1881

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Fisheries Research Report No. 1881
March 27, 1980

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

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VITAL STATISTICS OF THE FISH POPULATION IN MANISTEE LAKE, KALKASKA COUNTY, WITH SPECIAL EMPHASIS ON MORTALITY AND EXPLOITATION OF STOCKED 15-CM WALLEYE FINGERLINGS [1]

By Percy W. Laarman

Abstract

Walleyes stocked as 11- to 17-cm fingerlings in Manistee Lake, Kalkaska County from 1974 to 1977, had an average total mortality rate of 74% one year subsequent to planting. The mean total annual mortality rate of age-groups II-VII native and stocked walleyes was 56%. Mean total mortality rates of smallmouth bass, bluegills, pumpkinseeds, and black crappie were 60%, 66%, 72%, and 58%, respectively.

Fishing pressure was 35 angler hours per hectare in 1976, 16 in 1977, and 60 in 1978. For the same 3-year period, exploitation rate of all walleyes ranged from 3 to 35% with a mean of 17%. Eventually, an estimated 3.5% of the stocked walleyes will be harvested by anglers. Although the stocked fingerlings made a significant contribution to the walleye population in the lake, returns to the angler probably were not sufficient to justify raising the fingerlings to 15 cm prior to planting. The mean exploitation rates of smallmouth bass, bluegills, pumpkinseeds, and black crappie were 13%, 17%, 8%, and 19%, respectively.

Growth rates of all species except yellow perch exceeded the statewide average growth rates of fishes in Michigan.

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

Introduction

The literature pertaining to stocking and survival of walleyes (Stizostedion vitreum vitreum) is voluminous, but little information is available on survival of fingerlings stocked at lengths of 12 cm or larger (Laarman 1978). Schneider (1969) reviewed the plantings of walleye fingerlings made in Michigan for the years 1951-1963. Most walleyes were planted as fingerlings less than 9 cm long, and generally returns to the angler were not impressive. Johnson (1971), in a study in Minnesota of 13 lakes stocked with walleyes, reported that in years when stocking made a contribution to the fishery, the stocked fingerlings were larger than in years when stocking was not successful. In Michigan, native walleyes are usually 15 to 18 cm by the end of the first growing season. The hypothesis was that fingerlings stocked at that size would survive better than if stocked at the usual size of 9 cm or less.

The main objective of this study was to determine annual mortality and exploitation rates of walleye fingerlings stocked at 15 cm in length at an annual rate of 25 per hectare. A secondary objective was to determine abundance and mortality rates of other species of fish in the lake.

Study lake

Manistee Lake, Kalkaska County, is located in the north central part of the lower peninsula of Michigan. It covers an area of 348 hectares, has a maximum depth of 5.5 m, and a mean depth of 2 m. The water has a surface M. O. alkalinity ranging from 73 to 76 ppm and usually does not stratify. The bottom in the shallow water consists of sand, organic material, and a very limited amount of gravel while soft organic material is prevalent in the deeper water. Submerged vegetation is abundant but floating and emergent plants are sparse. About 75% of the shoreline is developed with cottages and permanent homes. Public access is available from a township park. Four small intermittent streams enter the northern part of the lake from lowlands. The one outlet flows through a culvert underneath County Road 612 and is the headwaters of a tributary of the Manistee River.

History of fish population

Prior to 1946, species stocked were walleyes, smallmouth bass (Micropterus dolomieui), largemouth bass (Micropterus salmoides), bluegill (Lepomis macrochirus), and yellow perch (Perca flavescens). In 1955, a biological survey was conducted and the results indicated an excellent population of walleyes, and numerous yellow perch, smallmouth bass, largemouth bass, pumpkinseed (Lepomis gibbosus), and rock bass (Ambloplites rupestris). In July 1967, a fish survey with boomshocker failed to find walleyes younger than age II. In 1969, 1971, and 1972, about 1 million walleye fry per year were stocked. Surveys with a boomshocker in October 1969, August 1970, and July 1972, failed to find evidence of survival of the stocked fry.

Before the early 1960's, the lake was known as one of the best walleye lakes in the area. A partial creel census conducted from 1 December 1935 to 15 April 1937 showed that of 1,957 fish seen by census clerks, 10% were walleyes. From 1956 to 1963, 54% of the fish harvested by anglers and recorded by Conservation Officers during the course of their normal duties on the lake were walleyes. Growth rates of all fish in the lake have been consistently average or better.

Methods

Experimental stockings of walleye fingerlings were made from 1972 to 1978. Fingerlings were marked by clipping left pelvic fins in even-numbered years and right pelvic fins in odd-numbered years, except in 1977, when right pectoral fins were clipped. Churchill (1963) reported that clipping those fins did not affect survival or growth of walleye fingerlings. Deaths due to handling and transportation were estimated at stocking, and subtracted from the total to determine net numbers stocked and subsequent survival rates.

Population estimate data (mark-and-recapture) were obtained by trap netting from mid-September to mid-October, 1973-1978. Twelve nets were lifted 6 days per week for 5 weeks. Three nets were used in each quadrant of the lake. Placement of nets was determined from a numbered

grid overlaid on a map of the lake. One net per quadrant was moved daily according to a predetermined grid selection which insured a random coverage of the entire lake.

Population estimates were calculated with the Schumacher-Eschmeyer formula (Schumacher and Eschmeyer 1943). Estimates were stratified by 2.5-cm groups when possible, although sometimes several centimeter groups were pooled. Symmetrical (instead of asymetrical) confidence limits were calculated, so that the variances of stratified estimates could be combined.

About 30 scale samples per 2.5-cm group per species were collected for age determinations. Growth rates of fishes in Manistee Lake were compared with the statewide mean growth of fishes in Michigan (Laarman 1963) as determined by the mean growth index. The mean growth index for a species is the mean deviation in length of represented age groups from the statewide average. Only age groups containing at least five fish were used.

Age-specific population estimates for walleye, smallmouth bass, bluegill, pumpkinseed, and black crappie (Pomoxis nigromaculatus) were determined by the method reported by Ketchen (1950). Basically, the method consists of determining the age composition from scale samples of fish per stratified length group. The percent represented by each age group within a stratified length group multiplied by the population estimate of that length group gave the age-specific population estimate per stratified length group. Population estimates of identical ages from stratified length groups were added to determine the age-specific population estimate for a species.

Annual survival rates were determined from smoothed age-specific population estimates. The data were smoothed by calculating the mean of five year-class estimates per age group. Variances on the age-group estimates were used to determine confidence intervals on the mean. This procedure reduced the influence of year-class strength on the estimated survival rate.

A creel census was conducted from 1 December 1975 to 30 November 1978, according to a predetermined statistically designed schedule based on a 40-hour biweekly time table, except during the summer of 1978, when 40 hours per week were used. During the winter (1 December-31 March) the schedule included two shifts ranging from 0700 to 2000 hours. Three shifts including 0600 to 2200 hours were used from 1 April to 30 November. Three counts of anglers were made per working day. About 20% of the estimated number of anglers were contacted by the census clerk.

Annual mortality rates are those defined by Ricker (1975): total (A), fishing or exploitation (u), and natural (v). The mean total mortality rate per species was determined from mean survival rates. For the three years of creel census (1976-78), confidence intervals on the mean total mortality rates were based on population estimates made each fall and the number of survivors from that estimate. Lengths of fish were similar for age groups included in estimates of total mortality rate and those age groups harvested by anglers. Annual exploitation rates (1976-78) were determined from the population estimate in the fall and the number of fish harvested by anglers the following year. Recruitment due to growth was considered by using population estimates of the length fish that would be vulnerable to angling during the succeeding year. For example, few bluegills less than 15 cm long appeared in the anglers' creel; therefore I used the population estimate of 14 cm and longer in the fall of 1975 as the number of bluegills available to the angler in 1976. The length used as the recruitment base for pumpkinseed was 14 cm; for black crappie 17.8 cm; smallmouth bass 27.9 cm; and walleye 35.6 cm. Beginning in 1976, the minimum legal size limit for smallmouth bass was 30.5 cm and for walleye 38.1 cm.

Since weights of fish were not taken in the field, biomass of the fish population was determined from unpublished data on the length-weight relationships of fishes in Michigan. The estimated number of fish per 2.5-cm length group times the mean weight of the mid-point of that length group gave the total weight per length group. Weights of each length group were added to obtain the total weight per species. Confidence intervals on

standing crops were determined from variances on the population estimates and a constant 10% variation on weights. The variation on weights was assumed to be reasonable, although actual data were not available.

Results

The goal of stocking 15-cm walleye fingerlings at the annual rate of 25 per hectare was not achieved. During the first 3 years of scheduled stocking, especially, there were difficulties in raising large numbers of fingerlings to the desired size. The net stocking rates were 4.0, 0.9, 6.7, 20.0, 17.7, 21.8, and 20.9 per hectare, in 1972-78, respectively (Table 1). Mean length of the stocked fingerlings ranged from 10.9 cm in 1973 to 17.1 cm in 1976. Estimated initial stocking mortality due to handling and transportation ranged from 2-16% with a mean of 10%.

Population estimates for 10 species of fishes are given in Table 2. Estimates are for fish larger than the following lengths: walleye, 27.9 cm; bluegill, pumpkinseed, and rock bass, 14.0 cm; black crappie and yellow perch, 17.8 cm; smallmouth bass, largemouth bass, and white sucker (Catostomus commersoni), 22.9 cm; and northern pike (Esox lucius), 45.7 cm. Although wide confidence intervals on many of the estimates prohibit interpretation of species interrelationships, some changes in the populations were evident. In 1973, the smallest walleye collected was 41 cm long and the population consisted of age-group III and older fish. The disappearance of old fish and paucity of young fish were reflected in the low population estimates in 1974 and 1975. Effects of the stocking program became evident in 1976 with an increase in the number of smaller fish. In 1976, the walleye population increased to the 1973 level and remained there through 1978. Large year classes of bluegills and pumpkinseeds were produced in 1973 and began to appear in the nets as age II fish in 1975. The population estimates of 1976 and 1977 continued to reflect the abundant 1973 year classes of bluegills and pumpkinseeds. The population of black crappie was significantly larger in 1975 to 1978 than in 1973 and 1974, but it was not dominated by a single year class. Relatively large year classes of yellow perch in 1972-74 bolstered the population estimates

beginning in 1975. Changes in abundance of other species were not evident.

Growth rates of walleyes were more rapid than the statewide average (Table 3). There was an increase in growth from 1973 to 1976, and a decline beginning in 1977.

All species except yellow perch were growing consistently faster than the statewide average as shown by the mean growth index (Table 4). The mean growth index for yellow perch decreased from +4.3 cm in 1973 to +0.3 in 1975 and decreased further to -1.9 in 1978. Age groups IV and V (1973 and 1974 year classes) had the greatest reduction in growth during 1978. The increase in abundance of those year classes may have contributed to their decline in growth.

The contribution of stocked walleye fingerlings to the population was evident from the proportion of fin-clipped fish to the total number (all lengths) collected in trap nets (Table 5). Experimentally stocked walleyes collected in nets increased from 0% in 1973 to 92% in 1977.

Apparently a very low level of natural reproduction of walleyes occurs in the lake. Non-clipped walleyes less than 35.6 cm (mostly young-of-the-year and age I) collected in trap nets reached a high of 16% in 1978 (Table 6). Forty of the 64 non-clipped fish collected in 1978 were age I. In 1977, while estimating initial stocking mortality, I found that some stocked fingerlings had not been fin clipped; therefore, 4-6% would probably be a more realistic figure for non-stocked fish collected in 1978. I did not find evidence of stocked fingerlings without a fin clip in other years.

Estimated fishing pressure, total catch, and catch per hour are given in Table 7. Annual fishing pressure was low compared to other lakes in Michigan. The number of angler hours per hectare ranged from 16 in 1977 to 60 in 1978. From 1946 to 1950, the mean fishing pressure on 12 Michigan lakes ranged from 121 to 654 hours per hectare (Christensen 1953). One of the 12 lakes, Fife Lake, located in the same general area as Manistee Lake, had a mean fishing pressure of 222 hours per hectare.

For the 3 years (1976-1978) at Manistee Lake, the mean catch per hour was 1.0 fish, and there was no significant difference between years.

Walleyes represented a small percentage of the total number of fish harvested, ranging from 0.2% in 1977 to 4% in 1978 (Table 8). About 54% of the walleyes harvested in 1978 were fin-clipped, according to the census clerk. However, I observed that 85% of the walleyes 35.6 cm and larger taken in trap nets during the fall of 1977, were fin-clipped; these fish should have reached the minimum legal length of 38.1 cm during 1978 and thus should have been available to anglers. The difference between 54% and 85% in harvested vs. netted marked walleyes may have been due to partial regeneration of clipped fins, a process which I observed while netting. The census clerk may have failed to recognize partially regenerated fins as stocked fish.

Annual survival rates of the 1974-77 stocked walleyes were determined from separate population estimates of those fish (Table 9). Insufficient numbers of fish were collected from the 1972 and 1973 plantings for separate estimates. Annual survival rates after 1 year in the lake of the 1974-77 plants were 25%, 27%, 21%, and 30%, respectively, with a mean of 26% (±5). Two years subsequent to planting, survival rates were 17%, 24%, and 10% for the respective 1974-76 plants. Three years after stocking, 12% and 22% of the 1974 and 1975 planted fish had survived. Survival 4 years subsequent to stocking was 7% for the 1974 planting.

Age-specific population estimates for stocked and native walleye, smallmouth bass, bluegill, pumpkinseed, and black crappie are given in Tables 10, 11, 12, 13, and 14, respectively. Variances were too large on population estimates of the other species to merit age-specific estimates. Based on point estimates, the annual survival rates of age-groups II-V walleyes were relatively constant, ranging from 56% to 74%, but survival of older walleyes was lower (Table 15). The mean survival rate for age-groups II-VIII was 44% (±12).

No significant differences in survival were evident among age groups of smallmouth bass (Table 16). The mean survival rate for age-groups II-VI was 40% (±34).

The overall survival rates of age groups III-VI bluegills and pumpkinseed were similar with respective means of 34% (±18) and 28% (±8) (Tables 17 and 18). Survival of all bluegills was similar, but survival of age-groups V and VI pumpkinseeds was significantly lower than for age-groups III and IV.

Annual survival rates of black crappie ranged from 62% for age-group IV to 15% for age-group V (Table 19). The mean survival rate for age-groups II-VI was 42% (±9).

Total annual mortality is complementary to annual survival and it can be divided into two components: harvest by anglers and death from all other causes. From population estimates (Table 2), creel census data (Table 8) and overall average survival rates (based on Tables 15-19), total, fishing, and natural mortalities were determined for walleyes, smallmouth bass, bluegills, pumpkinseeds, and black crappie (Tables 20-24). As a starting point in the calculations, the same rate of mean total mortality per species was assumed for each of the years.

For walleyes age II and older, the mean total annual mortality was 56% (±36) (Table 20). The broad confidence interval encompasses mortality rates reported in the literature for walleyes of similar ages. Kempinger and Carline (1977) reported total mortality ranged from 31-68% for age III+ walleyes in Escanaba Lake, Wisconsin. Total mortality rates ranged from 20% to 80% from 12 bodies of water in North America (Schneider 1978). In Manistee Lake, annual fishing mortality based on walleyes 35.6 cm or larger, which included the larger fish of age-group II and all fish in the older age groups, ranged from 3% to 35%, with a mean of 17%. Fishing mortality exceeded natural mortality in 1978 when fishing pressure was greatest.

Total mortality for smallmouth bass was 60%, and the mean fishing mortality was 13% (Table 21). Confidence intervals for total mortality were extremely wide (±70%), although the point estimate was within the range of 43%-66% reported for 12 different smallmouth bass populations by Coble (1975). Fishing mortality was only 1% in 1977, the year that fishing pressure was lowest.

Total mortality rates for bluegills and pumpkinseeds were 66% and 72%, respectively (Tables 22, 23). Schneider (1971) reported total mortality for bluegills ranged from 66%-82% in eight populations open to angling. The 5-year average (1948-1952) for total mortality of pumpkinseed in Sugarloaf Lake, Michigan, was 81% (Cooper and Latta 1954). In Manistee Lake, mean fishing mortality was 17% for bluegills and 8% for pumpkinseeds. Fishing mortality was greatest for both species in 1978.

For black crappie, total mortality was 58%; anglers harvested 19% (Table 24). The lowest fishing mortality (14%) occurred in 1978 when fishing pressure was highest. Cooper and Latta (1954) reported a 5-year mean of 81% total mortality and 28% fishing mortality from Sugarloaf Lake.

A large amount of effort is required to obtain reliable population estimates so that mortality rates of fish populations in lakes can be calculated. During the study more than 1,800 trap-net lifts were made, plus for 3 years a creel census was conducted. In spite of the effort expended, most of the mortality rates had wide confidence intervals. However, the confidence intervals did encompass the majority of point estimates reported in the literature.

Fall standing crops of fish were calculated using the population estimates given in Table 2. The mean standing crop from 1973 to 1978 was about 48 kg per hectare (Table 25). There was no significant difference among years. White suckers represented from 22% to 47% of the biomass. Schneider (1973) reported that lakes in Michigan with fish populations of normal species diversity and growth averaged about 98 kg per hectare. He adjusted his data to include species and sizes not vulnerable to trap nets. A similar adjustment to the standing crop estimate for Manistee Lake increases that figure to 100 kg per hectare, almost identical to the Michigan average.

Discussion

From 1972 to 1976, about 18,250 walleye fingerlings were stocked of which 15,000 had the potential of reaching the legal minimum length of 38.1 cm before the creel census was terminated. Of the 15,000, an

estimated 388 (2.6%) were harvested by anglers. The 2.6% is a conservative estimate since some stocked fish were probably harvested prior to the beginning of the census on 1 December 1975 and more would be caught after the census was terminated on 30 November 1978. Based on the mean total mortality and exploitation rates, I estimated that about 640 walleyes or 3.5% of the stocked fish would be harvested by anglers.

The costs of raising walleye fingerlings to a length of 15 cm prior to stocking are not available. The costs for raising smaller fingerlings were used to calculate comparable figures for raising fingerlings to a length of 15 cm. In 1974, the average cost to raise a fingerling to a length of 5.1 cm in rearing ponds was $0.04 (Anonymous 1975). Although the contribution to anglers from stocking smaller fingerlings has varied considerably, a 1% return has been used as an average. This results in a cost of $4.00 for each walleye harvested. Since angler harvest of stocked 15-cm fingerlings was 3.5 times greater than the harvest from the smaller fingerlings, a 3.5-fold increase in cost of raising large fingerlings should be the maximum. To stay within the $4.00 per walleye caught investment figure, the cost of raising a 15-cm fingerling should not exceed $0.14. Based on the difficulties experienced in raising large numbers of fingerlings to 15 cm and the survival found in Manistee Lake, stocking fingerlings at a length of 5-9 cm may be a better investment than the 15-cm fish at the present time.

Acknowledgments

During the study, 10 different persons assisted with the field work. J. R. Ryckman advised on statistical procedures. W. C. Latta and J. C. Schneider reviewed the manuscript.

Table 1.--Number, mean length, and estimated initial stocking mortality of walleyes planted in Manistee Lake, 1972-78.

Date	Stocked			Mean length (cm)
	Total number	Estimated loss	Net number	
Oct 12, 1972	1,400	...[a]	1,400	11.0
Oct 2, 1973	304	7	297	10.9
Aug 19-Sep 26 1974	2,535	206	2,329	13.6
July 15-Nov 2 1975	7,484	524	6,960	13.2
Sep 3-16, 1976	6,535	390	6,145	17.1
Sep 15, 1977	9,027	1,444	7,583	13.5
Sep 15-Oct 5 1978	8,024	754	7,270	13.0

[a] Estimated loss was not determined.

Table 2.--Population estimates (±2 standard errors) of fishes in Manistee Lake, September-October, 1973-78.[a]

Species	Year					
	1973	1974	1975	1976	1977	1978
Walleye	2,523	1,178	813	2,343	3,586	3,323
	±1,368	±294	±212	±282	±915	±606
Bluegill	20,685	8,435	29,905	47,241	30,483	28,315
	±15,095	±2,341	±6,350	±10,071	±8,341	±5,920
Pumpkinseed	13,362	5,874	15,614	38,958	38,218	19,963
	±10,490	±1,481	±3,509	±4,046	±7,565	±4,131
Black crappie	1,363	1,175	3,953	3,455	2,936	2,572
	±296	±355	±637	±393	±478	±310
Rock bass	2,906	2,048	925	2,208	2,778	2,198
	±4,159	±1,033	±394	±274	±2,694	±1,013
Yellow perch	...	517	2,761	5,090	6,726	7,340
		±805	±847	±2,553	±4,590	±26,236
Smallmouth bass	1,562	4,202	1,921	2,603	2,187	1,309
	±737	±3,866	±632	±1,037	±828	±559
Largemouth bass	...	...	126	129	...	164
			±94	±78		±141
Northern pike	395	377	2,022	2,555	1,002	1,449
	±262	±336	±4,614	±2,154	±1,062	±636
White sucker	6,831	4,758	...	3,978	4,777	4,737
	±2,436	±1,148		±2,635	±3,109	±1,631

[a] Estimates are for fish larger than the following lengths: walleye, 27.9 cm; bluegill, pumpkinseed, and rock bass, 14.0 cm; black crappie and yellow perch, 17.8 cm; smallmouth bass, largemouth bass, and white sucker, 22.9 cm; and northern pike, 45.7 cm.

Table 3.--Average lengths (centimeters), per age group, of walleyes in Manistee Lake, 1973-78, as compared to the statewide average.

Age group	Year						Statewide average[a]
	1973	1974	1975	1976	1977	1978	
I		34.3	30.0	30.7	29.5	28.7	24.1
II		38.9	39.4	40.1	36.6	36.8	33.8
III	43.2	43.4	44.7	47.5	45.2	42.7	38.6
IV	44.4	46.0	47.2	52.3	49.5	47.5	43.7
V	48.5	49.5	50.3	56.9	52.8	50.3	47.2
VI	50.0	50.3	53.3	60.2	58.4	53.1	48.8
VII	53.8	52.1	56.4	66.8	63.0	55.4	49.8
VIII	56.1	56.1			62.0	59.4	54.9
IX	56.9	56.1	61.2			58.9	54.4
X	59.7	62.7				62.0	64.0

[a] Statewide average lengths of walleyes for given age from Michigan waters (Laarman 1963).

Table 4.--Mean growth index, in centimeters, for fishes in Manistee Lake, 1973-78.[a]

Species	Year					
	1973	1974	1975	1976	1977	1978
Walleye	+2.3	+3.8	+4.8	+7.4	+5.1	+3.6
Northern pike	+7.4	+10.2	+8.9	+9.9	+13.7	+9.9
Smallmouth bass	+3.0	+3.6	+3.8	+3.6	+2.5	+1.9
Largemouth bass	+5.6	+5.1	+6.1	+6.1	+5.8	+4.8
Bluegill	+3.6	+3.3	+3.8	+2.8	+2.5	+1.9
Pumpkinseed	+3.6	+3.0	+3.6	+3.7	+3.6	+2.5
Black crappie	+5.1	+5.3	+5.1	+5.8	+5.1	+4.9
Rock bass	+1.5	+2.0	+2.3	+3.0	+2.0	+2.3
Yellow perch	+4.3	+3.3	+0.3	+0.8	+0.5	-1.9

[a] Deviation in centimeters from the statewide growth rate averages for each species (see methods).

Table 5.--Number of fin-clipped and non-clipped walleyes (all sizes) collected in trap nets, 1973-78.

Year	Number collected			Percent clipped
	Clipped	Non-clipped	Total	
1973	0	266	266	0
1974	7	280	287	2
1975	207	107	314	66
1976	623	75	698	89
1977	598	49	647	92
1978	778	109	887	88

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Table 6.--Number of fin-clipped and non-clipped walleyes less than 35.6 cm collected in trap nets, 1973-78.

Year	Number collected			Percent non-clipped
	Clipped	Non-clipped	Total	
1973	0	0	0	
1974	7	0	7	0
1975	200	10	210	5
1976	463	5	468	1
1977	393	6	396	2
1978	344	64	408	16

Table 7.--Estimated fishing pressure and catch of all fish at Manistee Lake, December 1, 1975 to November 30, 1978 (±2 standard errors).

Date	Angler hours	Angler trips	Total catch	Catch per hour
Dec 1, 1975- Nov 30, 1976	12,214 ±1,577	4,822 ±665	9,473 ±1,996	0.8 ±0.2
Dec 1, 1976- Nov 30, 1977	5,614 ±1,147	2,320 ±530	7,482 ±2,576	1.3 ±0.5
Dec 1, 1977- Nov 30, 1978	20,884 ±2,405	9,448 ±1,213	17,079 ±4,496	0.8 ±0.2

Table 8.--Estimated number of fish harvested by anglers from Manistee Lake, December 1, 1975-November 30, 1978.

Species	Date and number caught		
	1 Dec 1975-30 Nov 1976	1 Dec 1976-30 Nov 1977	1 Dec 1977-30 Nov 1978
All walleyes	62	16	713
Fin-clipped walleyes[a]	5	0	383
Bluegill	3,057	4,505	9,564
Pumpkinseed	1,204	1,785	3,631
Yellow perch	3,407	279	2,182
Black crappie	829	738	420
Rock bass	632	115	69
Smallmouth bass	140	16	158
Largemouth bass	117	0	81
Northern pike	25	28	261
Total	9,473	7,482	17,079
± 2 standard errors	±1,996	±2,576	±4,496

[a] Included in all walleye catch.

Table 9.--Population estimates, with 95% confidence intervals, of stocked walleyes after 1-4 years in Manistee Lake.

Stocked		Years			
Year	Number	1975	1976	1977	1978
1974	2,329	575 408-742	402 295-509	291 93-384	153 114-192
1975	6,960		1,849 1,548-2,150	1,645 982-2,308	1,566 956-2,180
1976	6,145			1,292 910-1,674	614 456-772
1977	7,583				2,240 1,584-2,896

Table 10--Age-specific population estimates of walleyes in Manistee Lake, year classes 1965-1975.

Year class	Age group							
	II	III	IV	V	VI	VII	VIII	IX
1975	1953	938						
1974	467	527	300					
1973	7	38	93	63				
1972	14	41	55	86	48			
1971	193[a]	120	88	60	29	19		
1970		281[b]	207	109	13	14	10	
1969			424	284	109	2	14	30
1968				479	375	17	0	0
1967					1032	139	0	0
1966						341	14	3
1965							111	5

[a] Estimated from mean survival rate for age group II, year classes 1972-1975 (Table 15), and 120 survivors.

[b] Estimated from mean survival rate for age group III, year classes 1971-1974 (Table 15), and 281 survivors.

Table 11.--Age-specific population estimates of smallmouth bass in Manistee Lake, year classes 1967-1975.

Year class	Age group					
	II	III	IV	V	VI	VII
1975	1475	713				
1974	1723	459	252			
1973	1814	753	171	40		
1972	1473	79	39	0	7	
1971	4196	1297	44	23	64	13
1970		566	551	15	34	11
1969			141	126	0	11
1968				250	294	7
1967					76	42

Table 12.--Age-specific population estimates of bluegills in Manistee Lake, year classes 1967-1974.

Year class	Age group				
	III	IV	V	VI	VII
1974	3,082	574			
1973	51,680	19,331	9,208		
1972	4,639	2,178	312	366	
1971	5,866	3,825	694	295	133
1970	18,736	2,023	1,120	70	17
1969		1,738	376	53	29
1968			1,714	198	177
1967				380	66

Table 13.--Age-specific population estimates of pumpkinseeds in Manistee Lake, year classes 1967-1974.

Year class	Age group				
	III	IV	V	VI	VII
1974	9,840	3,347			
1973	47,163	20,019	9,496		
1972	2,255	385	59	55	
1971	2,560	494	354	30	21
1970	6,143	1,272	883	100	22
1969		4,045	1,931	218	43
1968			2,376	609	0
1967				702	0

Table 14.--Age-specific population estimates of black crappie in Manistee Lake, year classes 1967-1975.

Year class	Age group					
	II	III	IV	V	VI	VII
1975	434	204				
1974	2036	1808	939			
1973	3789	1330	617	457		
1972	138	26	19	42	5	
1971	190	100	53	46	15	20
1970		421	210	53	27	19
1969			1054	613	61	3
1968				101	24	0
1967					4	0

Table 15.--Five-year mean age-specific population estimates from Table 10 and mean annual survival rates of walleyes, year classes 1965-1975 (±2 standard errors).

Year class	Age group								
	II	III	IV	V	VI	VII	VIII	IX	II-VIII
1971-75	527 ±114	333 ±74							
1970-74		201 ±52	149 ±69						
1969-73			173 ±55	120 ±63					
1968-72				204 ±68	115 ±29				
1967-71					312 ±122	38 ±15			
1966-70						103 ±88	8 ±4		
1965-69							28 ±16	8 ±4	
Survival rates	0.63 ±0.20	0.74 ±0.39	0.69 ±0.42	0.56 ±0.24	0.12 ±0.07	0.08 ±0.08	0.29 ±0.22		0.44 ±0.12

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Table 16.--Five-year mean age-specific population estimates from Table 11 and mean annual survival rates of smallmouth bass, year classes 1967-1975 (±2 standard errors).

Year class	Age group						
	II	III	IV	V	VI	VII	II-VI
1971-75	2136 ±380	660 ±352					
1970-74		631 ±353	211 ±143				
1969-73			189 ±141	41 ±41			
1968-72				83 ±53	80 ±76		
1967-71					94 ±78	17 ±17	
Survival rates	0.31 ±0.24	0.33 ±0.29	0.22 ±0.27	0.96 ±1.10	0.18 ±0.23		0.40 ±0.34

Table 17.--Five-year mean age-specific population estimates from Table 12 and mean annual survival rates of bluegills, year classes 1967-1974 (±2 standard errors).

Year class	Age group					
	III	IV	V	VI	VII	III-VI
1970-74	16,801 ±3,433	5586 ±1157				
1969-73		5819 ±1165	2342 ±846			
1968-72			843 ±284	196 ±113		
1967-71				199 ±81	84 ±51	
Survival rates	0.33 ±0.10	0.40 ±0.17	0.23 ±0.16	0.42 ±0.31		0.34 ±0.18

Table 18.--Five-year mean age-specific population estimates from Table 13 and mean annual survival rates of pumpkinseeds, year classes 1967-1974 (±2 standard errors).

Year class	Age group					
	III	IV	V	VI	VII	III-VI
1970-74	13,592 ±2,483	5103 ±1002				
1969-73		5243 ±1005	2545 ±475			
1968-72			1121 ±273	202 ±91		
1967-71				332 ±135	17 ±8	
Survival rates	0.38 ±0.10	0.49 ±0.13	0.18 ±0.09	0.05 ±0.03		0.28 ±0.08

Table 19.--Five-year mean age-specific population estimates from Table 14 and mean annual survival rates of black crappie, year classes 1967-1975 (±2 standard errors).

Year class	Age group						
	II	III	IV	V	VI	VII	II-VI
1971-75	1317 ±131	694 ±79					
1970-74		737 ±91	368 ±58				
1969-73			391 ±62	242 ±42			
1968-72				171 ±42	26 ±7		
1967-71					26 ±8	8 ±6	
Survival rates	0.53 ±0.11	0.50 ±0.14	0.62 ±0.15	0.15 ±0.06	0.31 ±0.25		0.42 ±0.09

Table 20.--Annual mortality rates for walleyes 35.6 cm and larger in Manistee Lake, 1 December 1975 to 30 November 1978 (±2 standard errors).

Date	Percent annual mortality		
	Total [a] (A)	Fishing (u)	Natural (v)
1 Dec 1975 - 30 Nov 1976	56 ± 34	13 ± 19	43 ± 31
1 Dec 1976 - 30 Nov 1977	56 ± 14	3 ± 10	53 ± 8
1 Dec 1977 - 30 Nov 1978	56 ± 34	35 ± 19	21 ± 28
Mean	56 ± 36	17 ± 21	39 ± 31

[a] Mean of age groups II to VIII.

Table 21.--Annual mortality rates for smallmouth bass 27.9 cm and larger in Manistee Lake, 1 December 1975 to 30 November 1978 (±2 standard errors).

Date	Percent annual mortality		
	Total [a] (A)	Fishing (u)	Natural (v)
1 Dec 1975 - 30 Nov 1976	60 ± 62	18 ± 20	42 ± 54
1 Dec 1976 - 30 Nov 1977	60 ± 79	1 ± 3	59 ± 78
1 Dec 1977 - 30 Nov 1978	60 ± 70	21 ± 19	39 ± 62
Mean	60 ± 70	13 ± 20	47 ± 81

[a] Mean of age groups II to VI.

Table 22.--Annual mortality rates for bluegills 14 cm and larger in Manistee Lake, 1 December 1975 to 30 November 1978 (±2 standard errors).

Date	Percent annual mortality		
	Total[a] (A)	Fishing (u)	Natural (v)
1 Dec 1975 - 30 Nov 1976	66 ± 22	10 ± 4	56 ± 21
1 Dec 1976 - 30 Nov 1977	66 ± 22	10 ± 5	56 ± 20
1 Dec 1977 - 30 Nov 1978	66 ± 24	31 ± 15	35 ± 16
Mean	66 ± 28	17 ± 12	49 ± 24

[a] Mean of age groups III to VI.

Table 23.--Annual mortality rates for pumpkinseeds 14 cm and larger in Manistee Lake, 1 December 1975 to 30 November 1978 (±2 standard errors).

Date	Percent annual mortality		
	Total[a] (A)	Fishing (u)	Natural (v)
1 Dec 1975 - 30 Nov 1976	72 ± 26	8 ± 3	64 ± 25
1 Dec 1976 - 30 Nov 1977	72 ± 11	5 ± 3	67 ± 11
1 Dec 1976 - 30 Nov 1977	72 ± 23	10 ± 4	62 ± 22
Mean	72 ± 26	8 ± 4	64 ± 25

[a] Mean of age groups III to VI.

Table 24.--Annual mortality rates for black crappie 17.8 cm and larger in Manistee Lake, 1 December 1975 to 30 November 1978 (±2 standard errors).

Date	Percent annual mortality		
	Total[a] (A)	Fishing (u)	Natural (v)
1 Dec 1975 - 30 Nov 1976	58 ± 16	21 ± 19	37 ± 6
1 Dec 1976 - 30 Nov 1977	58 ± 10	21 ± 20	37 ± 4
1 Dec 1977 - 30 Nov 1978	58 ± 16	14 ± 12	44 ± 10
Mean	58 ± 18	19 ± 22	39 ± 9

[a] Mean of age groups II to VI.

Table 25.--The fall standing crops (kilograms per hectare) of fish in Manistee Lake, 1973-1978 (±2 standard errors).[a]

Species	Year						Mean (kg/ha)
	1973	1974	1975	1976	1977	1978	
Walleye	7.9 ±4.4	3.6 ±1.0	1.6 ±0.4	2.7 ±0.4	5.3 ±1.4	4.7 ±1.0	4.3 ±1.0
Bluegill	6.6 ±4.8	2.7 ±0.8	6.5 ±1.5	11.4 ±2.7	8.3 ±2.4	9.7 ±2.2	7.5 ±1.4
Pumpkinseed	5.6 ±4.4	2.8 ±0.8	3.6 ±0.9	10.1 ±1.5	10.9 ±2.4	7.0 ±1.6	6.7 ±1.2
Black crappie	1.4 ±0.3	1.4 ±0.4	2.2 ±0.4	2.3 ±0.3	2.5 ±0.5	2.3 ±0.5	2.0 ±0.2
Rock bass	1.0 ±1.4	0.7 ±0.4	0.3 ±0.1	0.7 ±0.1	0.7 ±0.7	1.1 ±0.5	0.8 ±0.1
Yellow perch		0.3 ±0.5	1.0 ±0.3	2.3 ±1.2	2.5 ±1.7	2.1 ±1.4	1.6 ±0.1
Smallmouth bass	2.5 ±1.2	6.0 ±5.6	1.8 ±0.6	2.8 ±1.1	1.6 ±0.6	1.7 ±0.7	2.7 ±1.3
Largemouth bass			0.1 ±0.1	0.1 ±0.1		0.2 ±0.2	0.1 ±0.1[c]
Northern pike	2.3 ±1.5	2.0 ±1.8	8.8 ±20.1	10.8 ±9.2	4.1 ±4.4	6.4 ±2.9	5.7 ±4.9
White sucker	24.6 ±9.1	16.8 ±4.4	14.5[b] ±6.8	12.2 ±8.2	15.7 ±10.3	17.4 ±6.2	16.9 ±4.1
Total	51.9 ±14.5	36.3 ±8.7	40.4 ±24.1	55.4 ±14.5	51.6 ±13.8	52.6 ±8.6	48.3 ±7.8

[a] Standing crops are for fish larger than the following lengths: walleye, 27.9 cm; bluegill, pumpkinseed, and rock bass, 14.0 cm; black crappie and yellow perch, 17.8 cm; smallmouth bass, largemouth bass, and white sucker, 22.9 cm; and northern pike, 45.7 cm.

[b] Mean of the two adjacent estimates.

[c] Less than 0.1.

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Typed by M. S. McClure