MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

Fisheries Research Report No. 1834

October 8, 1975

FISHING REGULATIONS FOR SMALLMOUTH BASS IN MICHIGAN [1]

By W. C. Latta

ABSTRACT

Fishing regulations for smallmouth bass in Michigan were analyzed in Ricker's yield equation and with a review of previous fishing experiments from within the state and nationwide. Average rates for Michigan of growth, mortality, exploitation and reproduction were used in the equation. The size of greatest biomass for the growth and mortality rates postulated is about 11 inches. Under the presumed present rate of exploitation of 25%, the greatest harvest in weight occurs at an 8-inch minimum size limit. An increase in the rate of exploitation to 45% results in a maximum harvest at about 11 inches. Female smallmouth bass do not reach maturity until they are about 12.5 inches long. A 12-inch size limit insures at least equal replacement of the fingerlings needed to maintain the existing smallmouth population with an increase in exploitation to 45%. The total number of bass harvested under a 12-inch, as compared to a 10-inch, size limit will decrease by 40%, but the number of bass harvested larger than 12 inches will increase by 46%. The number of bass 10 inches or larger, which are available to be caught but not necessarily to be kept, will increase 19%. The creel limit is ineffective as a regulation to restrict the catch or insure a more even distribution among anglers. In Lake Michigan, less than 10% of anglers catch a limit of five bass, and the creel limit would have to be reduced to one bass to realize a 50% decrease in catch. Likewise the open season for smallmouth has not resulted in an increased harvest. At present a 12-inch minimum size limit, combined with the existing 5-fish creel limit and a fishing season which is open from the Saturday immediately preceding Memorial Day to December 31, seem to be appropriate fishing regulations.

---

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

Introduction

In Michigan substantial populations of smallmouth bass (Micropterus dolomieui) occur in the clear, cooler streams and inland lakes, and in many suitable areas of the Great Lakes. However, a suspected increase in fishing pressure and a deterioration of the environment have prompted a review of fishing regulations and management practices. The following report is an evaluation of creel limits, closed seasons, size limits and stocking practices for smallmouth in Michigan.

Spawning of smallmouth bass extends from mid-May in southern Michigan to late June in the Upper Peninsula and northern parts of the Great Lakes (Latta, 1963; Vannote and Ball, 1972; Clady, 1973, personal communication). As the water temperature reaches 60 F, the male fans out a saucer-like nest in the gravel bottom of the shallow water and entices a female or two to deposit eggs. The male guards the nest and the young after they hatch. An average nest will contain about 2,000 fry but often less than half of the nests will produce fry. The loss of eggs has been usually attributed to deposits of silt, fungus or predation. Until smallmouth are about 2 inches long, zooplankton and insects comprise their diet, then fish and crayfish become more important. As adults, in most habitats, crayfish make up the bulk of their food rather than fish.

In Michigan the largest angler-caught bass on record weighed 9 pounds, 4 ounces, but a fish 5 to 7 pounds in size is noteworthy. Seldom do Michigan smallmouth bass live longer than 10 years.

Population parameters

Population size, in numbers and weight, is dependent upon growth, mortality and recruitment. With average values for these parameters a typical smallmouth bass population for Michigan can be simulated and analyzed with regard to fishing regulations (Ricker, 1958). Also observed fecundity, standing crop and harvest can be related to the calculated population.

Growth

In 1963, Laarman compiled available growth data for smallmouth bass in Michigan. Average growth for each age group during the months January-April, May, June, July, August, September and October-December was calculated. I fitted a line by eye to the plotted points of average growth for the monthly periods (Fig. 1). Growth in the smallmouth bass has a distinct seasonal pattern with most of the increase taking place in June through September. For the older age groups, the monthly growth points are lacking, but presumably the seasonal growth pattern continues into the latter years. Average total length in inches for each age group of life in June and December was read from the graph in Figure 1 and used in simulating a bass population (Table 1). The weight, W, in pounds to the nearest hundredth, for each average length, L, in inches to the nearest tenth, was calculated from the length-weight equation (Laarman, 1974, personal communication):

$$\text{Log } W = -3.13982 + 3.02635 \log L$$

Mortality

The percentage decreases in smallmouth bass populations from fishing and natural losses are summarized in Table 2. Natural losses have varied from 13 to 49%. Rates of exploitation or percentage decreases attributed to fishing have varied from 5 to 33%. The estimates of natural mortality in most cases apply to all bass in the population 7 to 8 inches and longer. The exception was Clady's 2-year study of smallmouth in Katherine Lake, Michigan, where he estimated mortality by age group. In Katherine Lake mortality was high during the early years and then remained rather constant during the middle and latter years. My estimates of natural and fishing mortality for smallmouth at Waugoshance Point, Lake Michigan, are the only other available for Michigan. For the yield equation, I used my estimates supplemented with Clady's to obtain values for each age group. For rate of exploitation (u) I assumed a constant value of 0.25; for the annual values of the natural mortality fraction (v) I used for age-group 0--0.70, for age-group I--0.55, and for groups II through X--0.35.

The fishing season for smallmouth bass in Michigan extends from the Saturday in May immediately preceding Memorial Day to December 31, or essentially June through December. The yield equation was therefore developed for June-December and January-May intervals for growth and mortality. Although seasonal growth estimates were available (Fig. 1), there was nothing comparable for mortality rates, so mortality was proportioned to match growth for the two intervals, June-December, January-May, of each year of life (Table 1). It was assumed that most of the natural mortality occurred during the growing season rather than the winter, which seems a reasonable assumption for a species such as the smallmouth, which is essentially inactive during the cold months (Webster, 1954). The fishing season at present approximates the growing season.

Fecundity

In Michigan male smallmouth bass mature at age 3 or 10 inches in length and the females at age 4 or 12.5 inches in length; all males are mature at age 5 and all females at age 7 (Table 3). Observations from other populations in Ontario and New York are similar.

As in all centrarchids it is difficult to recognize mature ova in the ovaries of smallmouth bass because the ova are in various stages of development. The only substantial counts of eggs available are those made by Clady (1970) for bass in Katherine Lake, Michigan. A log transformation of number of eggs and total length of bass provided the regression:

$$\text{Log number of eggs} = 0.8653 + 2.5913 \text{ log total length}$$

With this relationship a 12.0-inch female smallmouth would carry about 4,500 mature eggs. Whether all mature eggs are deposited in nests during a spawning is not known. Clady (1975) found a 66 to 85% decrease between potential number of eggs to be deposited (those carried by females) and the number actually found in the nests. Only 0.3 to 0.6% of the egg potential resulted in fall fingerlings.

Standing crop and harvest

Estimates of standing crop and harvest for smallmouth bass in lakes and streams of Michigan are scarce (Table 4). The mean standing crop for lakes is 4.9 pounds per acre; the mean harvest is 1.2 pounds per acre. For these few data, harvest is about one-quarter of the standing crop. Carlander (1955) found a mean standing crop of 4.2 pounds per acre (range 0.04 to 11.8 pounds) for smallmouth in localities from Tennessee to Wisconsin.

Minimum size limits

Yield

The yield equation assumes a constant recruitment to the population and that changes in density of bass are not great enough to affect growth or mortality (Ricker, 1958). In this model recruitment consists of 1,000 pounds of 0-age bass in December. In the example in Table 1 the bass enter the catch at a minimum size of about 10 inches in June of their fourth year of life (age-group III). Yield then for this steady-state population is 4,255 pounds per 1,000 pounds of recruits. This calculation was repeated, using Paulik and Bayliff's (1967) computer program, for the approximate minimum size limits of 8.0, 10.0, 12.0, 14.0, 16.0, and 18.0 inches, and for 1/2, 1, 2, and 3 times the instantaneous fishing rate, p, of 0.382. The rate of exploitation, varies with age group but overall is about 0.15 for 1/2 p, 0.25 for 1 p, 0.45 for 2 p, and 0.55 for 3 p. The actual minimum size in June, and the corresponding age group at which bass will enter the fishery, are as follows: for the approximate minimum size of 8.0 inches the actual minimum size is 8.1 inches for age-group II; for 10.0 inches, 10.9, age-group III; 12.0 inches, 12.8, IV;

14.0 inches, 14.5, V; 16.0 inches, 16.4, VII; and 18.0 inches, 18.2, IX.

The rate of exploitation, 0.25, used in the calculations was higher than any value reported in the literature with the exception of the 0.33 reported by White (1970) (Table 2). However, White's exploitation figures are by age group and the mean value for ages 4 through 9 was only 0.18. Presumably doubling and tripling the fishing rate will match or exceed any extreme exploitation rates presumed in present populations, and halving the fishing rate approaches the many lower exploitation values reported in past studies.

For the rate of exploitation of 0.25, a minimum size limit of 8.0 inches yields the greatest weight (4,426 pounds per 1,000 pounds of recruits) (Table 5). A minimum size limit of 10 inches (the present legal limit) results in only 4,255 pounds, and a 6-inch size limit, only 3,695 pounds (not shown in Table 5). An increase in the size limit to 12 inches would result in 3,516 pounds or a 17% decrease from the present yield. An increase in exploitation to 0.45 (2 p) increases the maximum yield to 5,451 pounds, the maximum at that rate, at the minimum size of 10 inches (actually 10.9 inches, age III).

The point at which a population in a steady state, without the influence of fishing, reaches its maximum biomass is called the critical size (Ricker, 1958). Smallmouth bass in Michigan reach this point at age III and at a size of about 11 inches. The biomass without harvest, and with harvest, at the 0.25 rate for the minimum size of 10 inches is plotted in Figure 2.

The biomass or standing crop remaining after harvest is of concern if the size of the spawning stock becomes critically low. It is also of concern if the smallmouth fishery is being developed as a recreational catch-and-release activity. The biomass of bass in June, age III and older (or 10.9 inches and larger), for each minimum size and rate of exploitation proposed is given in Table 6. In the model, at the 0.25 (1 p) rate of exploitation, increasing the size limit from 10.0 to 12.0 inches increases the biomass from 13,969 pounds to 17,759 pounds. This is a 27% increase in biomass for a 17% decrease in yield. At the higher rates of exploitation the difference between biomass and yield becomes even greater. For the 0.45 (2 p) rate of exploitation the increase in size limit increases the biomass 48% while the yield decreases only 13%.

In a sport fishery the numbers of fish as well as the weight should be considered. The yield (harvest) weights in Table 5 were converted to numbers by dividing yield for each age group by the mean weight for the June-December interval and then summing the results for all age groups. The yield in numbers was then tabulated for the size categories 8, 10, 12, 14, 16 and 18 inches and larger, for the rates of exploitation and minimum sizes considered previously (Table 7). A similar tabulation was made for the biomass in numbers in June of each year for bass 10, 12, 16 and 18 inches and larger (Table 8). In this calculation the average weight in June of bass of each age group (starting with age III) was used to convert weight to numbers. The results for numbers differ from weight in that maximum yield decreases with an increase in minimum size for all rates of exploitation. An increase in the size limit from 10 to 12 inches at a rate of 0.25 (1 p) decreases the harvest by 40% from 3,734 to 2,241; for the biomass the same increase in size limit results in an increase in numbers of bass 10 inches or longer present in June from 14,803 to 17,589 or a 19% change.

How many additional larger bass will be caught if the size limit is increased? At the 0.25 rate of exploitation with a 10.0-inch size limit, the number of 12-inch and larger fish caught would be 1,530 (Table 7); however with an increase in the size limit to 12.0 inches the number of bass would increase to 2,241, for a 46% gain. Although the number of bass 12 inches and larger would increase, there would be a loss in the harvest of 1,493 bass (or a 40% decrease) between 10 and 12 inches. But if there were a drop in the rate of exploitation (which commonly happens with more restrictive regulations) to 0.15 (1/2 p), the catch of bass 12 inches and larger would decrease from 1,530 to

1,401 or 8%. However, in general, there is an increase in the number of larger fish with an increase in the size limit (Saila, 1958).

The results from a past experiment with fishing regulations in Michigan permit an evaluation of the model. In 1954-58 on Fife Lake the minimum size limit was 16 inches; for the previous 8 years the minimum size had been 10 inches. On Fife Lake the harvest decreased 78% under the higher size limit, from a mean of 1.1 pounds per acre to a mean of 0.2 pound. According to the model at a rate of exploitation of 0.25 (1 p) the yield per recruit should decrease from 4,255 at a 10-inch minimum size to 1,245 at a 16-inch minimum size, for a 71% decrease (Table 5). For this experiment, the only one available, the predictability is excellent.

Recruitment

Sufficient recruitment is vital for population success. In the model I assume that recruitment is constant although it is well known that many populations have year classes of variable size. The relationship between spawning stock and size of the year class produced is unknown. Watt (1959), Forney (1972), and Christie and Regier (1973) found no relationship between numbers of adult bass and numbers of young produced.

In lakes 44 to 77% of smallmouth bass nests produce fry (Stone, Pasko and Roecker, 1954; Latta, 1963; Turner and MacCrimmon, 1970; Neves, 1975). In the Red Cedar River, Michigan, 15 to 89% of nests were successful (Vannote and Ball, 1972). Lack of nest success and loss of eggs in smallmouth nests have been attributed to male desertion of the nest with falling temperatures, silt, carp, fungus, infertile eggs and predation (Webster, 1954; Cleary, 1956; Latta, 1963; Mraz, 1964; Pflieger, 1966; Neves, 1975). Temperature certainly influences the size of the brood in smallmouth bass. Fry and Watt (1957) found a correlation between size of year class in the fishery in South Bay, Lake Huron, and the algebraic sum of the monthly deviations from the mean air temperatures for the months of July through October in the year of hatching. Clady (1975) found the same relationship for smallmouth in a small lake in the Upper Peninsula of Michigan; however, the months were June through October. And, Forney (1972) in Oneida Lake, New York, found the same relationship, except that only June temperatures showed a strong positive correlation with year-class strength of bass. Watt (1959) made a more complete analysis of the South Bay data and obtained the same results as Fry and Watt (1957). Recently Christie and Regier (1973) reviewed the relationship between temperature and reproductive success in smallmouth bass and concluded that "year-to-year differences in reproductive success of smallmouth bass are closely dependent on summer air temperature. Further, besides the well known critical period early in the reproductive period--when male bass may desert their nests with falling temperatures and leave them exposed to a variety of hazards--there appears to be a further period of varying duration after the fry have become independent, in which heavy mortality can occur."

It is well established that mortality is most compensatory during the first few weeks of life in fish populations (Ricker, 1954). It is assumed that smallmouth bass would not be an exception and that when the number of young produced was small, mortality would be less, and when the number was great, the losses would be much more severe. However since this relationship cannot as yet be quantified, it seems worthwhile to consider for the model an average, direct relationship between spawners and young.

Clady (1975) recorded a 0.6% survival in 1967, 0.3% in 1968, and 0.5% in 1969 of smallmouth bass from estimated number of eggs carried by females, to fall fingerlings. I took the June biomass estimates in the model for each age group and converted them to numbers as described earlier. On the basis of Beckman's (1949) inspections of bass in Michigan, I assumed that half of the population were females. As indicated in Table 3 not all female smallmouth in a population are mature until they become 5 to 8 years old or about 12.5 inches long. At Waugoshance Point, Lake Michigan, 10% of the 4-year-old female bass were mature, 19% of the age-V females, 65% of age-VI and finally 100% of age-VII. Because the data from Waugoshance Point represent essentially only one year class during a period of slow growth of individual bass, it was not considered as typical; therefore an average of the Waugoshance and South Bay percentages was used to determine number of females mature in the calculated population (26% for age IV; 47%, age V; 82.5%, age VI). Unfortunately there are no comparable data for the inland waters of Michigan. With better growth conditions, as would be expected inland, presumably more bass would mature at an earlier age. The remaining maturity information for the New York and Ontario populations in Table 3 was not used in determining the averages because these populations are such a far distance from Michigan. The average percentage mature for each age group was used to determine the number of potential spawners in the population.

The number of eggs per female was calculated for each age group from the fecundity equation relating length of bass to number of eggs. The summation of the number of eggs for each age group was multiplied by the mean (0.5%) of Clady's survival values. The calculated number of fingerlings surviving to fall was then compared to number needed to equal 1,000 pounds of age-0 bass in the model (Table 1). At an average weight of 0.027 pound, the number of age-0 December fingerlings equals 37,037.

With a 10-inch minimum size limit and the typical rate of exploitation (0.25) the spring biomass has the potential to produce 46,409 fall fingerlings or 1.3 times as many as the 37,037 fingerlings needed to replace the population (Table 9). If the fishing rate is doubled (0.45), the number of fall fingerlings is reduced to 19,777, only 0.5 of the number needed for replacement; and if it is tripled (0.55), the replacement factor is reduced to 0.3. Under the 12-inch minimum size limit the population is replaced under all rates of fishing, except 0.55 where the replacement factor is 0.9. More observations are needed on age at maturity for smallmouth bass in inland waters, percentage survival of fingerlings and rates of exploitation before final judgments are made. In addition all of the above may be a useless exercise, for compensation in mortality, which is greatest at this time in the life of fish, may be more than enough to adjust for any calculated decrease in spawning stock. A very small increase in the percentage survival would result in a large increase in number of fall fingerlings.

Creel limits and closed seasons

Setting the creel limit at five smallmouth bass apparently is a very ineffective means of limiting the harvest. In Escanaba Lake, Wisconsin, Churchill (1957) estimated that catch of smallmouth would be reduced only 8% with a daily creel limit of five bass. At Waugoshance Point, Lake Michigan, in 1953-55, I estimated that only 4% to 9% of the anglers caught a limit of five bass. The percent of the catch expected under assumed creel limits of 1 to 4 bass with an actual limit of 5 for Waugoshance Point, 1953-55, is given in Figure 3. Obviously these are minimal percentages because no bass caught, over the limit being considered, were returned to the water. Another consideration is that in 1953 I did not sample anglers during the opening week of the season, and during 1955, I did not sample during the closing weeks. However, judging from Figure 3, a reduction in the creel limit to two bass would reduce the catch only 30%, and a creel limit of one bass would be necessary to realize a 50% reduction in catch.

Churchill (1957) also considered the effect of a closed season (January 16-June 19) on catch of smallmouth bass in Escanaba Lake. He estimated that the catch would be reduced only 6% with a closed season. Funk and Fleener (1966) concluded that a year-round season on the Niangua River, Missouri, did not increase the catch nor deplete the population, although the experiment was confounded by a strong year class of smallmouth bass in the years before an open season, and a diminishing of fishing pressure in the years after. They expressed concern about over-harvest with an increase in fishing pressure. In Michigan at Bear Lake, Manistee County, the catch of smallmouth bass was about 1.3 pounds per acre in 1951-53 with a closed season of January 1 through the latter part of June, and it remained at 1.3 pounds per acre for 1954-63 when bass could be caught and kept throughout the year (Taube, 1965). Apparently an open season for smallmouth bass does not result in an increase in the catch as it does in largemouth bass (Micropterus salmoides) (Latta, 1974).

Stocking of bass

Although the stocking of fingerling or larger smallmouth bass in lakes (Watt, 1959; Moen, 1960; Forney, 1972) or streams (Larimore, 1954; Brown, 1961; Funk and Fleener, 1974) to bolster existing populations has been tried several times, seldom has it been considered successful. For the seven lakes reported in the various studies, only the returns from West Okoboji, Iowa (Moen, 1960) suggested that the planted fish made any substantial contribution to the catch. For the streams, only Larimore (1954) for Jordan Creek, Illinois, has reported any major increase (34%) in the population as a result of stocking. Funk and Fleener (1974), who planted more than 92,000 marked fingerlings in the Big Piney River, Missouri, in 1952-55, reported a recovery of 2.3% of these fish, which made up only 3.7% of the total catch.

Although the stocking experiments to date have not been encouraging, they have also been marred by partial analyses and lack of continuity. Typically the abundance of the stocked fish in both the population and the catch has not been followed for the years necessary to evaluate the total contribution.

Smallmouth bass have not been stocked commonly in farm ponds and other small bodies of water, as have largemouth bass. Bennett and Childers (1957) had modest success with smallmouth in this type of habitat. They found, in central Illinois, smallmouth maintaining themselves more often in stone quarries and gravel pits with low fertility than in fertile farm ponds. Also competition from indigenous warmwater fish was more detrimental to smallmouth survival than high summer temperature or low dissolved oxygen. Most successful ponds were those in which smallmouth were by themselves, or with some other fish less prolific than bluegills (Lepomis macrochirus), green sunfish (Lepomis cyanellus) or black bullheads (Ictalurus melas). A particularly successful stocking combination in Illinois was smallmouth bass with lake chubsuckers (Erimyzon sucetta) which produced annual hook-and-line yields of 28 to 97 pounds per acre for 13 years from a 1.2-acre gravel pit (Bennett and Childers, 1972).

The introduction of smallmouth bass into large lakes where it has established viable populations apparently has not been obviously detrimental to other fish species living there. Fedoruk (1966) reported no competition for food between the principal native walleye (Stizostedion vitreum) and smallmouth bass in Falcon Lake, Manitoba. The bass, introduced in 1946, became the most abundant game fish in the lake. In Lake Opeongo, Ontario, the smallmouth, introduced in 1928, has had no apparent major impact on the salmonid community, and it has buffered fishing pressure on the lake trout (Martin and Fry, 1972).

Discussion

At present, a 12-inch minimum size limit, combined with the existing 5-fish creel limit and a season open from the Saturday immediately preceding Memorial Day to December 31, would be appropriate fishing regulations for smallmouth bass in Michigan. These regulations are identical to those for largemouth bass. The critical size, or size of greatest biomass, for the growth and mortality rates postulated for smallmouth is about 11 inches (Fig. 2) while for the largemouth in Michigan, it is 12 inches (Latta, 1974). Under the presumed present rate of exploitation of 0.25 (1 p) the greatest harvest in weight of smallmouth bass occurs at an 8.0-inch minimum size limit. An increase in the rate of exploitation to 0.45 (2 p) results in a maximum harvest at a minimum size limit of 10.9 or about 11 inches (Table 5). A female smallmouth bass does not reach maturity until she is about 12.5 inches long. At this size she contains about 5,100 eggs in comparison with the female largemouth of this size which contains about

18,500 eggs. Obviously the reproductive potential of the smallmouth is considerably less than the largemouth. Although the relationship between spawning stock and progeny is not known for smallmouth bass, and compensatory survival is great among newly hatched fry, it would seem prudent to protect the biomass of adults 12 inches and larger, particularly if exploitation is increasing. At a 10-inch size limit a rate of exploitation two times greater than the assumed 0.25 (1 p) rate results in only one-half as many fingerlings as needed to replace the existing smallmouth population (Table 9). A 12-inch size limit insures at least equal replacement with the doubling of the exploitation rate.

At the assumed rate of exploitation of 0.25 (1 p) an increase in size limit from 10 inches to 12 inches will decrease the yield in weight by 17% (Table 5), but increase the biomass by 27% (Table 6). The total number of bass harvested will decrease by 40%, but the number of bass harvested larger than 12 inches would increase by 46% (Table 7). The number of smallmouth 10 inches or larger, which are available to be caught but not necessarily to be kept, will increase 19% (Table 8). The final consideration in the determination of the proper size limit for smallmouth bass is that many anglers have difficulties in distinguishing smallmouth from largemouth bass. The 12-inch minimum size is judged to be appropriate for both the largemouth and smallmouth, after consideration of yield, biomass and reproduction in both species (Latta, 1974).

On Oneida Lake, New York, Forney (1972) made yield calculations and recommended a 12-inch minimum size limit for smallmouth bass. For the smallmouth in the Red Cedar River, Wisconsin, Paragamian and Coble (1975) calculated a critical size which fell between 15 and 16 inches. The high growth rate of the bass was responsible for the relatively large critical size. For smallmouth bass in the Shenandoah River, Virginia, Surber (1969), in evaluating the effects of a 12-inch minimum size limit, noted an increase in the numbers of fish caught and released but not in legal-size bass harvested. Also, from counts of bass nests, he noted a substantial increase in fish of spawning size. On the Big Piney River, Missouri, a 12-inch size limit resulted in a reduced harvest in pounds of smallmouth of legal size, however, the catch rate, including those released, nearly doubled (Fajen, 1974). Similarly in Elkhorn Creek, Kentucky, a 11-inch size limit increased the number of basses (mainly smallmouth) from 10.9 fish per acre in 1961 to 24.7 fish per acre in 1965 (Jones, 1968). The greatest increase was in intermediate-size fish but legal-size bass also increased in number.

The creel limit is apparently ineffective as a regulation to restrict the catch or to insure a more even distribution among anglers. In Lake Michigan, less than 10% of anglers catch a limit of five bass, and the creel limit would have to be reduced to one bass to realize a 50% decrease in the catch. Likewise the open season for smallmouth bass has not resulted in an increased harvest, as it has for the largemouth.

The stocking of fingerling bass to bolster existing populations in streams and lakes has been tried several times but with little success. However, in most cases, either the number of bass stocked was small or the evaluation was not complete. More stocking experiments are needed under strictly controlled conditions.

Table 1.--Computation of yield for a typical population of smallmouth bass in Michigan

Age group and month	Total length (inches)	Weight (pounds)	Growth rate g	Mortality rate Natural q	Mortality rate Fishing p	Weight of stock (pounds)	Yield (pounds)
0							
Dec	3.8	0.02	0.174	0.108	0.000	1000	
I							
Jun	4.0	0.03	1.896	0.679	0.000	1068	
Dec	7.5	0.21	0.231	0.120	0.000	3607	
II							
Jun	8.1	0.27	0.871	0.513	0.000	4032	
Dec	10.8	0.64	0.030	0.021	0.000	5769	
III							
Jun	10.9	0.66	0.438	0.456	0.382	5816	1856
Dec	12.6	1.02	0.049	0.059	0.000	3902	
IV							
Jun	12.8	1.07	0.358	0.502	0.382	3863	1173
Dec	14.4	1.53	0.020	0.032	0.000	2282	
V							
Jun	14.5	1.57	0.166	0.476	0.382	2254	646
Dec	15.3	1.84	0.020	0.059	0.000	1128	
VI							
Jun	15.4	1.88	0.174	0.481	0.382	1085	311
Dec	16.3	2.23	0.020	0.053	0.000	545	
VII							
Jun	16.4	2.27	0.166	0.481	0.382	527	150
Dec	17.3	2.67	0.020	0.053	0.000	262	
VIII							
Jun	17.4	2.72	0.122	0.471	0.382	254	71
Dec	18.1	3.06	0.020	0.064	0.000	122	
IX							
Jun	18.2	3.12	0.113	0.470	0.382	117	33
Dec	18.9	3.49	0.020	0.064	0.000	56	
X							
Jun	19.0	3.55	0.095	0.470	0.382	53	15
Dec	19.6	3.90	...	...	...	25	
Total							4255

Table 2.--Reported mortalities for smallmouth bass

Water	Author	Mortality Total a	Mortality Natural v	Mortality Fishing u
L. Michigan, Mich.	Latta, 1963	0.58	0.36	0.22
L. Huron, Ontario	White, 1970	0.57	0.23-0.46	0.09-0.33
South Bay, Ontario	Watt, 1959	0.60	....	....
Katherine L., Mich.	Clady, 1970	....	0.49, 0.46	....
Oneida L., N.Y.	Forney, 1961	0.52, 0.58, 0.18	0.34, 0.37, 0.13	0.18, 0.21, 0.05
Devoe L., Mich.	Patriarche, 1960	0.60	....	....
Oneida L., N.Y.	Forney, 1972	0.33	0.13	0.20
L. St. Clair, Mich.	Haas, 1973[a]	0.46, 0.47, 0.54	....	....
Red Cedar R., Wisc.	Paragamian and Coble, 1975	0.55	0.26	0.29
L. Michigan, Wisc.	Wiegert, 1966	....	....	0.16

[a] Personal communication R. C. Haas, Michigan Department of Natural Resources.

Table 3.--Age and size of smallmouth bass at maturity

Water	Author	Age	Males: Average length	Males: Percent mature	Females: Average length	Females: Percent mature
Waugoshance Pt., L. Michigan, Mich.	Latta, 1963	III	10.2	22	....	0
		IV	9.9	84	12.8	10
		V	10.9	100	12.7	19
		VI	....	...	12.5	65
		VII	....	...	14.2	100
South Bay, L. Huron, Ont.	Fraser, 1955	III	9.2 [a]	50	9.2 [a]	0
		IV	10.4	78	10.4	42
		V	11.6	92	11.6	75
		VI	12.8	100	12.8	100
St. Lawrence R. L. Ontario, N.Y.	Stone et al., 1954	IV	10.3 [b]	few	.... [b]	...
		VI	11.9	100	11.9	few
		VIII	....	...	13.7	100
Tadenac L., Ont.	Turner and MacCrimmon 1970	IV	9.1 [b]	33	9.1 [b]	9
		V	11.5	88	11.5	82
		VI	12.4	100	12.4	100
Cayuga L., N.Y.	Webster, 1954	II	9.2	41	....	0
		III	....	100	11.8	13
		IV	....	...	12.4	62
		V	....	...	....	100

[a] Fork length rather than total for fish examined in census and nets.

[b] Growth figures for entire population.

Table 4.--Annual harvest and standing crop for smallmouth bass in Michigan

Water and size (acres)	Standing crop (pounds per acre)	Harvest (pounds per acre)	Author
Fife L. (619)	12.5	...	Cooper, 1952
	....	1.1	Taube, 1965
Cub L. (28)	1.6	...	Clady, 1970
Marsh L. (65)	4.6	...	Clady, 1970
Katherine L. (48)	9.7	...	Clady, 1970
North Twin L. (27)	2.0	...	Schneider, 1975, personal communication
Big Bear L. (362)	3.0	...	" " "
Cadillac L. (1150)	1.0	...	" " "
Bear L. (1740)	....	1.3	Taube, 1965
Red Cedar R. (17.5)	13.3	...	Vannote and Ball, 1972

Table 5.--Yield per 1000 pounds of recruits for smallmouth bass at four rates of exploitation and various minimum sizes

Minimum size limit (inches)	Rate of exploitation			
	0.15 [a] (1/2 p)	0.25 (1 p)	0.45 (2 p)	0.55 (3 p)
8.0 (8.1) [b]	3,261	4,426	5,106	5,311
10.0 (10.9)	2,931	4,255	5,451	6,132
12.0 (12.8)	2,330	3,516	4,749	5,534
14.0 (14.5)	1,699	2,633	3,686	4,404
16.0 (16.4)	769	1,245	1,812	2,193
18.0 (18.2)	270	474	767	981

[a] Instantaneous fishing mortality rate p equals 0.382.

[b] Actual total length in inches in June at opening of the fishing season.

Table 6.--Biomass per 1000 pounds of recruits for smallmouth bass 10.9 inches total length (age III) and longer in June of each year of life at four rates of exploitation and various minimum sizes

Minimum size limit (inches)	Rate of exploitation			
	0.15[a] (1/2 p)	0.25 (1 p)	0.45 (2 p)	0.55 (3 p)
8.0 (8.1)[b]	14,936	9,535	4,668	2,624
10.0 (10.9)	18,077	13,969	10,016	8,247
12.0 (12.8)	20,655	17,759	14,829	13,459
14.0 (14.5)	22,586	20,679	18,671	17,711
16.0 (16.4)	24,787	24,100	23,274	22,834
18.0 (18.2)	25,654	25,543	25,375	25,261

[a] Instantaneous fishing mortality p equals 0.382.

[b] Actual total length in inches in June at opening of the fishing season.

Table 7.--Number of smallmouth bass per 1000 pounds of recruits, 8 to 18 inches or longer, expected to be harvested at four rates of exploitation and various minimum sizes

Minimum size limit (inches)	Length category (inches)	Rate of exploitation			
		0.15 [a] (1/2 p)	0.25 (1 p)	0.45 (2 p)	0.55 (3 p)
8.0 (8.1) [b]	8 or longer	3,786	5,889	8,128	9,425
	10 "	1,944	2,551	2,499	2,052
	12 "	956	1,046	707	400
	16 "	107	69	15	2
	18 "	21	10	1	0
10.0 (10.9)	10 "	2,352	3,734	5,366	6,452
	12 "	1,157	1,530	1,519	1,257
	16 "	130	100	33	8
	18 "	25	14	3	0
12.0 (12.8)	12 "	1,401	2,241	3,259	3,955
	16 "	156	146	70	27
	18 "	30	21	5	1
14.0 (14.5)	14 "	835	1,352	2,000	2,465
	16 "	189	214	149	87
	18 "	37	30	10	4
16.0 (16.4)	16 "	277	460	690	854
	18 "	53	65	48	30
18.0 (18.2)	18 "	79	139	226	291

[a] Instantaneous fishing mortality rate p equals 0.382.

[b] Actual total length in inches in June at opening of the fishing season.

Table 8.--Number of smallmouth bass per 1000 pounds of recruits, 10 to 18 inches or longer, estimated to be present in the June biomass at four rates of exploitation and various minimum sizes

Minimum size limit (inches)	Length category (inches)	Rate of exploitation 0.15[a] (1/2 p)	0.25 (1 p)	0.45 (2 p)	0.55 (3 p)
8.0 (8.1)[b]	10 or longer	14,221	10,104	5,681	3,461
	12 "	6,939	4,089	1,575	658
	16 "	756	258	33	5
	18 "	47	10	1	0
10.0 (10.9)	10 "	17,212	14,803	12,190	10,872
	12 "	8,400	5,991	3,378	2,060
	16 "	914	378	69	13
	18 "	57	15	1	0
12.0 (12.8)	10 "	18,979	17,589	16,062	10,020
	12 "	10,167	8,777	7,250	1,208
	16 "	1,107	553	148	42
	18 "	69	22	2	0
14.0 (14.5)	10 "	20,009	19,218	18,333	17,879
	12 "	11,197	10,406	9,521	9,067
	16 "	1,340	810	318	133
	18 "	84	32	5	1
16.0 (16.4)	10 "	20,947	20,722	20,447	20,296
	12 "	12,135	11,910	11,635	11,484
	16 "	1,963	1,738	1,463	1,312
	18 "	123	69	22	7
18.0 (18.2)	10 "	21,231	21,200	21,152	21,120
	12 "	12,419	12,388	12,340	12,308
	16 "	2,247	2,216	2,168	2,136
	18 "	180	149	101	69

[a] Instantaneous fishing mortality rate p equals 0.382.

[b] Actual total length in inches in June at opening of the fishing season.

Table 9.--Number of smallmouth bass fall fingerlings estimated to survive from the June biomass. The ratio of fall fingerlings produced to fingerlings per 1000 pounds of recruits needed is in parentheses.

Minimum size (inches)	Rate of exploitation			
	0.15[a] (1/2 p)	0.25 (1 p)	0.45 (2 p)	0.55 (3 p)
10.0 (10.9)[b]	78,567	46,409	19,777	10,118
	(2.1)	(1.3)	(0.5)	(0.3)
12.0 (12.8)	95,175	68,011	42,428	31,721
	(2.6)	(1.8)	(1.1)	(0.9)

[a] Instantaneous fishing mortality p equals 0.382.

[b] Actual total length in inches in June at opening of the fishing season.

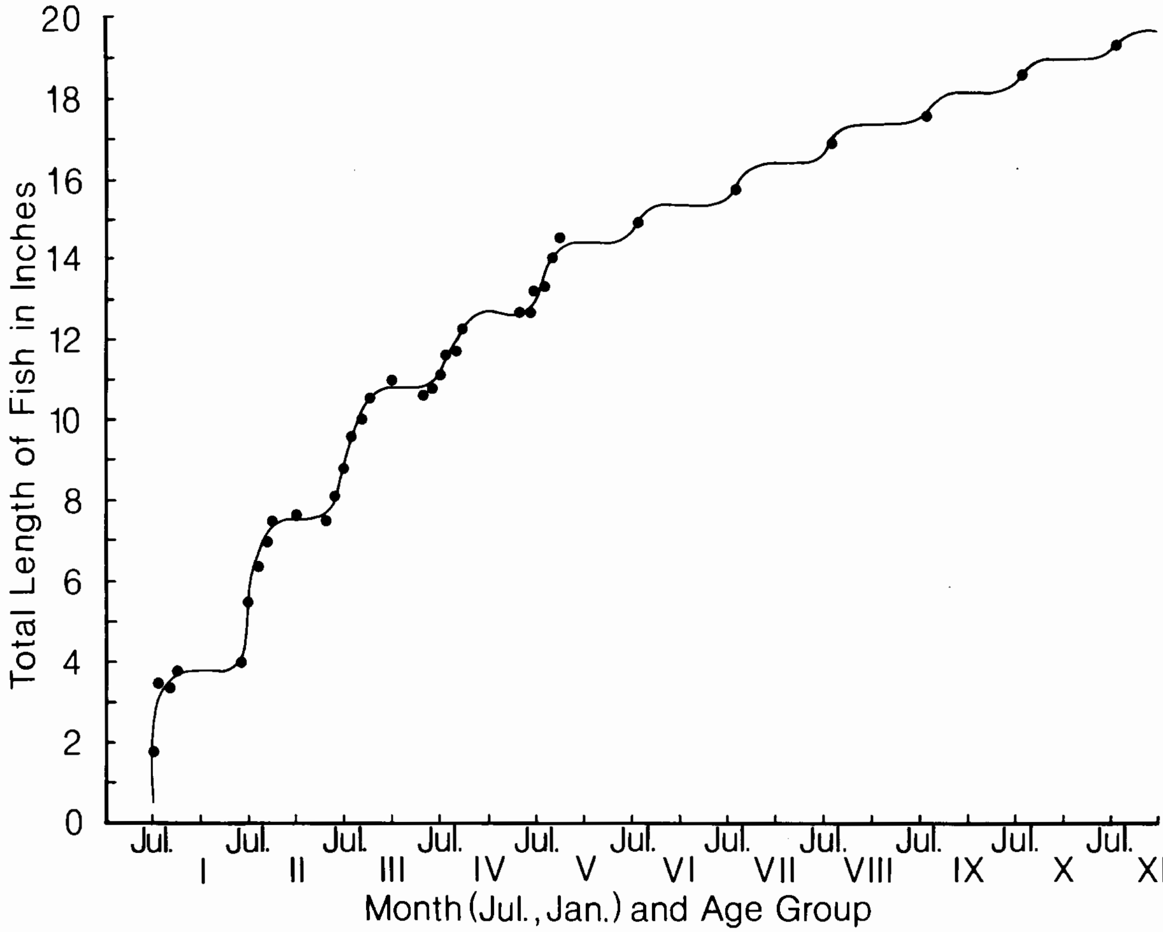

Figure 1.--Average seasonal growth in length of smallmouth bass in Michigan.

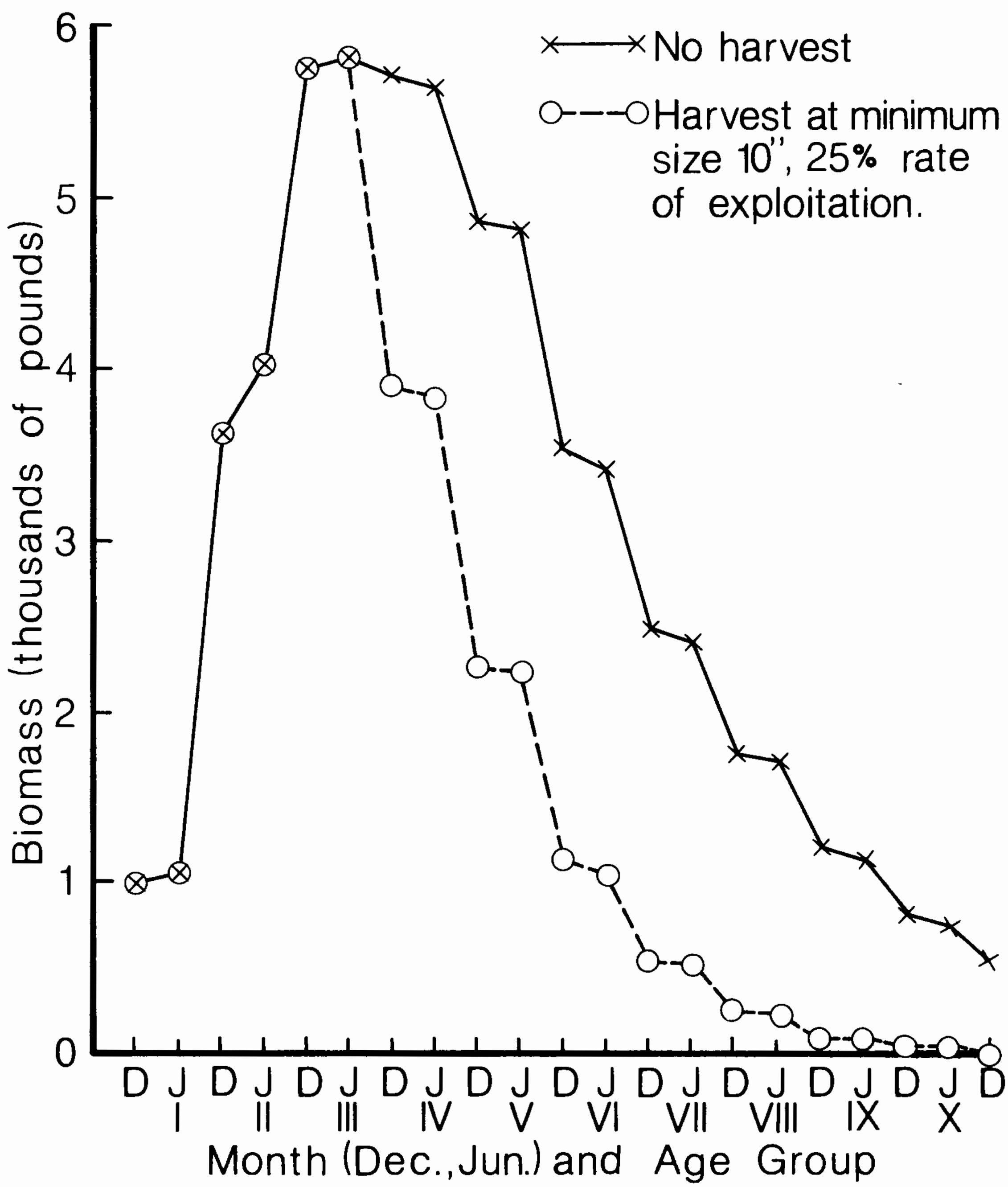

Figure 2.--Biomass of smallmouth bass in a typical population in Michigan, without harvest, and with harvest at a minimum size of 10 inches and a 25% rate of exploitation.

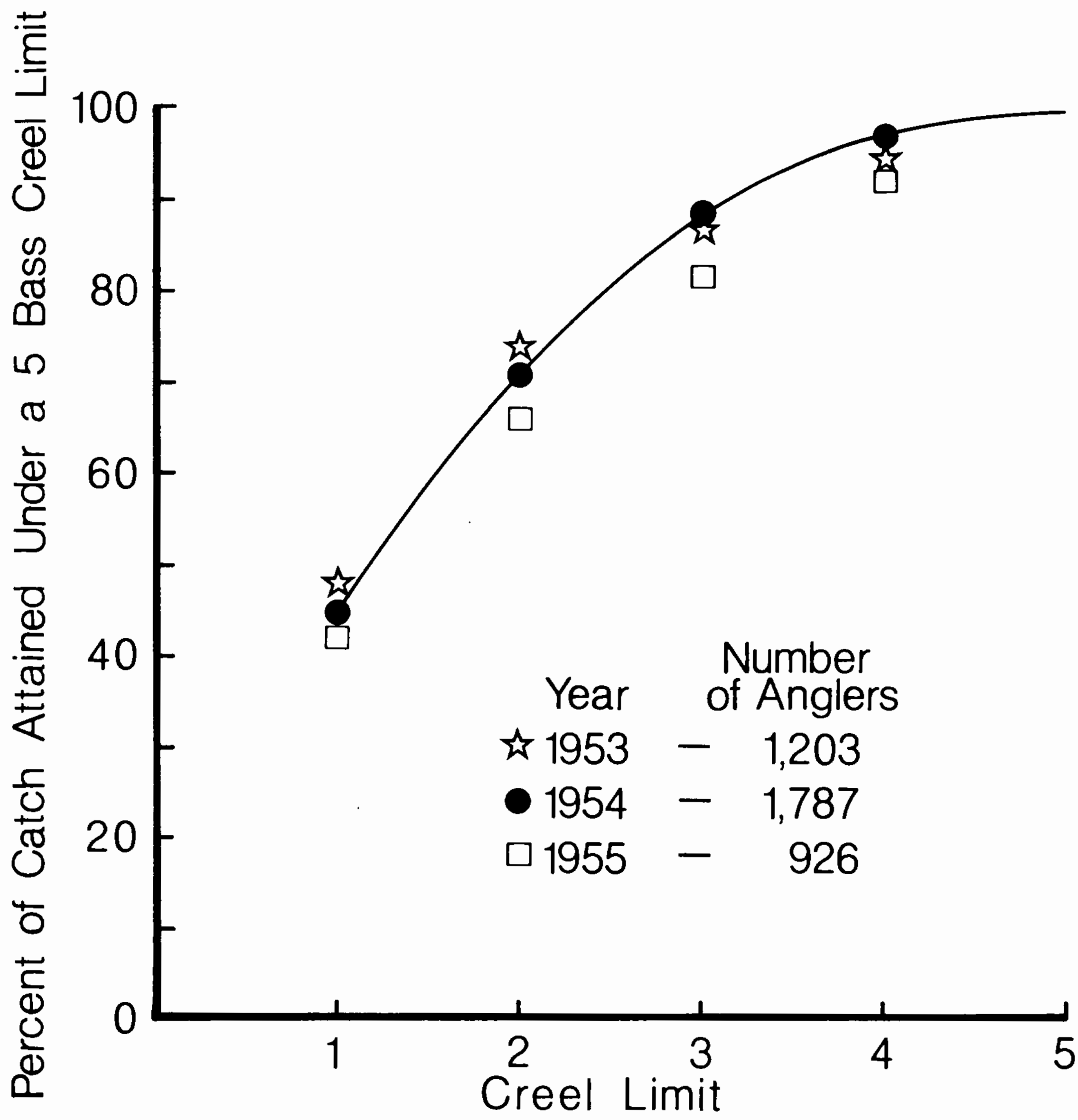

Figure 3.--Effect of creel limits of less than 5 in reducing the catches of smallmouth bass at Waugoshance Point, Lake Michigan, 1953-55.

Literature cited

Beckman, William C. 1949. The rate of growth and sex ratio for seven Michigan fishes. Trans. Amer. Fish. Soc., 76(1946): 63-81.

Bennett, George W., and William F. Childers. 1957. The smallmouth bass, Micropterus dolomieui, in warm-water ponds. J. Wildl. Manage., 21(4): 414-424.

Bennett, George W., and William F. Childers. 1972. Thirteen-year yield of smallmouth bass from a gravel pit pond. J. Wildl. Manage., 36(4): 1249-1253.

Brown, Edward H., Jr. 1961. Movement of native and hatchery-reared game fish in a warm-water stream. Trans. Amer. Fish. Soc., 90(4): 449-456.

Carlander, Kenneth D. 1955. The standing crop of fish in lakes. J. Fish. Res. Bd. Canada, 12(4): 543-570.

Christie, W. J., and H. A. Regier. 1973. Temperature as a major factor influencing reproductive success of fish--two examples. Consul International pour L'Exploration de la Mer, Rapports et Procès-Verbaux, 164: 208-218.

Churchill, Warren. 1957. Conclusions from a ten-year creel census on a lake with no angling restrictions. J. Wildl. Manage., 21(2): 182-188.

Clady, Michael D. 1970. Regulation of fish populations in three lightly exploited lakes in northern Michigan. PhD thesis, Univ. Mich., Ann Arbor, 86 pp.

Clady, Michael D. 1975. Early survival and recruitment of smallmouth bass in northern Michigan. J. Wildl. Manage., 39(1): 194-200.

Cleary, Robert E. 1956. Observations on factors affecting smallmouth bass production in Iowa. J. Wildl. Manage., 20(4): 353-359.

Cooper, Gerald P. 1952. Estimation of fish populations in Michigan lakes. Trans. Amer. Fish. Soc., 81(1951): 4-16.

Fajen, Otto. 1974. A foot closer to good stream fishing. Missouri Dep. Conserv., The Conservationist, 35(4): 10-11.

Fedoruk, A. N. 1966. Feeding relationship of walleye and smallmouth bass. J. Fish. Res. Bd. Canada, 23(6): 941-943.

Forney, John L. 1961. Growth, movements and survival of smallmouth bass (Micropterus dolomieui) in Oneida Lake, New York. N.Y. Fish Game J., 8(2): 88-105.

Forney, John L. 1972. Biology and management of smallmouth bass in Oneida Lake, New York. N.Y. Fish Game J., 19(2): 132-154.

Fraser, J. M. 1955. The smallmouth bass fishery of South Bay, Lake Huron. J. Fish. Res. Bd. Canada, 12(1): 147-177.

Fry, F. E. J., and K. E. F. Watt. 1957. Yields of year classes of the smallmouth bass hatched in the decade of 1940 in Manitoulin Island waters. Trans. Amer. Fish. Soc., 85: 135-143.

Funk, John L., and George G. Fleener. 1966. Evaluation of a year-round open fishing season upon an Ozark smallmouth bass stream, Niangua River, Missouri. Missouri Dep. Conserv., Div. Fish. D-J Series No. 2, 21 pp.

Funk, John L., and George G. Fleener. 1974. The fishery of a Missouri Ozark stream, Big Piney River, and the effects of stocking fingerling smallmouth bass. Trans. Amer. Fish. Soc., 103(4): 757-771.

Jones, Albert R. 1968. Changes in the bass population of Elkhorn Creek following the establishment of a size limit. Kentucky Dep. Fish Wildl. Res., Fish. Bull. No. 45, 34 pp.

Laarman, Percy W. 1963. Average growth rates of fishes in Michigan. Michigan Dep. Conserv., Inst. Fish. Res. Rep. No. 1675, 9 pp.

Larimore, R. Weldon. 1954. Dispersal, growth, and influence of smallmouth bass stocked in a warm-water stream. J. Wildl. Manage., 18(2): 207-216.

Latta, William C. 1963. The life history of the smallmouth bass, Micropterus d. dolomieui, at Waugoshance Point, Lake Michigan. Michigan Dep. Conserv., Inst. Fish. Res. Bull. No. 5, 56 pp.

Latta, W. C. 1974. Fishing regulations for largemouth bass in Michigan. Michigan Dep. Nat. Resources, Fish. Res. Rep. No. 1818, 38 pp.

Martin, N. V., and F. E. J. Fry. 1972. Lake Opeongo: Effects of exploitation and introductions on the salmonid community. J. Fish. Res. Bd. Canada, 29(6): 795-805.

Moen, Tom. 1960. Survival of stocked smallmouth bass in Iowa natural lakes. Iowa Conserv. Comm., Quart. Biol. Rep. 12(4): 5-10.

Mraz, Donald. 1964. Observations on large and smallmouth bass nesting and early life history. Wisc. Conserv. Dep., Res. Planning Div., Fish. Res. Rep. No. 11, 13 pp.

Neves, Richard J. 1975. Factors affecting fry production of smallmouth bass (Micropterus dolomieui) in South Branch Lake, Maine. Trans.. Amer. Fish. Soc., 104(1): 83-87.

Paragamian, Vaughn L., and Daniel W. Coble. 1975. Vital statistics of smallmouth bass in two Wisconsin rivers and other waters. J. Wildl. Manage., 39(1): 201-209.

Patriarche, Mercer H. 1960. A twelve-year history of fishing in the lakes of the Rifle River Area, Ogemaw County, Michigan, 1945-1956. Mich. Dep. Conserv., Inst. Fish. Res., Misc. Publ. No. 13, 45 pp.

Paulik, G. J., and William H. Bayliff. 1967. A generalized computer program for the Ricker model of equilibrium yield per recruitment. J. Fish. Res. Bd. Canada, 24(2): 249-259.

Pflieger, William L. 1966. Reproduction of the smallmouth bass (Micropterus dolomieui) in a small Ozark stream. Amer. Midl. Nat., 76(2): 410-418.

Ricker, W. E. 1954. Stock and recruitment. J. Fish. Res. Bd. Canada, 11(5): 559-623.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Bd. Canada No. 119, 300 pp.

Saila, Saul B. 1958. Size limits in largemouth black bass management. Trans. Amer. Fish. Soc., 87(1957): 229-239.

Stone, Udell B., Donald G. Pasko, and Robert M. Roecker. 1954. A study of Lake Ontario-St. Lawrence River smallmouth bass. N. Y. Fish Game J., 1(1): 1-26.

Surber, Eugene W. 1969. Effects of a 12-inch size limit on smallmouth bass populations and fishing pressure in the Shenandoah River, Virginia. Proc. S.E. Assoc. Game Fish Comm., 22: 300-311.

Taube, C. M. 1965. Evaluation of fish management procedures. Dingell-Johnson Final Project Report, F-27-R-2, Work Plan No. 2, pp. 11-51.

Turner, Gary E., and Hugh R. MacCrimmon. 1970. Reproduction and growth of smallmouth bass, Micropterus dolomieui, in a Precambrian lake. J. Fish. Res. Bd. Canada, 27(2): 395-400.

Vannote, Robin L., and Robert C. Ball. 1972. Community productivity and energy flow in an enriched warm-water stream. Mich. State Univ., Inst. Water Res. Tech. Rep. No. 27, 156 pp.

Watt, Kenneth E. F. 1959. Studies on population productivity. II. Factors governing productivity in a population of smallmouth bass. Ecol. Monogr., 29: 367-392.

Webster, Dwight A. 1954. Smallmouth bass, Micropterus dolomieui, in Cayuga Lake. Part 1. Life history and environment. Cornell Univ. Agr. Exp. Sta. Memoir 327, 39 pp.

White, Wesley James. 1970. A study of a population of smallmouth bass Micropterus dolomieui Lacépède at Baie du Doré, Ontario. MS thesis, Univ. Toronto, Toronto, 83 pp.

Wiegert, Lawrence. 1966. A four-year study of the smallmouth bass in the outlying waters of Door County, Wisconsin. Wisc. Conserv. Dep., Fish Div. Manage. Rep. No. 1, 10 pp.

Report approved by G. P. Cooper

Typed by M. S. McClure