13			
5.2-5.3	3	1				9			
5.4-5.5	2	6				9			
5.6-5.7		2				2	1		
5.8-5.9		2				8	...		
6.0-6.1		10				3	1		
6.2-6.3		15				5	2		
6.4-6.5		14	1			7	...	2	
6.6-6.7		16	...			3	1	2	
6.8-6.9		12	...			1	2	2	
7.0-7.1		19	...			3	4	4	
7.2-7.3		13	3				...	5	
7.4-7.5		5	...				1	4	
7.6-7.7		4	1				3	6	
7.8-7.9		...	1					5	1
8.0-8.1		1	...					...	1
8.2-8.3		1	1					1	
8.4-8.5			1					1	
8.6-8.7				2					
8.8-8.9									
9.0-9.1					1				
9.2-9.3					1				
9.4-9.5					1				
9.6-9.7				1	1				
9.8-9.9					1				
Total	10	121	8	3	1,1,2,1	99	15	32	2
Mean length	5.05	6.67	7.55	8.97	9.1-9.7	5.34	6.87	7.38	7.95

[1] Individual length records on older rock bass: VII, 9.1; VIII, 9.2; IX, 9.5, 9.9; X, 9.7.

Table 8.--Average total lengths in inches (upper figure) by age groups and age-frequency distributions (lower figure) of miscellaneous species from Whitmore Lake, spring of 1953

Age in completed winters	Warmouth	Northern pike	Yellow perch	Bowfin[1]	Mud pickerel	White sucker	Chub sucker	Smallmouth bass	Redhorse sp.	Carp
I	...	15.7	...	...	...	...				
	...	6	...	...	...	...				
II	...	21.6	...	...	...	...				
	...	19	...	...	...	...				
III	...	24.2	5.5	18.7	...	...	7.09			19.8
	...	45	1	18	...	...	17			5
IV	5.66	26.4	8.04	22.3	12.1	11.9	8.52	10.9		26.4
	8	4	5	12	3	8	13	1		1
V	6.39	26.4	8.93	24.9	...	17.1	9.12	16.7	15.0	
	8	3	3	3	...	11	5	1	1	
VI	7.17	26.7	9.3	23.9	...	17.9	9.55			
	3	2	1	5	...	4	2			
VII	...	24.8	...	25.5	...	18.4			17.2	
	...	1	...	1	...	12			1	
VIII	6.7	...	...	...	...	...				
	1	...	...	...	...	...				
Number of fish	20	80	10	39	3	35	37	2	1	6

[1] Age determinations on bowfin, from scale examinations, are tentative.

One of the main purposes of the present study was to compute the annual mortality rates for game species from age-frequency distributions of scale-sampled fish, and to resolve total annual mortality into angling mortality rate (from available creel census data) and natural mortality rate. Total mortality rate is the complement of survival rate which is computed from the formula of Ricker (1945):

$$s \text{ (survival)} = \frac{\ldots + \text{III} + \text{IV} + \text{V} + \ldots}{\ldots + \text{II} + \text{III} + \text{IV} + \ldots}$$

in which the numbers of fish in particular age groups are substituted for the corresponding year groups. The formula, when applied over the span of age groups represented among the data, gives a survival rate which is weighted according to numbers of fish. Use of the formula is based on the assumption that the age-frequency distribution of the samples is representative of the fish population in the lake both at the time of sampling and over a period of years. If a particular year class is unusually abundant, age-frequency data are needed over the period during which the abundant year class runs its course. The present data for Whitmore Lake are judged to be quite representative of legal-size fish in the lake during the year of 1953, as judged from the length-frequency and age-frequency data in Tables 4 to 8. For example, the trap nets caught bluegills abundantly down to a size of about five inches and an age of four years. Smaller and younger bluegills were taken infrequently, presumably because of limitations of the gear and not because of a scarcity of fish. On the basis of adequacy of sampling, the analysis of survival for the bluegill should be computed from data on Age-Groups IV to X. Correspondingly, for other species, survival should be based on Age-Groups IV to XV for the largemouth bass, III to VI for the black crappie, IV to VII for the pumpkinseed, IV to X for the rock bass, and II to VII for the northern pike.

But when survival rates are computed on the basis of these data, the results are far from realistic for the bluegill (survival rate 9.1 per cent), crappie (5.9), rock bass (17.8), northern pike (75.3), and possibly for the pumpkinseed (33.6); the considerable dominance of a particular age group is the cause. Survival rates computed for some of these same species from age-frequency data starting at one year younger in age are likewise unrealistic for the bluegill (99.6), black crappie (88.8), and rock bass (93.8), but in this case the computed figures are far too high. It means that a precise measure of annual mortality rate for legal-size bluegills, crappies, pumpkinseed, rock bass, and northern pike in Whitmore Lake will require age-frequency analyses and population data over a period of years while the dominant Age Groups III or IV are running their course; and such studies are planned.

For the present, a reasonable estimate of survival rate is available only for the largemouth bass (58.4), in which the age-frequency distribution of fish over three years of age was quite normal; and present estimates of angling and natural mortality rates are limited to this one species. From a total annual mortality rate of 41.6 per cent, and from a population figure of 4,532 fish representing what is left at the end of a year of mortality, total annual mortality is computed to be $41.6/58.4 \times 4,532 = 3,228$. During a complete year just prior to the spring of 1953, anglers took a computed 707 largemouth bass from the lake, according to creel census estimates provided by Mr. Christensen (Table 3). Angler harvest of bass for the year 1952 is thus computed to be only 22 per cent of the total mortality among legal-size bass in the lake. Not too much significance should be given to this figure (22 per cent) on rate of angling exploitation for bass in 1952; fishing intensity and the bass

catch on Whitmore were relatively low in 1952 as compared to 1953, and a population study planned for the spring of 1954 probably will show that the rate in 1953 was much higher than that in 1952 (see catch figures in Table 3).

Total angler harvest of principal species for the years 1952 and 1953 (excluding winter for 1953), from data supplied by Mr. Christensen, is given in Table 3.

Conditions of Population Estimate

The population estimate by the mark-and-recapture procedure is based on two assumptions: (1) that the population is not being altered during the field operations by either migration, mortality, or recruitment due to growth, and (2) that either the marked fish are distributed at random among unmarked fish, or the collecting is randomly distributed over the lake. In the present study, these requirements were met closely.

During the netting period there was no functional inlet or outlet to the lake. There was only a limited amount of fishing done during this spring period, and very few fish were removed by anglers. Observed natural mortality on the lake was extremely low. During the netting period, fish in the lake were making very little growth, as shown by an analysis for several species of average lengths of fish caught during the period of April 17 to 30 as compared to those caught during the period of May 1 to 19. The 729 IV-year-old bluegills taken in April averaged 6.36 ± 0.02 inches in length, whereas the 969 IV-year-olds taken in May averaged 6.18 ± 0.02. For the various age groups of large-mouth bass, May fish were not significantly longer than April fish--among IV-year-olds, as an example, 185 fish in April averaged 11.88 ± 0.06, whereas 284 fish in May averaged 11.64 ± 0.02. Furthermore, the scales

of these fish, upon microscopical examination, showed either no, or very little, growth for the spring of 1953.

Random distribution of marked fish over the lake was assured by the large number of randomly distributed netting sites over the lake and by the liberation of marked fish at the site of capture. Furthermore, the collecting was randomly distributed over the lake (Table 1, and previous discussion).

Trap-net catches as indices of population density

There is the question of how reliable trap-net catches might be for a direct estimate of population density. For example, if it proved to be true that trap nets of certain specifications consistently caught a certain percentage of the fish in a lake per given area, and if this percentage could be established, then trap-net catches subsequently could be used for a direct estimate of population density. Another possibility is that net catches per unit of net-effort and time-effort may be used (in fact, are being used by some fisheries workers) as indices of relative abundance in comparing different waters, different parts of a lake, etc. In either case, the degree of precision which can be obtained is a function of the number of net sets and the degree of variability of individual catches.

On Whitmore Lake the individual net catches were so variable as to offer little encouragement for pursuing the question beyond a perfunctory comment. The 168 over-night trap-net sets had a mean catch of 18.1 ± 3.09 legal-size bluegills, with a standard deviation of 40, and a maximum range of 0 to 293. For legal-size largemouth bass the mean was 8.2 ± 0.93 with a standard deviation of 12 and a range of 0 to 79. Similar data for legal-size fish of other species are:

	Mean catch per net	Standard deviation
Black crappie	1.5 ± 0.36	4.7
Pumpkinseed	0.5 ± 0.08	1.0
Rock bass	0.8 ± 0.12	1.6
Northern pike	0.5 ± 0.07	0.9
Yellow bullhead	3.5 ± 0.35	4.5
Brown bullhead	3.6 ± 0.42	5.5

The figures on population density per acre (in Table 3) could be divided by the above mean catches to give conversion factors for computing population per acre from trap net-catches, but the application of these conversion factors to mean catches of a relatively few net sets, or to catches made in other lakes, or even at other seasons on Whitmore Lake, would give highly questionable results. The same may be said for the use of mean catches as indices of relative abundance, in which the degree of precision would be little, if any, better.

The high degree of variability in net catches on Whitmore Lake was due to variability as related to depth of water, as related to date within the 33-day netting period (April 17 to May 19), as related to different geographical portions of the lake (Fig. 1), and as related, no doubt, to other factors such as type of bottom, abundance of vegetation, and other factors not considered in the present analyses. The mean catch per net and its standard deviation were computed for each species, legals and sub-legals separately, by 5-foot depth intervals, by three date intervals, and for four geographic areas of the lake. The data, in part, are given in Table 9. One of the unexplainable sources of variation was operating in the depth distribution of catches of legal-size bluegills which showed an affinity for consecutively alternate depth intervals from the 3-5 to the 30-35 interval; data for sub-legal bluegills (not included in the table) match the pattern for legal-size bluegills. Largemouth bass were most abundant in 5-10 feet of water and were progressively less

abundant in deeper water. Nets fished during the mid-part (April 28-May 8) of the netting period caught more fish than nets fished earlier (April 17-27) or later (May 9-19), presumably because of greater activity of fish during the mid-period. Certain species were more abundant in one particular "quarter" of the lake than in others, and this varied with time periods (Table 10). The bluegill was least abundant in the northwest quarter (NW 1/4) of the lake during the first time period, but the most abundant in this same quarter during the second time period; furthermore the bluegill was twice as abundant in the north half of the lake as compared to the south half, for the netting period as a whole. Sub-legal bluegills showed the same abundance pattern as the legals. The largemouth bass, in contrast to the bluegill, was two to three times as abundant in the southeast quarter of the lake as elsewhere during the first third of the netting period, but had distributed itself quite uniformly over the entire lake by the final third of the period. Among the averages given in Tables 9 and 10, in most cases the extreme differences within a given species are highly significant statistically.

Problems of sampling fish for studies of age and growth

In general practice, samples of fish for age and growth studies are collected by a variety of gear, to different degrees of sampling intensity, and with different degrees of geographical coverage over a body of water. That these factors are important in causing bias in samples is at least suspected by most fisheries workers, and is well illustrated by some of the Whitmore Lake data. The trap-net catches of III-year-old bluegills (Table 4) and of II-year-old largemouth bass (Table 5) obviously were biased numerically and probably also as to length distribution. But, more importantly, the Whitmore Lake data show other types of bias which might often be overlooked.

Table 9.--Catch of legal-size fish of principal species per net-day by trap nets in Whitmore Lake, April 17 to May 19, 1953, analyzed according to depth of water, geographical divisions of the lake (see Fig. 1), and subdivision of the netting period. M = mean catch per net-day; SD = standard deviation of catch per net-day

Water depth, ft.:		3-5	5-10	10-15	15-20	20-25	25-30	30-35
Number net sets :		48	52	22	16	13	12	5
Species								
Bluegill	M	32.3	6.7	28.8	2.6	18.3	3.3	36.2
	SD	43	13	68	3.6	42	6.4	79
Largemouth bass	M	7.8	13.3	6.7	5.1	3.8	1.5	1.4
	SD	11	17	7.1	7.5	5.8	2.3	3.1
Black crappie	M	1.8	1.9	1.4	0.2	0.8	0.8	0.8
	SD	7.5	3.8	3.2	0.4	1.3	2.0	1.8
Rock bass	M	1.8	0.6	0.3	0.3	0.4	0	0.6
	SD	2.6	0.8	0.7	0.6	0.8	0	0.9
Yellow bullhead	M	4.5	4.7	2.6	1.9	1.8	1.1	1.0
	SD	5.4	4.9	3.4	1.5	2.8	2.3	1.7
Brown bullhead	M	2.7	5.2	2.0	3.3	4.8	3.7	0
	SD	6.3	5.8	2.1	4.5	5.3	6.1	0
Geog. div.; date period:		NW 1/4	NE 1/4	SW 1/4	SE 1/4	Apr. 17-27	Apr. 28-May 8	May 9-19
Number net sets:		25	26	73	44	55	58	55
Bluegill	M	29.1	27.3	12.4	15.6	12.8	25.4	15.5
	SD	69	35	30	34	22	57	31
Largemouth bass	M	6.8	3.9	6.9	13.6	8.6	10.2	5.6
	SD	7.1	4.5	9.8	18	17	11	6.3
Black crappie	M	0.6	0.6	1.4	2.5	0.9	2.8	0.7
	SD	1.5	1.1	6.1	4.5	1.6	7.7	1.2
Rock bass	M	0.7	0.5	0.7	1.3	0.4	0.8	1.3
	SD	1.4	0.9	1.9	1.6	0.9	1.2	2.3
Yellow bullhead	M	2.4	4.2	2.7	5.1	2.3	3.9	4.3
	SD	3.1	3.9	4.1	5.6	3.8	4.4	5.0
Brown bullhead	M	1.4	4.4	2.8	5.8	4.4	4.2	2.2
	SD	2.3	6.2	4.3	7.2	6.7	5.3	4.0

Table 10.--Catch of principal fish species per net-day by trap nets in Whitmore Lake, spring of 1953, analyzing geographical divisions of the lake in relation to subdivisions of the netting period (A = Apr. 17-27, B = April 18-May 8, C = May 9-19) Av. = Average number of fish per net-day; SD = standard deviation of catch per net day

Species, and size	Division of netting period	Statistic	Geographical divisions of the lake, and number of net sets			
			NW 1/4	NE 1/4	SW 1/4	SE 1/4
	A	...	6	7	28	14
	B	...	10	10	20	18
	C	...	9	9	25	12
Bluegill, legal	A	Av.	4.7	23	10	16
		SD	7.4	23	25	19
	B	Av.	61	32	8.8	21
		SD	103	48	19	50
	C	Av.	9.7	26	18	7.4
		SD	15	28	41	12
Bluegill, sub-legal	A	Av.	1.5	4.6	4.1	6.4
		SD	2.1	4.8	8.0	13
	B	Av.	19	12	3.3	11
		SD	38	23	6.3	29
	C	Av.	7.2	10	9.4	3.5
		SD	9.3	15	13	5.8
Black crappie, legal	A	Av.	0.2	0.1	0.6	2.2
		SD	0.4	0.4	0.9	2.5
	B	Av.	1.3	0.4	3.6	3.9
		SD	2.1	0.5	12	6.3
	C	Av.	0.2	1.1	0.6	0.8
		SD	0.7	1.7	0.9	1.5
Rock bass, legal	A	Av.	0.2	0.4	0.2	0.9
		SD	0.4	1.1	0.4	1.3
	B	Av.	0.7	0.3	0.4	1.5
		SD	1.2	0.7	0.8	1.5
	C	Av.	1.1	0.7	1.6	1.4
		SD	2.0	0.9	2.9	1.9
Largemouth bass, legal	A	Av.	3.8	1.0	5.7	20
		SD	3.9	1.5	12	26
	B	Av.	8.6	5.0	10	14
		SD	6.2	5.4	9.7	15
	C	Av.	6.7	5.0	5.8	4.8
		SD	9.5	4.2	6.6	4.1
Largemouth bass, sub-legal	A	Av.	0.2	...	0.6	1.5
		SD	0.4	...	1.2	2.6
	B	Av.	1.1	1.5	0.3	0.4
		SD	1.9	2.8	0.5	0.7
	C	Av.	0.7	1.8	0.8	0.8
		SD	1.3	4.2	2.2	1.2
Yellow bullhead	A	Av.	0.8	1.7	1.4	5.1
		SD	1.3	2.0	1.5	6.5
	B	Av.	4.1	4.0	2.8	5.1
		SD	4.2	3.7	3.1	5.8
	C	Av.	1.4	6.4	4.2	5.1
		SD	1.2	4.3	5.9	4.6
Brown bullhead	A	Av.	1.3	3.3	2.8	9.5
		SD	1.6	6.3	3.4	10
	B	Av.	1.8	5.6	3.7	5.3
		SD	3.3	7.3	5.0	5.2
	C	Av.	1.1	4.0	2.0	2.1
		SD	1.4	5.1	4.6	2.5

One possibility is that age-frequency distribution might be related to depth. Among 1,293 trap-netted largemouth bass, 390 from 3 to 5 feet of water had a mean age of 4.79 ± 0.09 years, 148 from 10 to 15 feet of water had a mean age of 5.30 ± 0.15 years, 48 from 20 to 25 feet of water had a mean age of 5.73 ± 0.33 years; the first group is significantly different from the second and third. For the bass, considering all depth intervals, there was not a significant correlation between average age and depth, but a significant variation between certain intervals was found. Among 1,877 bluegills, the older fish were generally in the shallower water, a condition possibly related to the approach of the spawning season. Average ages of bluegills for the seven consecutive 5-foot depth intervals, starting with shallow water, were 4.28 ± 0.04, 4.54 ± 0.14, 4.22 ± 0.03, 4.04 ± 0.08, 4.11 ± 0.03, 4.00 ± 0, and 4.17 ± 0.04. The first three are significantly different from the last four. Likewise, for the bluegill, the mean ages of fish from the four geographic quarters of the lake were variable, with some statistically significant differences.

Among the 1,877 trap-netted bluegills on which age determinations were made, 1,698 (90 per cent) were in Age-Group IV. Their mean length was 6.26 ± 0.014 inches, range 4.6 to 7.8. The problem of adequate sampling is illustrated by one comparison which can be made for these IV-year-olds. The 729 fish collected during April 17-30 in 29 trap-net sets had an average length of 6.36 ± 0.021 inches, while the 969 IV-year-olds collected during May 1-19 in 23 trap-net sets had an average length of 6.18 ± 0.018; the difference between these two means is highly significant statistically ($t = 6.7$), although the amount of the difference is small. One possible explanation is that the IV-year-olds shrank in length appreciably during this period, but the more likely explanation is that the difference was due to sampling bias combined with significant

differences in the distribution over the lake of fast-growing and slow-growing IV-year-olds.

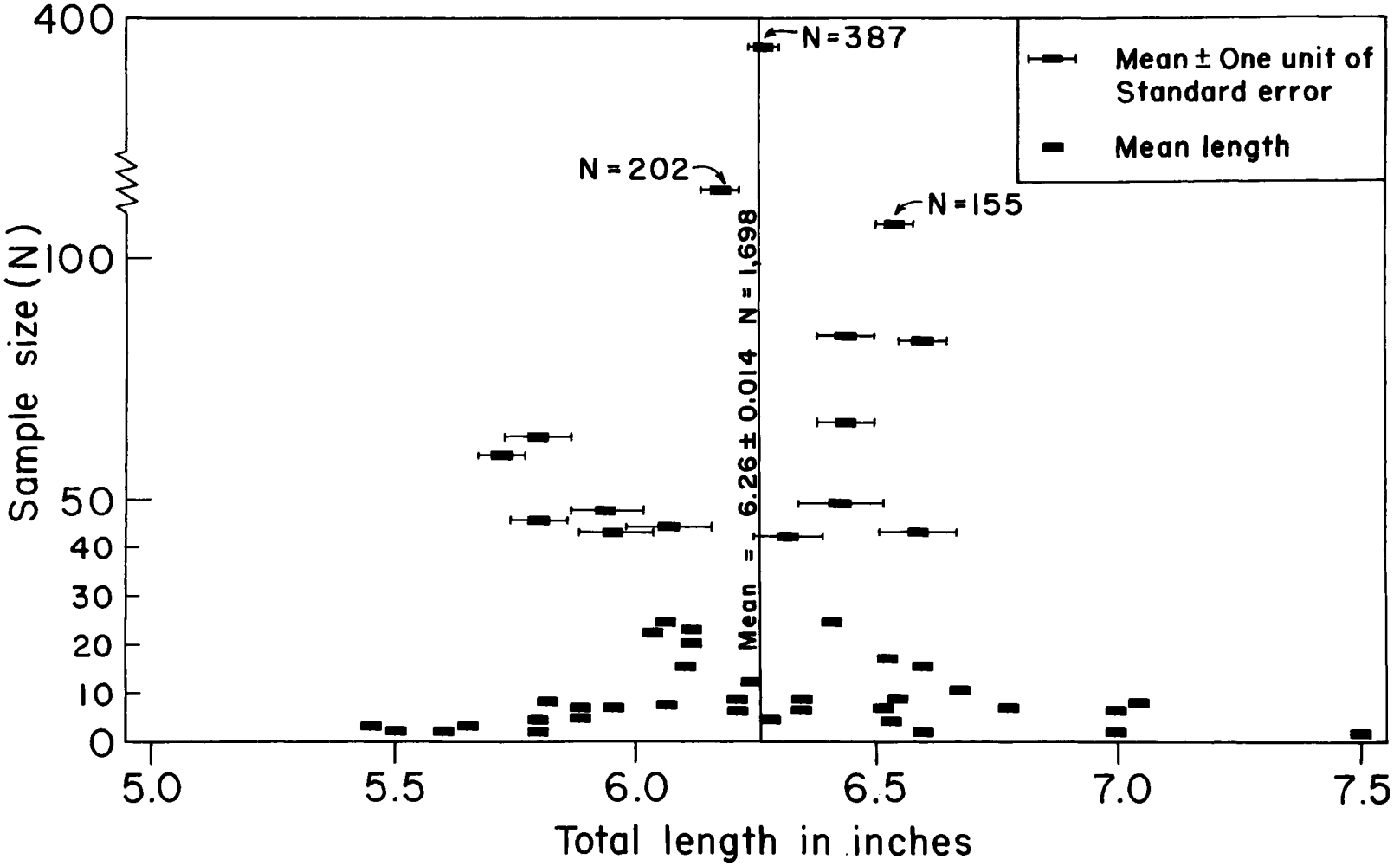
The 1,698 IV-year-olds were the combined total catch of 52 trap-net sets. Many of the 52 lots contained only one to five specimens, but many contained 40 or more. Among these lots of 40 or more specimens, the differences between sample means, and between a sample mean and the mean of the whole group, were, in many comparisons, highly significant statistically (Table 11 and Figure 2). The significance of this conclusion is that even if a numerically adequate sample is obtained from a lake (under circumstances similar to Whitmore), the sample will not necessarily give a true average for the lake as a whole if the sample was obtained entirely at one point in the lake. Collections from several places in the lake, representing good geographical and depth coverage, should be obtained and combined.

The conclusion is that the population of fish, by species, in a lake even as small as Whitmore (677 acres) is not distributed uniformly over the lake, even within a particular year class of one species. Rather there appear to be significant differences not only in abundance but in age- and size-frequency distributions within a given species. These differences were found to be related to depth of water and geographical locations on the lake, but the differences are probably primarily related to food, cover, and other factors vital to the fish.

Table 11.--Average lengths of IV-year-old bluegills in 52 trap-net samples, Whitmore Lake, spring of 1953. Average length includes the standard error

Net station number	Date	Sample size	Average length, inches	Range in length, inches
3	April 17	2	5.65 ± 0.35	5.3 - 6.0
7	18	15	6.60 ± 0.18	5.5 - 7.8
9	18	20	6.13 ± 0.18	4.6 - 7.7
16	19	4	6.23 ± 0.27	5.6 - 6.8
20	19	4	5.95 ± 0.15	5.6 - 7.2
22	20	17	6.25 ± 0.10	5.2 - 6.7
25	20	49	6.43 ± 0.09	5.1 - 7.6
29	21	1	7.00	7.0
33	21	3	5.87 ± 0.28	5.3 - 6.2
38	22	4	5.83 ± 0.31	5.2 - 6.6
42	22	2	5.45 ± 0.55	4.9 - 6.0
44	23	3	5.87 ± 0.03	5.8 - 5.9
51	23	4	7.00 ± 0.45	5.7 - 7.8
128	24	43	6.59 ± 0.08	5.3 - 7.6
55	24	7	6.06 ± 0.18	5.4 - 6.8
60	25	4	7.08 ± 0.28	6.5 - 7.6
63	25	1	5.60	5.6
64	25	83	6.60 ± 0.05	5.6 - 7.6
67	26	24	6.42 ± 0.12	5.3 - 7.6
70	26	17	6.54 ± 0.11	5.6 - 7.2
75	27	15	6.11 ± 0.12	5.3 - 7.0
79	27	4	6.78 ± 0.13	6.4 - 7.0
82	28	4	6.53 ± 0.46	5.7 - 7.6
86	28	202	6.18 ± 0.04	5.0 - 7.5
90	29	1	5.80	5.8
91	29	4	6.35 ± 0.16	6.1 - 6.8
92	29	84	6.44 ± 0.06	5.5 - 7.8
96	30	42	6.32 ± 0.07	5.5 - 7.4
97	30	66	6.44 ± 0.06	5.5 - 7.5
101	May 1	5	6.34 ± 0.22	5.8 - 6.9
104	1	3	6.27 ± 0.15	6.0 - 6.5
112	2	387	6.27 ± 0.03	4.9 - 7.6
115	3	155	6.54 ± 0.04	5.5 - 7.8
121	4	10	6.67 ± 0.14	6.0 - 7.3
124	5	3	6.57 ± 0.44	5.7 - 7.1
130	5	1	6.60	6.6
138	6	13	6.25 ± 0.15	5.3 - 7.2
147	8	1	7.50	7.5
151	8	4	6.53 ± 0.24	6.1 - 7.2
155	9	1	5.50	5.5
162	9	44	6.07 ± 0.09	4.9 - 7.6
165	10	59	5.72 ± 0.05	4.8 - 6.6
187	12	45	5.80 ± 0.06	4.9 - 6.9
198	13	8	6.55 ± 0.22	5.7 - 7.3
206	14	1	5.80	5.8
218	15	9	6.21 ± 0.18	5.6 - 7.0
220	16	45	5.94 ± 0.08	5.1 - 7.4
78	17	24	6.06 ± 0.08	5.3 - 6.8
232	18	43	5.96 ± 0.08	4.8 - 7.0
233	18	23	6.04 ± 0.09	5.5 - 6.7
235	19	22	6.13 ± 0.14	4.9 - 7.4
236	19	63	5.80 ± 0.07	5.0 - 7.5
Totals	...	1,698	6.26 ± 0.014	4.6 - 7.8

Fig. 2. Average lengths of IV-year-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 the 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)
N=387
N=202
N=155
Mean ± One unit of Standard error
Mean length
Mean = 6.26 ± 0.014 N = 1,698
5.0
5.5
6.0
6.5
7.0
7.5
Total length in inches

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INSTITUTE FOR FISHERIES RESEARCH

Gerald P. Cooper and Robert N. Schaefer

Report approved by: A. S. Hazzard

Report typed by: P. R. Darling