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Growth Rates of Yellow Perch, Perca Flavescens (Mitchell), in two North Dakota Lakes After Population Reduction with Toxaphene

Donald C. Warnick

GROWTH RATES OF YELLOW PERCH, PERCA FLAVESCENS (MITCHILL), IN TWO NORTH DAKOTA LAKES AFTER POPULATION REDUCTION WITH TOXAPHENE

BY

DONALD C. WARNICK

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

Fishery waters overpopulated with desirable species generally produce few harvestable fish because of slow growth rates. In 1962, Bennett stated that no fish of harvestable size were found in some waters thus affected. Eschmeyer (1936) made a similar observation concerning overcrowded populations of yellow perch (*Perca flavescens*). For lack of more efficient remedial measures the use of piscicides has been recommended to reduce the numbers of the problem species.

Relatively low toxaphene concentrations in two North Dakota lakes substantially reduced the density of the yellow perch populations; the effect on other fish species was less obvious. The results reported (Henegar, 1961) were incidental to the determination of the minimum toxaphene concentration necessary for fish eradication in that state. The present study was initiated in 1960 to determine the growth rates of the yellow perch surviving in Brush and Long lakes, and thus gain information concerning the suitability of toxaphene for reducing the numbers of fish in overpopulated waters. The scale method was employed to calculate the growth rates of Brush Lake fish for the 1960 and 1961 growing seasons. Post-treatment growth rates of Long Lake fish were determined for part of the 1960 growing season and for all of the 1961 season.

Several authors reporting the use of rotenone to thin overcrowded populations or to restore balance between fish species considered the results to be favorable. Beckman (1941) noted that the growth rates of fish surviving the treatment of one-half of Booth Lake, Michigan, were too great to be accounted for by normal variation. Substantially increased harvests, apparently the results of accelerated growth rates of remaining fishes, were reported by Swingle, Prather, and Lawrence (1953) subsequent to the poisoning of some Alabama ponds. Hooper and Crance (1960) stated that the use of rotenone was an effective and economical method to restore balance to certain fish populations. Reports of unfavorable results with rotenone, or of similar use of other piscicides, were not found. However, the use of toxaphene was recommended by several authors including Hemphill (1954) who first used the chemical for fish eradication.

The cost of fish eradication with toxaphene is approximately 15 per cent of the cost with rotenone. On the basis of recommended concentrations and methods for thinning overcrowded fish populations with these chemicals, the use of toxaphene would be even more economical. Definite information relevant to this use of the poison and the subsequent results is conspicuously absent.

Unfavorable results from the early use of toxaphene for fish eradication were not uncommon and tended to delay the acceptance of the piscicide for use in fisheries management (Prevost, 1960). Consequences of a serious nature were: the failure of the poison to kill all fish; the extended toxicity of some treated waters; and the reduction or elimination of many aquatic organisms. Hooper and Grzenda (1955) first suggested that such results were due to confusion concerning lethal concentrations and the belief was substantiated by the accumulation of additional evidence (Stringer and McMynn, 1960). Increased proficiency in using the chemical for fish eradication has led to its general acceptance for that purpose as was indicated by Gebhards' 1960 review of past and proposed use in numerous western states.

Toxaphene concentrations used for fish eradication reportedly reduce or eliminate many fish-food and food-chain species, some of which do not reappear quantitatively for extended periods of time (Stringer and McMynn, 1958). In a similar respect, relatively little is known concerning the effects of the lesser toxaphene application rates recommended for reducing the density of overcrowded fish populations. A paucity of fish-food organisms in the North Dakota lakes--even for a comparatively short period after toxaphene application--would affect the growth rates of the surviving fish and thus be indicated during scale analysis.

THE STUDY LAKES

The minimum concentration of toxaphene required for fish eradication is determined on the basis of the physical and chemical characteristics of the water for which treatment is proposed in addition to certain biological conditions, and this is assumed to be true with regard to application rates for reducing the density of fish in overpopulated waters. Some physical and chemical characteristics of Brush Lake and Long Lake are presented in Table 1. The following history is pertinent to the study of the post-treatment growth rates and is based on material presented by Henegar in 1961.

Both lakes were treated with toxaphene to attain concentrations of approximately 0.010 parts per million using an emulsifiable concentrate containing six pounds of the active ingredient per gallon. Brush Lake was treated on October 5, 1959, and Long Lake on July 17, 1960. The method of application was that commonly used by the North Dakota Game and Fish Department, and similar to one described by Stringer and McMynn (1958).

Dilution of the waters by rainfall or by runoff from melting snow was inconsequential after toxaphene treatment due to unusual drought conditions. Water levels receded somewhat during the course of the study. Rooted aquatic vegetation was present along portions of the shoreline and in several small shallow areas of Long Lake at the time of treatment, but was nearly absent from Brush Lake because of the late-season treatment date.

Table 1. Some Physical and Chemical Characteristics of the Lakes

Item	Brush Lake	Long Lake
Location (North Dakota)	McLean County	Bottineau County
General area of state	central	north central
Origin of Lakes	glacial	glacial
Bottom type	silt-loam	silt-loam
Surface acres	160	291
Acre feet	1,527	2,391
Maximum depth (feet)	23-24	23-24
Average depth (feet)	9.5	8.2
pH*	8.5	8.3
Phenolphthalein alkalinity*	40	40
Methyl orange alkalinity*	460	220
Hardness*	476	308
Total dissolved solids*	290	307

*Indicated condition on date of application in parts per million if applicable.

All young-of-the-year yellow perch apparently were eliminated from both lakes. Observations established the mortality of some young-of-the-year northern pike (Esox lucius) in Long Lake, but post-treatment netting disclosed that they were not eliminated. The effect of the poison on adult fish of several species in both lakes was less evident than the effect on yellow perch, the dominant species.

Excluding the young-of-the-year, yellow perch density was reduced approximately 91 per cent in Brush Lake and 79 per cent in Long Lake. The figures are derived from the results of qualitative test-netting just before and several months after poisoning. Netting results also indicated that a greater percentage of the smaller yellow perch (less than 140 millimeters) was eliminated than of the larger fish. Observation for several days after toxaphene application to Long Lake tended to substantiate the latter netting results.

Populations of fathead minnows (Pimephales promelas) were established in the lakes after treatment. Brush Lake was stocked on May 27, 1960, and Long Lake on August 18, 1960. The establishment of minnow populations after toxaphene treatment is a general practice of the North Dakota Game and Fish Department.

AGE AND GROWTH

Varied evidence has been presented in support of the validity of the scale method for the determination of the age and growth of fishes (Lee, 1920; Van Oosten, 1929). Similar evidence indicates that the method is valid for determining the age and growth rates of yellow perch. Joeris (1957) indicated that additional evidence on the validity of the annulus would accumulate from the further study of Green Bay (Lake Michigan) perch. Jobes, as early as 1932, assumed the validity of the method for yellow perch. The North Dakota study was based on the assumption that the method is valid.

Scale samples of yellow perch from the study lakes were obtained from specimens netted before and after the poisoning, from poisoned fish, and from winterkilled specimens. The scales were removed from the left side of the body below the lateral line and directly under the middle of the spiny dorsal fin. The samples were individually sealed in scale envelopes on which the date of collection, the lake, and other relevant information was recorded.

In the laboratory, several scales from each sample were prepared for microprojection on a device of the type described by Lagler (1956). After soaking and cleaning the scales, wet mounts were made by placing them between two common microscope slides and adding several drops of water. All scale measurements from which lengths and growth increments were calculated were made from the projected images of these wet mounts. Ink markings were made on the glass screen of the projector of the scale focus, the annuli, and the anterior margin to facilitate measuring with a millimeter rule. Measurements taken along a median anterior lobe were recorded on a form designed for the purpose. A direct-proportion relationship of scale radius to total fish length was the basis for all calculations.

It was apparent during the analysis of the scale samples obtained from Long Lake July 12-17, 1960, that the distinction of the age classes would be difficult. The determination of the age composition for this group was dependent on the identification of all annuli for each individual scale sample. For many of them it could not be established whether the 1960 annulus had been formed. The samples from smaller fish (80-120 millimeters) generally evidenced annulus formation and some subsequent growth. However, the 1960 annulus was apparently unformed on some of the scales of larger fish. Because of relatively little scale growth the previous season, it could not be determined whether the annulus was recently formed and the later scale growth was of the 1960 growing season, or if the annulus was unformed and the scale growth of the previous year was represented. An error of one year would be introduced by the wrong choice.

A similar difficulty was noted by Joeris (1957) during analysis of yellow perch scales. Beckman (1943) reported that the time of annulus formation may vary notably among species and within age groups of the same species. Annulus formation probably would have occurred before the July collection date with more favorable growth conditions.

Even without the previously described difficulty, the determination of age classes would have been somewhat subjective. Annuli were not distinct and markings assumed to be false annuli were common. Temporary dry mounts were made by blotting the scales before placing them between the microscope slides and permanent mounts of cellulose acetate were made with a roller press similar to one described by Smith (1954). These two mounts were projected on a light background by means of a microprojection attachment on a 35 millimeter slide projector. A larger image was produced than with the other projector and the permanent mounts allowed the distinction of more detail near the center of the scale, but the effort was not particularly fruitful. Analyses of the group of scales were made on separate occasions. A comparison of results disclosed some error with respect to the assignment of age and notable error in the locating of annuli. Thus the age classes and specific growth rates of fish before treatment are not included.

Post-treatment scale samples from both lakes were obtained after the interruption of growth for the 1961 season and before 1962 growth was begun. An annulus was assumed at the scale margin although none was evident. All discernable increase in scale growth of the Long Lake fish was included between the margin and the annulus of the previous year. The scale growth of Long Lake fish during the remainder of the 1960 season after poisoning was not distinguishable from previous scale growth. Growth increments for the 1961 growing season are presented in Table 2. Errors other than mechanical are

Table 2. The Calculated Growth Increments of Yellow Perch from Long Lake for the 1961 Growing Season (in millimeters).

Number of fish	Total length at capture		Calculated growth increment	
	range	average	range	average
*17	103-132	115		
1		178		82
5	201-210	205	58-101	75
1		219		59
21	221-230	227	59-120	74
32	231-240	235	45-116	75
28	241-250	247	56-106	79
12	251-260	253	75-116	83
7	261-270	265	54-99	78

*Young-of-the-year in 1961.

unlikely because of the distinctive scale growth and the absence of false annuli during that period.

No scale samples were obtained from Brush Lake fish until two years after treatment. Accelerated scale growth was obvious between the scale margin and annuli of the two previous years. The calculated growth rates for the corresponding periods are contained in Table 3. Similar to the scales of Long Lake fish, growth previous to poisoning was obscured by the presence of numerous false annuli.

Table 3. The Calculated Growth Increments of Yellow Perch from Brush Lake for the 1960 and 1961 Growing Seasons (in millimeters).

Number of fish	Total length at capture	Average 1960 increment	Average 1961 increment
*6	175--200	95	98
0	201--225		
7	226--250	89	45
15	251--275	95	51
8	276--300	100	57

*Young-of-the-year in 1960.

When an annulus of the year previous to those located for the preparation of Tables 2 and 3 was obvious, as it was on some scales, a direct comparison of scale growth before and after poisoning was made. On this basis the post-treatment growth during the first year was approximately six times greater than was evident for the previous year.

Table 4 demonstrates the relationship of fish length to subsequent growth—both calculated. The fact that greater length increments were recorded for smaller fish lends validity to the scale

Table 4. The Relationship of Fish Lengths to Subsequent Growth Increments (Both Calculated) for Yellow Perch from Long Lake (in millimeters).

Number of fish	Calculated lengths May 1961	Growth increment 1961 range	average
*17	103--132	103--132	115
2	91--100	82--121	101
2	101--110	101--119	110
1	111--120		91
0	121--130		
8	131--140	64--116	92
15	141--150	61--104	85
27	151--160	58--96	76
29	161--170	59--101	76
12	171--180	67--89	75
8	181--190	45--82	67
1	191--200		66
1	201--210		54

*Young-of-the-year in 1961. The lengths are measured total lengths.

method as applied to the present study.

An obvious change in the size composition of Long Lake fish is evident in Table 5. The numbers of fish in the last column represent a sub-sample of winterkilled specimens in addition to several obtained by qualitative test-netting. The numbers of fish in the other columns represent the results of qualitative test-netting at the time indicated. Excluding the 17 young-of-the-year of 1961, the lengths of fish in the last column are approximately 75 to 100 millimeters

Table 5. The Toxaphene-effected Change in the Yellow Perch Population of Long Lake Based on the Measured Total Lengths of Fish Taken During the Study

Length range in millimeters	Total fish July 1960 before treatment	Total fish October 1960 after treatment	Total fish May 1962 after treatment
45--65	1010	0	0
66--100	527	0	0
101--125	312	0	17*
126--150	198	152	0
151--175	196	243	0
176--200	7	0	1
201--225	0	0	12
226--250	0	0	75
251--275	0	0	19
	2,250	395	124

*Young-of-the-year in 1961.

greater than the lengths of fish in the previous column. Despite the time interval, only one growing season--1961--is represented. The calculated average growth increment was 82 millimeters for the period on the basis of scale analysis. The validity of the scale method as applied in the present study is thus supported by the data presented in Table 5.

DISCUSSION

The yellow perch is a popular species in recreational fisheries, especially for winter fishing, but fish shorter than a total length of seven inches or approximately 175 millimeters are not readily sought and removed by fishermen. Considering this length as the minimum harvestable size, the growth rates recorded for the yellow perch from the North Dakota lakes are significant with respect to the relatively short time required for the apparent improvement of recreational fisheries. All yellow perch surviving similar treatment rates could be expected to exceed the minimum harvestable size during the subsequent growing season, and young-of-the-year after only two growing seasons, as was the evident situation in the study lakes.

Young-of-the-year yellow perch commonly attain a harvestable size in three or more growing seasons except in overpopulated waters where growth is further restricted. The growth rates of surviving fish were exceptionally rapid during the growing season subsequent to the poisoning--1960 for Brush Lake and 1961 for Long Lake--when compared with growth rates of yellow perch in other areas, and similar growth increments were not often recorded even for southern latitudes having longer growing seasons (Carlander, 1953). For these periods, the combined average increment determined by scale analysis was 83 millimeters. Extremes were few, and shorter fish exhibited the most rapid growth in length.

On the basis of this study, better recreational fishing could be provided at low cost in some lakes and small impoundments which are overpopulated with yellow perch. Improved recreational fishing was assumed in the North Dakota lakes since more fish of harvestable size were produced, but the determination of increased harvests would be conclusive. Comparable results might also be expected following the thinning of other commonly overpopulated species inasmuch as the present study was primarily a matter of chance and not selection of species.

Low toxaphene concentrations in North Dakota lakes have been observed to eliminate small fish of many species including the bullhead (*Ictalurus melas*) which has been reported by Kallman, Cope, and Navarre (1962) to be somewhat resistant to the poison. The policy in North Dakota of introducing minnows in waters after treatment with toxaphene is based on this observation.

An assumed quantitative absence of prey fish is believed to explain the continued slow growth of the yellow perch in Long Lake during the 1960 growing season, after the mid-July application of toxaphene. The May 27, 1960, introduction of 180,000 fathead minnows in Brush Lake evidently assured the presence of significant numbers for the same growing season and no unusual period of slow growth was apparent during scale analysis. The reduction or elimination of prey fish by the mid-July poisoning, and the August 18, 1960, stocking of 200,000 fathead minnows, leaves doubt that significant numbers were present in Long Lake until the 1961 growing season when the growth rates of yellow perch were greatly accelerated. A need for more conclusive information concerning the relationship of prey species to growth rates is indicated.

Assuming need for the introduction of prey species, a definite advantage is apparent for the fall treatment of waters since stocking could be accomplished early in the subsequent growing season. Treatment in April or May would probably be more advantageous than during the growing season, but conditions are not favorable for rapid detoxification at that time and stocking of prey species might be delayed.

The toxaphene treatment rate which allowed the survival of yellow perch in the North Dakota lakes was approximately one-third of the determined rate for fish eradication in most waters of that state. A belief that the reductions were excessive can be temporized since the possibility that an optimum number of fish survived in either lake is unlikely, and greater growth rates could hardly be expected. Unqualified test-netting of both lakes and observation after a partial winterkill of Long Lake in 1962 substantiates the belief. Concentrations approximating 0.008 parts per million (one-fourth of the minimum lethal rate) probably would have allowed the survival of greater numbers of fish without significantly reducing their rate of growth.

On the basis of a recent report by Kallman, Cope, and Navarre (1962), the presence of relatively large quantities of vegetation at the time of treatment could affect the outcome, especially in consideration of the low toxaphene concentrations required for the thinning of fish populations. It was indicated that high concentrations of toxaphene are accumulated by certain vegetative species in a relatively short time, thus essentially removing the chemical from the water--at least temporarily--and the further disposition of the chemical was unknown. Therefore, more consistent results might be obtained, with regard to the degree of reduction, by treatment during the absence of most aquatic vegetation.

The appropriate reduction for any population necessarily depends on a variety of conditions, some unknown. The difficulty of determining the magnitude of fish populations, particularly after treatment, seriously affects an evaluation of the results. Additional information concerning the use of toxaphene for reducing the density of fish populations is needed for its proficient use.

SUMMARY AND CONCLUSIONS

1. Greatly accelerated growth rates and increased harvests have been the reported results of the use of rotenone for thinning overcrowded fish populations.
2. For greater economy a similar use of toxaphene has been recommended, but its use--other than for fish eradication--has apparently not been reported.
3. On the basis of previous reports, increased growth rates of fishes surviving the thinning of overcrowded populations with toxaphene might be precluded, at least temporarily, by the adverse effect of the chemical on fish-food or food-chain organisms.
4. Yellow perch populations in two North Dakota lakes were substantially reduced by low toxaphene concentrations. The growth rates of surviving fish were determined by the scale method for two years after treatment.
5. Greatly increased growth rates were evident for both growing seasons following the fall treatment of Brush Lake.
6. Increased growth rates were not evident for Long Lake fish after the July 17, 1960, treatment until the 1961 growing season.
7. All yellow perch surviving the poisoning exceeded what may be considered to be the minimum harvestable size during the first full growing season after treatment. Comparable results can be expected from similar and perhaps lesser reductions with toxaphene.

8. Further use of toxaphene is recommended for reducing the density of yellow perch populations and thus improve certain recreational fisheries. Other species might be similarly managed.

9. The reduction or elimination of prey species was believed to explain the continued slow growth of Long Lake fish for approximately two months immediately after toxaphene application.

10. Fall treatment is apparently the most timely, especially with regard to assuring the presence of significant numbers of prey species during the growing season.

11. Numerous conditions affect the concentration of toxaphene needed for fish eradication and the approximate concentration for reducing the density of fish populations is believed to be 25 per cent of that rate.

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