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TECHNICAL REPORT

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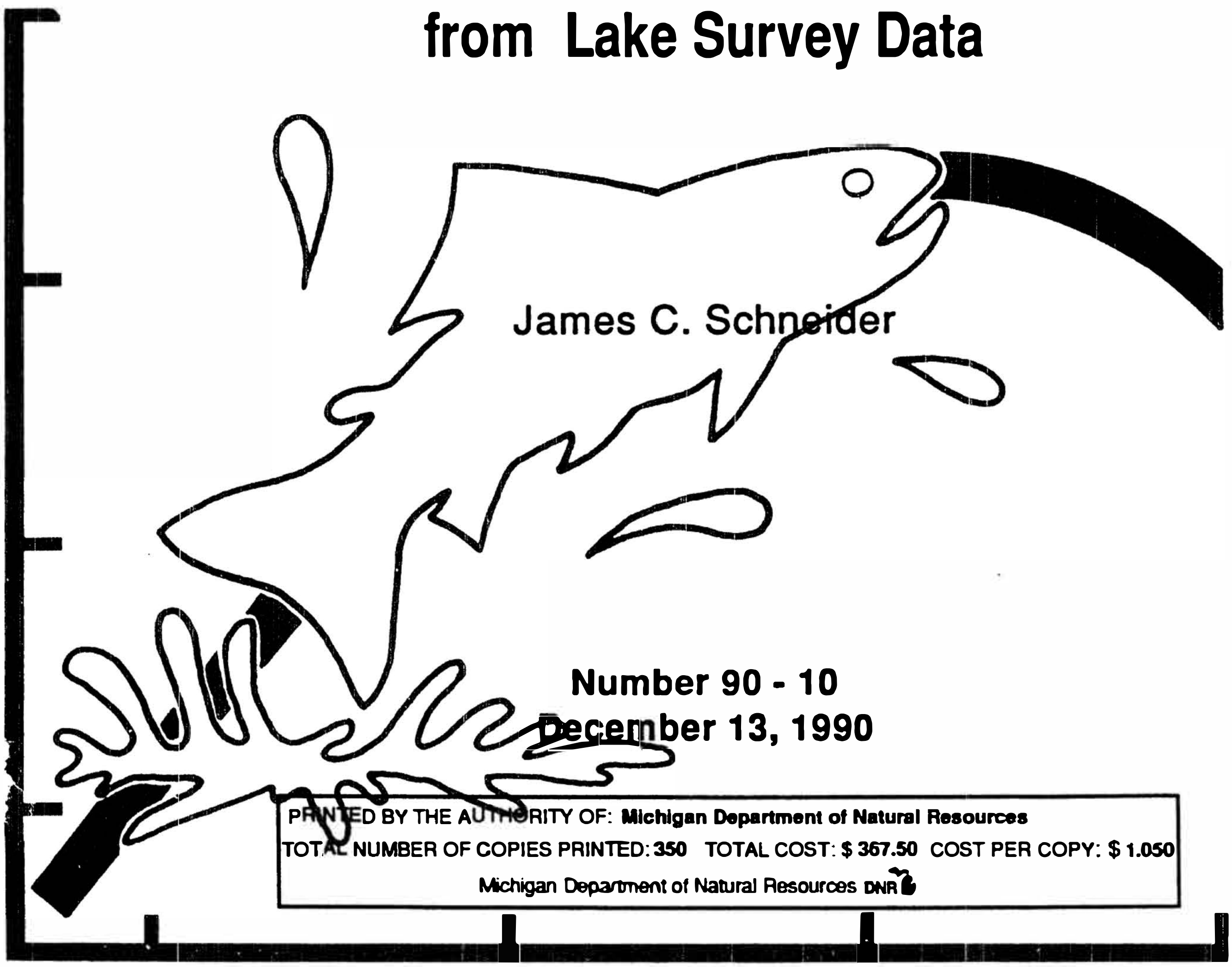

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CLASSIFYING BLUEGILL POPULATIONS FROM LAKE SURVEY DATA[1]

James C. Schneider

[1]A contribution from Dingell-Johnson Project F-35-R, Michigan.

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Classifying Bluegill Populations from Lake Survey Data

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Abstract.—I present a scoring and ranking system for interpreting length-frequency samples of bluegill populations and comparing samples taken with various types of sampling gear. Gear considered are trap and fyke nets, large seines, and boom shockers. Gear-specific standards are presented for four indices of length-frequency distribution: average length, % >6.0 inches, % >7.0 inches, and % >8.0 inches. In addition, these are combined into "size score" (SS), a single index of a bluegill population's size distribution. Values for each index are scored on a scale from 1 to 7, in which 1 represents an extreme preponderance of small bluegills, 3-4 is average for Michigan populations, and 7 represents a rare preponderance of large bluegills. Growth index is also matched to the 1-7 scale to provide "growth score" (GS). The system has been satisfactorily applied to samples from 303 lakes. Examples from 129 lakes are given to show its utility for classifying bluegill populations and interpreting trends from meager historic data.

Over the years Michigan biologists have used a wide variety of gear types to sample fish populations in lakes. In the 1930s, 1940s, and 1950s, the primary sampling tools were small seines, experimental-mesh gill nets, and angling. Use of trap nets began in the 1950s and use of fyke nets began in the 1960s. Large, winch-pulled seines (800-1,600 feet long) were used extensively from 1958 to 1964, then discontinued. Electrofishing boom shockers were developed during the 1960s and have mostly replaced seines. Small-mesh fyke and trap nets have received some use in recent years. Rotenone and other toxicants have, in a sense, been used to sample fish but their use has been limited to poor or unusual communities so will not be considered here.

Each gear type is selective as to species, size, and season and none gives an unbiased sample of the total fish community, as pointed out by Merna et al. (1981). Consequently, a system is needed for objectively interpreting survey catches and for making comparisons across gear types. This becomes especially important when monitoring long-term population trends or when classifying lakes into similar groups for management or research purposes (Schneider 1989).

While it was the goal of most lake surveys to sample all species and all sizes present in the lake, often the bluegill population was the only one adequately sampled. Bluegill catches were usually adequate because the bluegill is relatively abundant in most lakes. Furthermore, the bluegill was targeted for sampling (and properly so) because of its key role in determining community structure and overall sportfishing quality (Schneider 1981).

Interpreting the length-frequency data from these surveys is also difficult. First, on certain reporting forms the length groups were too broad; consequently, the data have been forever pooled. Second, the data were biased towards larger fish due to size selectivity of the gear. These problems preclude rigorous statistical analysis or application of one of the length categorization systems developed during the 1970s and 1980s (Anderson and Gutreuter 1983; Gablehouse 1984). For bluegills, for example, these systems require that the proportion of the catch sample larger than 3.0, 6.0, 8.0, 10.0, and 12.0 inches be known and recorded. More importantly, they require that a relatively unbiased sampling gear be used to collect the sample so that bluegills larger than 3.0 inches are represented in proportion to their true relative abundance. Electrofishing is considered to be the standard gear for these categorization systems, but it too has some bias. In Michigan, many samples have been collected with trap or fyke nets made of 1.5-inch (stretched) webbing. These nets do not take representative samples of 3- to 5-inch bluegills but sample 8-inch and larger bluegills very well (Latta 1959; Laarman and Ryckman 1980). These nets continue to be the best tool for sampling adult bluegill populations.

The purpose of this report is to present a system for comparing and interpreting samples of bluegill populations collected with gear types which historically have been used in Michigan. This system was developed and applied in Dingell-Johnson Study 624 (Schneider 1989).

Important Bluegill Population Characteristics

The following bluegill population characteristics provide useful insights and some or all of them can be derived from historical survey records:

1. *Length frequency.*—The correlation between the abundance of large bluegills and the quality of fishing is obvious, but no one index of length frequency has been satisfactory to date. Proposed here is "size score" (SS), which is an average based on the following four indices of length frequency:

   a) Percentage of the catch larger than 6.0 inches in length (% >6"). A 6-inch bluegill has traditionally been considered to be the minimum size desired by anglers. However, this index does not always reflect the presence or absence of more desirable larger bluegills. This index is labeled "%LA" on the survey form currently in use.

   b) Percentage of the catch larger than 7.0 inches (% >7"). The relative frequency of 7-inch bluegills is a better index of fishing quality, but it cannot be derived from some old survey forms.

   c) Percentage of catch larger than 8.0 inches (% >8"). The presence of any bluegills this large usually signals good fishing (Schneider 1981). It is the most useful indicator for interpreting meager information about maximum size, as might be obtained from length-range data, creel census, and reports from anglers.

   d) Average length of catch (Avg L). This has been traditionally reported on old survey forms but contains less useful information about size range and the presence of large bluegills than a, b, or c.

2. *Growth.*—The relative abundance of large fish in the population and the quality of fishing are mainly determined by the growth rate of individual fish. A very useful growth index (GI) was defined by Merna et al. (1981) as the average deviation of average length at age from the seasonal state average. Growth rates close to or above the state average (GI ≥0) usually result in desirable length-frequency distributions that contain large bluegills. However, there are some blue-

gill populations with satisfactory growth which produce no large bluegills, apparently because their mortality rate is above normal and the fish simply do not live long enough to grow to a large size. Conversely, there are some populations in which growth is relatively poor yet produce some 8-inch bluegills, apparently because their mortality rate is below normal. Proposed here is that growth indices also be ranked ("growth score", GS) to correspond to the proposed ranking system for length-frequency indices.

A Classification System

A scoring system was devised for each of the population indices described above—growth and the four indices of length frequency (Table 1). A score of 1 was the poorest possible, a score of 7 was the highest, and scores of 3 to 4 represented average bluegill populations. The length-frequency portion of Table 1 is subdivided according to two major gear types to compensate for gear size selectivity, as discussed below.

A system of ranking adjectives corresponding to the numerical scores has also been suggested in Table 1. These range from "very poor" up to "superior". The adjectives are more readily understood than the score numbers when describing to the public how the quality of one bluegill population compares to this standard and to other populations.

A single index of size structure, the size score (SS) may be obtained by averaging the four size scores. However, in some populations there may be meaningful patterns within the size scores which could be obscured by averaging. For most populations the four scores will be similar.

Break points between the scores were determined by trial and error. The goal was to obtain as much consistency in scoring as possible, first within the four indices of length frequency for each sample, then among samples taken with each gear type, then across gear types. Seven levels of scores were eventually recognized, mainly because seven divisions seemed to give a natural symmetry to the break points for the Avg L scale, and more levels (e.g., 10) would have implied an unrealistic degree of precision could be extracted from these data. Only bluegill populations likely to be in "equilibrium" (i.e., not thinned prior to sampling) were considered when establishing Table 1.

Obtaining consistency in scoring across gear types was difficult because no populations had been simultaneously sampled with all types of gear. However, many populations have been sampled with two types of gear at about the same time. The best data set was for Mill Lake, which was sampled with three types of gear (Figure 1). Shown are the size selectivity of electroshocker, seine, and trap net compared to an unbiased length-frequency distribution derived from mark-recapture population estimates. Other problems in comparing across gear types were reconciling differences in mesh size (sometimes unspecified in the records) and standardizing the effort made to pick up small bluegills during electrofishing. In addition, electrofishing samples can be greatly effected by time of day and season.

Balancing precision against practicality, two major gear types were eventually recognized. Standard trap nets and fyke nets (1.5-inch stretch mesh in the pots) give similar length-frequency distributions (skewed toward large fish), and large seines and electrofishing give similar length-frequency distributions (skewed towards small fish). Small seines catch so few desirable-sized bluegills that their data are not useful for rigorous analysis, but they may confirm the presence (but not the absence) of large fish. Gill nets rarely catch enough bluegills of any size to give a good sample but seem to be biased toward large bluegills; consequently the scale used for trap- and fyke-net samples is also appropriate for gill-net samples. Fyke or trap nets with small mesh (typically 0.75-inch stretched-mesh pots) usually yield samples similar to electrofishing samples.

If one or two of these length-frequency scores is unknown because of missing data, compute the SS from the known scores (using the appropriate denominator) to salvage some information.

Note that failure to capture 8-inch or larger bluegills may reflect either that large bluegills were really absent from the lake, or that large bluegills were present but were missed by the sampling. Large bluegills are relatively rare in most lakes and, by chance, may not show up in samples of less than 1,000 fish. Therefore, a score of 2 should be arbitrarily assigned if % >8" is less than 0.1%. Since this score will be averaged in with the scores for the three other length indices to obtain SS, no important bias will be introduced. Consequently, SS can range from 1.2 to 7.0 for typical sample sizes.

Also shown in Table 1 is the relationship of the growth index to the scoring and ranking system. For example, a growth index of -0.3 inches would have a growth score of 3 (rank of "acceptable"), and would likely occur in a bluegill population with size score of 3. Size scores and growth scores should not be averaged together. Discrepancies between them provide evidence for unusually high or low mortality rates, as discussed above and below, and may aid in diagnosing problems.

An Example

To illustrate the use of Table 1, a bluegill population well sampled with all types of gear might give the following length-frequency indices:

Trap-net, fyke-net, or gill-net samples—Avg L = 6.2 inches; % >6"= 60; % > 7"=15; % >8"=0.5.

Electroshocker, large seine, or small-mesh fyke net samples—Avg L = 5.0 inches; % >6" = 22; % >7"= 3.2; % >8"=0.3.

And the growth index for this population might have been +0.2.

Corresponding scores are "3" for electroshocker % >7" and "4" for each of the other indices. Such minor sampling variation is to be expected. These scores clearly indicate a bluegill population with "satisfactory", average, characteristics.

Size score (an average) is calculated from the equation:

$$SS = \frac{[(Avg\ L\ score) + (\%>6''\ score) + (\%>7''\ score) + (\%>8''\ score)]}{4}$$

Ordinarily by gear type, as follows:

$$SS\ for\ trap\ net,\ etc. = \frac{(4+4+4+4)}{4} = 4.0$$

$$SS\ for\ electroshocker,\ etc. = \frac{(4+4+3+4)}{4} = 3.8$$

Statistical Analyses

Lakes which had been sampled with two or more types of gear were analyzed to confirm if similar scores would be obtained for each gear. Rarely were the samples taken concurrently. Therefore, to increase the number of comparisons, samples taken when the population appeared to be in the same steady state (unperturbed for at least 7 years) were also used. Even so, the number of comparisons which could be used was meager.

The system performed satisfactorily. It did not seem to contain systematic bias and was judged as accurate and practical as the quality of the data would allow. For 39 comparisons of samples taken with either trap net or fyke net to samples taken with electroshocking, size scores were within 0.9 units for 69% of them. For 16 comparisons of either trap net or fyke net to seine, size scores were within 0.9 units for 62% of them. For nine comparisons of electroshocking to seine, size scores were within 0.9 units for 88% of them. The other comparisons had five or fewer pairs of data and were of little value. Overall, for 62 comparisons of gear selective for large bluegills to gear selective for small bluegills, the correlation between size scores was 0.72.

Other statistical characteristics of the scoring system were examined for samples collected with various types of gear from 303 lakes. One sample was selected from each lake for analyses of correlation and frequency.

of a steady-state bluegill population (no known fish kills or environmental disturbances within 7 years prior to the sample), and was either the most recent or the most complete sample available in the files.

Correlations among indices of size and growth were not as strong as expected considering the redundancy built into the size indices (Table 2). For example, average length was a mediocre predictor of the proportion of large bluegills (r = 0.49 between Avg L score and % >8" score). This confirms that each length index contains some unique and valuable information, and their average (SS) integrates that fairly. Also, growth score (which was perfectly correlated to growth index) was not highly correlated to the length indices (r = 0.36 to 0.55). The unexplained variation is attributed to differences in mortality rates among populations and to sampling variation.

Similar correlation analyses, using both raw data and scores, were made on subsets of lakes which had been sampled with only one type of gear. The conclusions from those analyses were the same as for the pooled sample of 303 lakes.

The frequency analysis of the samples from 303 lakes indicated the system performed satisfactorily overall. However, scores of 1 were too common for % >7" and % >8", and this caused skewing in the distribution of their scores. This was due to the unavoidable statistical problem of dealing with zero catches, and to the high proportion of poor bluegill lakes in the samples.

Unfortunately, this sample of 303 lakes cannot serve as a good standard for all Michigan bluegill populations because it is skewed towards poor populations. Although a wide range of populations was represented, GI averaged -0.3 (instead of 0.0, the accepted Michigan average) and SS averaged 3.3 (instead of 4.0, the center of the scale). The sample contains a high proportion of poor lakes because (1) it includes lakes selected for other research because they had a poor reputation and (2) most management surveys are conducted in response to complaints of poor fishing. The latter makes it impossible to confidently obtain a true random sample of Michigan bluegill populations from file data. Given these qualifications, the percentile distributions below may provide some guidance for comparing lakes:

Percentile	SS
5	1.3
10	1.5
25	2.0
50	3.0
75	4.3
90	5.3
95	6.0

That is, 50% of the 303 lakes had a size score of 3.0 or below.

Application and Discussion

Table 3 shows the application of the system to a sample of 129 lakes. For some lakes, data are presented by gear types and year to show variability; for other lakes, samples are pooled to show the norm for the lake.

The full range in bluegill population quality is represented by the examples in Table 3. Algonquin Lake is one of many lakes with a very poor bluegill population; its size scores are always close to 1.6 and it rarely contains bluegills as large as 7.0 inches. Houghton Lake, as most observers would agree, contains excellent bluegills (SS = 6.0). Blueberry Lake has a superior population with a SS close to 7. It contains extremely high proportions (67% by trap net) of 8.0- to 8.9-inch bluegills (but very few larger than that). Growth scores for these lakes show the same trend: 1-2 for Algonquin Lake, 4 for Houghton Lake, and 5 for Blueberry Lake. (Note: The GS for Blueberry Lake is not as high as expected because a unique pattern of very rapid growth for ages 0 to 5 is averaged against very slow growth for ages 6 to 12).

Bankson Lake illustrates a population which declined from satisfactory (SS = 4.2) in 1962 to very poor (SS = 1.5) in 1986. This change in length distribution was paralleled by declining growth (GS declined from 3 to 1) and complaints about fishing quality.

and complaints about fishing quality. Conversely, Garver Lake improved between 1962 (SS = 2.0 and GS = 3) and 1985 (SS = 4.7 and GS = 4).

This scoring system also provides an objective method for evaluating effects of fisheries management on bluegill populations. Shown in Table 4 is a 27-year series of data collected at Long Lake, which was treated with antimycin in 1977 to thin a stunted bluegill population. The SS's and GS's indicate the "poor" bluegill population which existed from 1963-76 (scores 1 to 2.7) improved to "acceptable" in 1978-82 (scores mostly 3 to 3.5). The 1986 sample indicated size structure and growth had deteriorated (SS = 1.5 and GS = 1); however, the 1990 sample had acceptable size structure but very poor growth. Given such poor growth, it is likely that small bluegills will soon become a problem and additional management will be needed. Even so, treatment benefits were evident for a relatively long period—about 7 years.

The scoring system aided this analysis of trends because it enabled catches from a variety of gear types to be compared. In addition, the analysis indicates the improvement was primarily in average size and proportions of 6-inch fish, rather than in proportions of 8-inch fish.

Many other examples of applying the ranking system to monitoring long-term population trends may be found elsewhere (Schneider 1989).

Some of the more extreme sampling variability which may be encountered is illustrated by collections made at Big Pine Island Lake in 1961. A SS = 1.2 was derived from trap-net and fyke-net samples and a SS = 2.5 was derived from large-seine samples. While the difference seems rather large, the conclusion is still the same: the bluegill population was undesirable.

The value of using four length-frequency characteristics is illustrated by two surveys at Big Blue Lake for which some data are missing. Only average lengths were reported, and those were scored at 4 and 6. No other length information was given except that contained in the ranges on the Fish Growth Analysis form. It can deduced that one or more bluegills larger than 8.9 inches were collected and scale sampled. Consequently, the % >8 inches scores had to be 4 or more. The SS is thus in the healthy 4-5 range and is consistent with the 1978 GS of 4.

This system may also be used to generalize the results of several surveys by focusing on ranges and medians in scores. For example, at Big Whitefish Lake length-frequency ranks ranged between 2 and 6 over a 20-year period. This probably reflects natural population fluctuations and sampling variability because no change in growth was detected. The median scores, SS = 4 and GS = 3, indicate the population is close to average. At Lakeville Lake, however, the conclusion from 12 years of surveys is that scores were mostly below satisfactory, varying from 1 to 4 with a median SS of about 2.5, and the lake may be a promising candidate for corrective management.

Insights may be gained by comparing the four length scores derived from a sample with each other. A number of lakes (e.g., Clear and Crispell) show a pattern in which the scores for Avg L and % >6 inches are higher than the scores for % >7 inches and % >8 inches. That is, relative to the frequency of 6-inch bluegills, these lakes contained lower than expected proportions of large bluegills. Most likely, this is caused by a slowing of growth after the bluegills reach 6 inches in length, a type of "stunting". Another possible explanation is that a large year class is moving through the population which, at that point in time, is clustered around 6 inches.

Differences in mortality rate may be implied from inconsistencies between length indices and growth indices. For example, Mill Lake bluegills had relatively slow growth (GS = 2 and GI = -0.6), yet the lake produced favorable proportions of bluegills larger than 7 and 8 inches (scores = 4 and 5, respectively). Sand Lake bluegills (Newaygo County, 1984-87) had better growth (GS = 3 and GI = -0.4) but this lake rarely contained bluegills as large as 7 inches (% 7" score = 1). This implies that the mortality rate of adult bluegills was relatively low at Mill Lake and relatively high at Sand Lake, and might indicate differences in fishing or natural mortality.

This scoring and ranking system has several advantages over published length categorization systems (Anderson and Gutreuter 1953; Gablehouse 1984). First, data from trap nets, which do not catch bluegills as small as 3.0 inches ("stock size") can be interpreted and compared to other types of gear. Second, size distribution can be expressed in one index (SS), the best single expression of the information contained in the four component indices. A comparison among the four component indices provides additional information. Third, missing data can be handled in a systematic way.

Disadvantages of this system include the potential for high variation in the electrofishing catches of small bluegills (less than 3.0 inches) to bias the calculations. In addition, some might argue that the establishment of break points and ranks was, by necessity, somewhat subjective. However, the ranking of "quality" will always have personal overtones and lack rigorous definition and complete consensus.

Two final comments. First, this scoring system provides a way of ranking bluegill population quality but not quantity. For example, many northern lakes have a favorable ratio of large to small bluegills but have insignificant bluegill populations. Other species are more abundant and they dictate the overall character of the fishery. Second, the system rests on the assumption that a representative sample of the population's length-frequency distribution was obtained by the sampling gear. Electrofishing surveys in which small bluegills are ignored and only large bluegills are picked up obviously violate this assumption. At the other extreme, daytime electrofishing surveys in which small bluegills are targeted will give scores which are too low. More subtly, differences in distribution and movement among small, medium, and large bluegills on any given day might bias net or electroshocking catches one way or another. This bias can be compensated for to some extent by conducting surveys over two or more days/nights and by varying sampling gear and season. Spring and fall, when large bluegills are most likely to be inshore, are the preferred sampling seasons. As always, the final interpretation of survey and ranking results must be tempered with practical judgement as to whether or not the sample was truly representative.

Management Recommendations

I encourage managers to test this system. Comments regarding the location of the break points and the utility of the system for interpreting surveys and making management decisions would be appreciated. If this system proves to be useful, it could be incorporated into the Manual of Fisheries Survey Methods.

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Gary Towns, Jan Fenske, and James Breck reviewed the manuscript and provided many helpful suggestions.

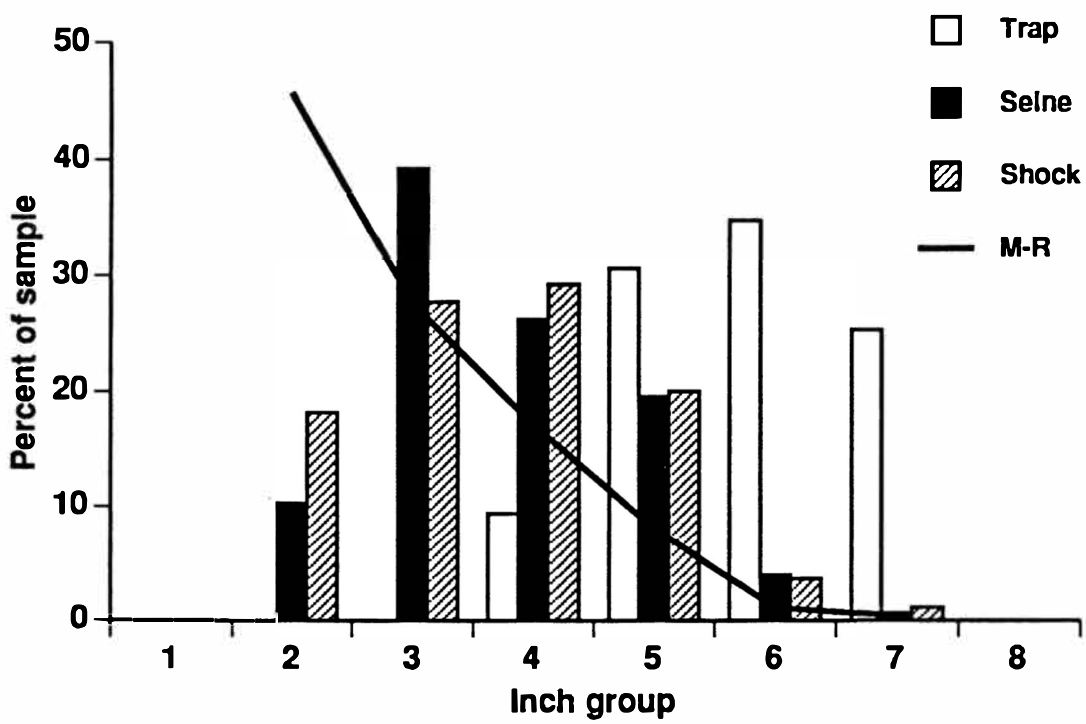

Figure 1.—Bluegill length-frequency distributions in samples taken by 230-volt AC boom shocker, 800-foot seine (with 1-inch stretched-mesh pot) and trap net (with 1.5-inch stretched-mesh pot). The actual length distribution, based on mark-recapture (M-R) population estimates, is shown as a curve to illustrate gear size selectivity. Samples were taken from Mill Lake in fall 1969 (Schneider 1971 and unpublished data). Number of bluegills sampled were 4,267 by electroshocker (10 trips), 5,038 by seine (8 hauls), and 170 by trap net (42 lifts).

Table 1.—Scores (1-7) for five indices of bluegill population characteristics obtained during lake surveys. The four length indices are given for two basic gear types; growth index is independent of gear type. Also given are ranks (very poor to superior) corresponding to the scores.

		Trap net or fyke net[a]				Shocker or large seine[b]				Growth
Rank	Score	Avg L[d]	% >6"[e]	% >7"[f]	% >8"[g]	Avg L	% >6"	% >7"	% >8"	index[c]
Very poor	1	<5.0	0-9	0-1.9	<0.1	<3.8	0-3	0-0.7	<0.1	<-1.0
Poor	2	5.0-5.4	10-24	2-4	<0.1	3.8-4.2	4-8	0.8-1.7	<0.1	-1.0 to -0.6
Acceptable	3	5.5-5.9	25-49	5-9	<0.1	4.3-4.7	9-17	1.8-3.3	<0.1	-0.5 to -0.1
Satisfactory	4	6.0-6.4	50-74	10-29	0.1-0.9	4.8-5.2	18-29	3.3-9.9	0.1-0.9	0 to 0.4
Good	5	6.5-6.9	75-85	30-49	1-9	5.3-5.7	30-39	10-24	1.0-2.9	0.5 to 0.9
Excellent	6	7.0-7.5	86-95	50-79	10-39	5.8-6.2	40-49	25-39	3-19	1.0 to 1.4
Superior	7	≥7.6	≥96	≥80	≥40	≥6.3	≥50	≥40	≥20	≥1.5

[a]Impounding nets with 1.5-inch stretched mesh in pots; also gill nets.

[b]Boom shockers or large seines; also fyke or trap nets with small mesh.

[c]Average deviation (inches) from the seasonal state average length at age (GI).

[d]Average length of catch in inches.

[e-g]Percent of catch greater than 6.0, 7.0, and 8.0 inches in length, respectively.

Directions for use: Determine a score of 1 to 7 for each index. (If the percent of the catch greater than 8 inches is <0.1, then its score = 2). Then compute "size score" (SS) by averaging the scores for average length (Avg L), percent over 6 inches (% >6"), percent over 7 inches (% >7"), and percent over 8 inches (% >8"). If one or two of the length scores is unknown because of missing data, compute SS by averaging the known scores.

Example: Sugarloaf Lake, Washtenaw County, was sampled by electrofishing in 1977 (Table 2). Indices were: Avg L = 5.2", % >6" = 48, % >7" = 15, % >8" = ? (not required on old form). Corresponding scores derived from Table 1 are: Avg L = 4, % >6" = 6, % >7" = 5, % >8" = ? The SS (4 + 6 + 5)/3 = 5.0.

Table 2.—Correlations (*r*) among the scores for length and growth indices based on bluegill samples from 303 lakes. All are statistically significant at $P = \leq 0.01$.

	Avg L	% >6"	% >7"	% >8"	SS
Avg L	—				
% >6"	0.78	—			
% >7"	0.67	0.82	—		
% >8	0.49	0.59	0.79	—	
SS	0.84	0.94	0.94	0.81	—
GS	0.36	0.49	0.54	0.54	0.55

Table 3.—Examples of classifying bluegill populations in 129 Michigan lakes from length-frequency and growth indices obtained during surveys using a variety of gear.

Lake and (county)	Gear[a]	Size score (SS)	Length indices[b]: Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Algonquin (Barry)	sn,es	1.6	3.0-4.3	2-3	1-2	1	0-0.1	1	0	2	-0.9 to -1.6	1-2	58,64,81
Allens (Lenawee)	tn,fn	5.1	6.5-6.7	5	83-91	5-6	31-40	5	4	5	+0.3	4	76,84
Baptist (Newaygo)	sn,es	1.6	4.1-4.4	2-3	0-1	1	0	1	0	2	-1.6 to -2.0	1	57,58,67
	tn,fn	1.2	4.3-4.8	1	7-8	1	0.9-1.3	1	0	2	-1.2	1	85,87
Bankson (Van Buren)	sn	4.2	5.2	4	22	4	20	5	0.1	4	-0.3	3	62
	tn,fn	1.5	5.0	2	5	1	0	1	0	1	-1.2	1	86
Barnes (Lapeer)	es	1.8	3.5	1	13	3	0	1	0	1			70
Baseline (Allegan)	es	2.1	3.9-5.0	2-4	0.2-10	1-3	0-1.0	1-2	0	2	-0.5 to -0.8	2-3	59,75,79
Bass (Kent)	tn	2.2	5.0	2	23	2	5.5	3	0	2	-1.0	2	80
	sn,es	1.9	4.0-4.6	2-3	4-6	2	0.5-0.7	1	0	2	-1.1 to -2.5	1	83,57
Baw Beese (Hillsdale)	es	4.0	5.0	4	26	4	6	4	0.7	4	-0.2	3	82
Bear (Hillsdale)	tn	6.0	7.2	6	93	6	66	6	15	6	+0.6	5	87
Belleville (Wayne)	tn,fn	5.8	7.0	6	93	6	59	6	1.2	5	+1.7	7	82
Big (Oakland)	tn	1.2	4.9	1	1	1	0	1	0	2	-0.7	2	85
Big Blue (Muskegon)	tn	4	6.4	4					+	4+	+0.4	4	78
	es	5	6.0	6					+	4+	-0.7	2	79
Big Brower (Kent)	tn,gn	1.2	4.5	1	8	1	1.5	1	0	2	-0.8	2	86
Big Fish (Lapeer)	sn	4.3	5.4	5	27	4	3.8	4	?		-1.2	1	57
Big Pine Island (Kent)		tn,fn	1.2	4.0	1	5	1	0.2	1	0	2	-1.0	26
	sn	2.5	4.7	3	13	3	1.2	2	0	2	-1.2	1	61
Big Seven (Oakland)	tn	1.2	4.9	1	2	1	0.2	1	0	2	-1.6	1	83

Table 3.—Continued:

Lake and (county)	Gear[a]	Size score (SS)	Length indices[b] Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Big Silver	es	5.3	5.3	5	48	6	14	5	0?			77	
(Washtenaw)	sn	2.5	3.9	2	2	1	2	3	0.3	4	~+0.6	5	62
Big Whitefish (Montcalm)	sn,es,fn	4		2-4		2-6		2-4		3-5		3	64-83
Bills (Newaygo)	tn	4.0	5.5	3	51	4	10	4	4	5	+0.5	5	84
Birch	es	5.0	5.4	5	34	5	10	5	1	5	+0.9	5	72
(Cass)	es	3.8	4.5	3	14	3	5	4	2.4	5			83
Blueberry	tn	7.0	8.0	7	~100	7	95	7	67	7	+0.5	5	84
(Livingston)	es	6.8	5.9	6	51	7	44	7	29	7			84
Bogart	es	3.8	4.4	3	22	4	8	4	0.3	4	+0.7	5	82
(Cass)	fn,gn	4.2	6.4	4	63	4	28	4	3.5	5			82
Camp (Kent)	es	6.0	6.4	7	57	7	27	6	0.6	4	+0.5	5	71
Carter	tn,fn	1.5	5.0	2	4	1	0	1	0	2	-1.1	1	85
(Barry)	es	1.5	4.0	2	3	1	0	1	0	2	-0.7	2	78
Cassidy	tn	4.2	6.4	4	68	4	26	4	1.4	5	0	4	64
(Washtenaw)	sn	4.5	5.3	5	32	5	6	4	0.2	4			64
	tn	5.0	6.6	5	76	5	30	5	1.0	5	0	4	87
	es	3.2	4.4	3	23	4	3.6	4	0	2	0	4	87
Center (Jackson)	tn	2.0	5.0-5.2	2	26-34	3	0.3-3.8	1	0	2	-1.4	1	70,78
Clear	sn	2.5	4.7	3	14	3	1	2	0?	2	-0.7	2	61
(Jackson)	tn,fn	2.8	5.5	3	69	4	4	2	0?	2			71
Clear	fn,gn	2.2	5.6	3	30	3	0.6	1	0	2			66
(St. Joseph)	es,sn	2.2	4.1-4.8	2-4	4-9	2-3	0-0.3	1	0	2	-0.6 to 1.2	1-2	72,62,79
Clifford	sn	4.2	5.6	5	30	5	2.3	3	0.1	4			57
(Montcalm)	es	2.8	4.7-4.8	3-4	11-15	3	0-3.6	1-4	0	2			71,77,79
	tn,fn	2.0	5.6	3	26	3	0	1	0	2	-1.0	2	78,79
Cloverdale (Barry)	sn	4.0	4.5	3	18	4	6.4	4	2.9	5			61
Cowden (Montcalm)	tn,fn	1.6	5.1-5.2	2	4-10	1-2	0.9	1	0	2			78
Cranberry (Kent-Ottawa)	fn,gn	4.0	6.3	4	75	5	8	3	0.1	+4	+1.0	6	72

Table 3.—Continued:

Lake and (county)	Gear[a]	Size score (SS)	Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Crescent	fn	3.5	5.9	3	42	3	5	3	2.8	5	+0.6	5	72
(Oakland)	es	1.8	4.5	3	2	1	0	1	0	2	-0.7	2	84
Crispell	tn	2.6	5.6-5.9	3	41-86	4	0.4-3.1	1-2	0	2	-0.1 to -0.8	2-3	76,82
(Jackson)													
Crockery	fn,tn,gn	1.5	5.1	2	0	1	0	1	0	2	0	4	77
(Ottawa)													
Crooked	tn	4.2	6.3	4	66	4	26	4	7	5	0 to -0.4	4	87
(Oakland)													
Crooked	tn,fn,gn	3.9	5.9	3	64	4	27	4	?	4-5			71
(Washtenaw)													
Crooked	sn,smfn	1.6	3.7-4.1	1-2	0-9	1-3	0	1	0	2	-0.6 to -1.0	2	62,83
(Clare)													
Crotched	sn	3.0	4.4	3	4	2	2	3	0.5	4	+0.2	4	61
(Oakland)													
Crystal	es	5.4	5.2-5.7	4-5	36-59	5-7	12-28	5-6	3-8	5-6	-1.5 to +0.8	1-5	70,79,83
(Montcalm)													
Davidson	tn	4.0	5.8	3	66	4	43	5	?		+0.2	4	77
(Lapeer)													
Dead	tn	5.2	6.8	5	82	5	35	5	12	6	+0.3	4	83
(Washtenaw)													
Deep	tn	6.0	7.2	6	99	7	55	6	4.5	5	+1.0	6	76
(Lenawee)	es	5.2	5.7	5	31	5	21	5	3	6	+1.0	6	86
Diamond	sn	6.0	6.3	7	64	7	16	5	1	5	+0.1	4	58
(Osceola)													
Dickerson	es	3.5	5.2	4	24	4	4	4	0	2	-?	~2	71
(Montcalm)													
Dickinson	tn,fn	1.8	5.2	2	16	2	1	1	0	2	-1.4	1	83
(Oakland)													
Duck	sn	3.2	4.2	2	20	4	5.5	2	1.9	5			61
(Calhoun)	es	4.0	4.6	3	33	5	9.7	4	?		~+1.0	6	77
Eagle	es	6.8	6.7	7	82	7	40	7	6.1	6			85
(Allegan)	es	6.3	5.8	6	59	7	25	6	+	4+	-0.5	3	74
Eagle	sn,es	1.4	3.4-4.1	1-2	0-1	1	1-0.03	1	0	2	-0.8 to -1.3	1-2	57,62
(Kalamazoo)													

Table 3.—Continued:

Lake and (county)	Gear[a]	Size score (SS)	Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Fenton (Genesee)	tn	4.0	5.9	3	57	4	25	4	5.4	5	+0.4	5	83
Fishers (St. Joseph)	fn,tn	6.0	7.1	6	86	6	59	6	18	6	+0.4	4	86
Ford (Washtenaw)	tn,fn	3.7	6.0	4	47	3	15	4	?		+1.7	7	79
Fourteen (Van Buren)	es	1.6	4.2-5.0	2-4	1-5	1-2	0	1	0	2	-0.8 to -1.0	2	66,76,83
Fremont (Newaygo)	fn,gn	4.0	6.2	4	56	4	29	4	?				69
Garver (Cass)	sn	2.0	4.3	3	4	2	0.2	1	0?		-0.2	3	62
	es	4.7	6.0	6	58	7	9.8	4	0	2	+0.4	4	85
Gilead (Branch)	tn	4.3	6.2	4	69	4	42	5	+	4+	+0.9	5	78
Gilletts (Jackson)	sn	1.3	4.1	2	2	1	0.3	1	?		-1.6	1	63
	tn	1.8	5.0	2	13	2	0.3	1	0	2	-1.0	1	85
Goguac (Calhoun)	tn	2.8	5.8	3	48	3	1	1	0.06	4	-0.5	3	81
Graham (Oakland)	es,sn	3.2	5.2-5.4	4-5	24-29	4	1.7-3	2-3	0	2	-0.2	3	71,61
Gun (Barry)	fn	3.5	6.0	4	53	4	13	4	0	2			83
	es	3.5	4.7	3	16	3	6	4	0.6	4			83
	sn	4.5	4.8	4	29	4	6	4	3.7	6	+0.2	4	61
Halfmoon (Washtenaw)	tn	6.5	7.4	6	98	7	84	7	16	6	+0.9	5	83
Hall (Barry)	es	1.6	3.8-4.4	2-3	1	1	0	1	0	2	-1.4 to -1.9	1	76,83
Heron (Oakland)	tn	2.0	5.1	2	13	2	1.0	1	.009	3	-0.8	2	84
Homer (Calhoun)	es	2.8	4.3	3	32	5	0	1	0	2	~-0.7	2	68
	tn	3.5	6.2	4	65	4	3.6	2	0.4	4			84
Houghton (Roscommon)	tn,fn	6.0	7.4	6	81	5	66	6	40	7	+0.2	4	83
Hutchins (Allegan)	sn	1.5	3.9	2	3	1	0.2	1	0	2	0	4	62

Table 3.—Continued:

Lake and (county)	Gear[a]	Size score (SS)	Length indices[b] Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Joslin (Washtenaw)	tn	2.2	5.2	2	20	2	8	3	0	2	-0.6	2	85
Kimball (Newaygo)	tn	5.8	6.8	5	94	6	73	6	16	6	+0.1	4	84
Little Silver (Oakland)	tn	2.7	5.8-6.0	3-4	42-67	3-4	0.8-5.6	1-3	0	2			69,87
Little Sugarloaf (Kalamazoo)	es	4.0	5.5	5	39	5	8	4	0	2	-0.2	3	81
Little Whitefish	sn	2.2	4.2	2	4	2	0.3	1	0	2	-1.1	1	63
(Montcalm)	es	3.5	5.7	5	30	5	1	2	0	2	~-0.5	3	71
Lakeville (Oakland)	es,sn,tn	2.5		2-3		2-4		1	0	2	-0.6 to -1.2	1-2	62-74
Leach (Barry)	es	4.2	4.9	4	27	4	14	5	0.5	4	-0.3	3	78
Lee (Calhoun)	es	7.0	6.7	7	69	7	48	7	23	7	+1.3	6	86
Lincoln	tn,fn	1.8	5.1	2	11	2	1	1	0	2	-0.3	3	71
(Kent)	tn	3.2	5.4	2	48	3	10	4	0.6	4	-0.8	2	84
Lobdell (Genesee)	tn	3.0	5.7	3	30	3	2.2	2	0.2	4	-1.3	1	84
Long (Kent)	tn,fn,gn	1.4	4.5-5.1	1-2	5-7	1	0	1	0	2	-1.0 to -1.7	1	70,85
Long	tn,fn	2.0	5.6	3	23	2	0	1	0	2	-0.6	2	85
(St. Joseph)	sn	1.8	4.4	3	3	1	0	1	0	2	-1.0	2	63
Long	sn	2.3	4.8	4	5	2	0.4	1	?		-1.3	1	58
(Clare)	tn,gn	2.0	<5	1	19	2	9	3	0	2	-1.5	1	78
Loon (Oakland)	tn	6.0	7.5	6	93	6	76	6	32	6	+0.6	5	86
Loon (Oscoda)	gn	6.7	7.6-8.6	7	95-99	6-7	70-95	6-7	75	7	+1.8	7	81,73
Lower Brace (Calhoun)	tn	3.5	6.1	4	60	4	12	4	0	2	-1.0	2	82

Table 3.—Continued:

Lake and (county)	Gear[a]	Size score (SS)	Length indices[b]: Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Maceday-Lotus (Oakland)	es	5.6	6.0	6	89	7	9	4	0?		-0.2	3	80
Magician	sn	3.2	4.5	3	9	3	2.4	3	0.5	4	-0.2	3	62
(Cass)	es	2.5	4.7	3	17	3	1.7	2	0	2	-1.0	2	85
Maple (Van Buren)	sn	4.5	5.7	5	32	5	9.9	4	0.6	4	+1.2	6	62
Matteson	tn	2.2	5.3	2	44	3	2	2	0	2	-1.3	1	78
(Branch)	tn	1.5	5.3	2	3	1	0.001	1	0	2	-0.5	3	85
Middle	sn	2.5	4.3	3	7	2	0.6	1	0.2	4	-0.4	3	61
(Barry)	es	3.7	4.8	4	28	4	10	3	0?		-0.4	3	79
Mill (Washtenaw)	tn	4.2	6.2	4	51	4	20	4	1.7	5	-0.6	2	65
Miner (Allegan)	es	3.0	4.2	2	16	3	3.7	4	?		-1.1	1	79
Murphy (Tuscola)	tn	1.5	5.1	2	1	1	0.1	1	0	2	-0.3	3	84
Muskellunge	es	2.0	4.7	3	4	2	0	1	0	2	-1.6	1	69
(Montcalm)	tn,fn	1.8	4.9	1	16	2	4.3	2	0	2	-0.4	3	76
Nepessing	sn	3.8	5.7	5	29	4	3.4	4	0	2	-0.7	2	58
(Lapeer)	tn	3.2	5.6	3	50	4	4	2	0.3	4	-1.0	2	84
North (Washtenaw)	tn	2.2	5.7	3	36	3	1.1	1	0	2	-1.3	1	85
Nottawa (Calhoun)	es	3.8	4.6	3	18	4	4.8	4	0.9	4	-0.2	3	83
Orion (Oakland)	tn	1.8	5.2-5.4	2	13-26	2-3	.06-0.4	1	0	2	-1.0	2	70,82
Pickerel (Newaygo)	tn	4.2	5.9	3	66	4	30	5	5	5	+0.1	4	84
Pine	es	2.7	4.4	3	8	2	1.4	2	0.1	4	-1.1	1	78
(Barry)	sn	2.7	4.3	3	8	2	1	2	0.1	4	-1.3	1	60
Pleasant (Barry)	sn	2.0	3.8	2	1	1	0.4	1	0.1	4	+0.8	5	61
Pleasant (Jackson)	tn	3.0	5.9-6.0	3-4	47-59	3-4	6.6-7.7	3	0	2	-0.1 to -0.6	2-3	78,86

Table 3.—Continued:

Lake and (county)	Gear[a]	Size score (SS)	Length indices[b] Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Pontiac (Oakland)	tn,fn	1.2	4.9	1	1	1	0	1	0	2	-1.6	1	78
Pretty (Mecosta)	sn	5.3	5.5	5	59	7	6.7	4	0?		+0.2	4	59
Prince (Oakland)	tn	3.5	6.2	4	57	4	13	4	0	2	+0.4	7	85
Rainbow (Montcalm)	tn	1.9	4.7-5.2	1-2	14-48	2-3	0-2.5	1	0	2	-0.6 to -0.9	2	84,85
	sn,es	2.0	4.6-4.7	3	4-6	2	-0.6	1	0	2	-0.2 to -1.6	1-3	57-59,69
Rifle (Ogemaw)	tn	4.0	5.8	3	83	5	16	4	0?		0	4	77
	es	4.0	4.8	4	35	5	8.3	4	0?		-0.1	3	78
Rose (Osceola)	sn	2.5	4.2-5.0	2-4	1-12	1-3	0-4	1-4	0-1	2-5	-1.2 to -1.8	1	58-61
Round (Jackson)	tn	5.0	6.7	5	78	5	35	5	9	5	-0.1	3	85
Sand (Lenawee)	tn	5.5	7.0	6	79	5	50	6	9	5	+0.5	5	86
Sand (Newaygo)	tn	1.2	4.2-4.8	1	0-7	1	0-1.8	1	0	2	-0.4	3	84-87
	es,sn	2.0	3.6-5.0	1-4	1-12	1-3	0.1-1.5	1-2	0	2	-1.0	2	57,76
Selkirk (Allegan)	es	2.0	4.6	3	5	2	0.1	1	0	2	-1.1	1	80
Sherman (Kalamazoo)	es	4.5	5.6	5	28	4	9	4	~1	5	+.4	4	72
Silver (Branch)	tn,fn	4.8	6.4	4	58	4	32	5	31	6	0	4	84
Sterling (Monroe)	tn,fn,gn	3.2	5.8	3	48	3	2	2	2	5	+.7	5	83
Strawberry (Livingston)	tn	6.2	7.3	6	96	7	68	6	17	6	+1.7	7	85
Sugarloaf (Washtenaw)	tn	4.8	6.4	4	66	4	50	6	7	5	-0.6	2	85
	es	5.0	5.2	4	48	6	15	5	?				77
Swains (Jackson)	tn,gn	2.2	5.4	2	33	3	2	2	0	2	+0.1	4	79
Teeple (Oakland)	sn	4.0	5.7	5	39	5	5.5	4	0	2	-0.8	2	60
	es	4.0	5.5	5	26	4	13	5	0	2			71

Table 3.—Continued:

Lake and (county)	Gear[a]	Size score (SS)	Length indices[b] Avg L inches	Avg L score	>6" %	>6" score	>7" %	>7" score	>8" %	>8" score	Growth index GI[c]	Growth index score	Survey year(s) (19__)
Thompson (Livingston)	tn,gn	1.5	5.1	2	4.2	1	0	1	0	2	-1.0	2	86
Three-legged (Van Buren)	es	1.8	4.5	3	3	1	0	1	0	2			66
Townline (Montcalm)	sn	1.7	4.7	3	2	1	0	1	0	2			57
Union (Oakland)	tn	4.0	6.1	4	57	4	25	4	0.6	4			85
Vinyard (Jackson)	tn	5.0	6.8	5	79	5	46	5	8	5	+0.5	5	82
	es	6.0	6.1	6	48	6	30	6	14	6			82
Wakeley (Crawford)	tn	5.8	7.4	6	74	4	52	6	41	7	+0.3	4	86
White (Oakland)	tn	1.5	4.8-5.4	1-2	5-14	1-2	0.1-1.6	1	0	2	-1.1	1	83,86
Wildwood/Valley		sn	1.7	4.2	2	4	2	0.1	1	0?		-0.2	95
(Oakland)	tn,fn	3.5	5.7	3	66	4	8	3	0.1	4	+0.4	4	63
	tn	3.5	6.0	4	46	3	9	3	0.3	4			87
Wolf (Muskegon)	es	1.7	4.2	2	3	1	0.4	2	0	2	+0.2	4	71
Wolverine (Oakland)	tn	1.2	4.7	1	1	1	0.1	1	0	2	-1.1	1	82
Woodard (Ionia)	sn	1.8	4.5	3	1	1	0	1	0	2	-1.1	1	63
Woodland (Livingston)	tn	2.8	5.1-6.4	2-4	6-82	1-5	0-16	1-4	0	2	-0.4 to -0.9	2-3	68-85

[a]Gear codes: es = electroshocker; fn = fyke net; gn = gill net; smfn = small-mesh fyke net; sn = seine; tn = trap net.

[b]Length-frequency indices: Avg L = Average length of catch in inches; >6", >7", and >8" = percent of catch greater than 6.0, 7.0, and 8.0 inches, respectively.

[c]GI = Growth index, the average deviation in inches from the seasonal state average length at age.

Table 4.—Trends in length and growth indices for the bluegill population in Long Lake (Ionia County), 1963-90.[a]

Year	Gear	Size score (SS)	Avg L		>6"		>7"		>8"		Growth	
			Inch	Score	Percent	Score	Percent	Score	Percent	Score	Index	Score
1963	sn	2.0	4.5	3	6	2	0.6	1	?	?	-1.0	2
1971	tn,fn	2.7	5.8	3	33	3	4.2	2	?	?	-0.8	2
1972	es	1.8	3.8	2	5	2	0	1	0	2	-1.3	1
1976	sn	2.3	4.9	4	5	2	0.2	1	0	2	-1.3	1
1977	Partial chemical treatment to thin bluegill population.											
1978	tn,fn	3.0	6.4	4	?	?	?	?	0	2	-0.6	2
1979	tn,gn	3.5	6.5	5	?	?	?	?	0	2	-0.3	3
1980	tn	3.5	6.0	4	59	4	16.6	4	0	2	—	—
1982	tn	3.5	5.4	2	46	3	21.4	4	2.3	5	—	—
1986	tn,gn	1.5	4.8	1	22	2	1.8	1	0	2	-1.4	1
1990	tn	3.5	6.2	4	66	4	14.6	4	0	2	-1.4	1

[a]See footnotes in Table 3.

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