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WALLEYE STOCKING EXPERIMENTS AND FISH POPULATION STUDIES AT MANISTEE LAKE, 1972–84[1]

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

ABSTRACT

The walleye population of Manistee Lake was supplemented by stocking with fry, small fingerlings (2–3 inches), and large fingerlings (4–7 inches) from 1968 to 1984. Intensive sampling was done with trap nets annually from 1973 to 1978 and 1981 to 1984 to determine the density, growth, and survival of walleye and all other fishes.

First-year survival estimates were 28% for large yearling walleyes stocked in spring, 24% for large fingerlings stocked in summer or fall, and 14% for small fingerlings stocked in summer. Survival averaged 58% per year thereafter. Based on the characteristics of the population and fishery, it was calculated that 3.3% of the large fingerlings and 1.9% of the small fingerlings would eventually be harvested by anglers. A modest walleye population (1.5 to 7.2 pounds per acre) and fishery were maintained by stocking. Poor natural reproduction over the last 3 decades was linked to marginal spawning habitat and weather but could not be fully explained.

Large changes in species populations were observed but total fish biomass remained close to 47 pounds per acre. Bluegill, pumpkinseed, and northern pike populations peaked in the mid-1970's, then were replaced by yellow perch and walleye. The biomass of adult perch increased from less than 1 to over 20 pounds per acre due to improved recruitment, growth, and (probably) survival. Growth of walleye and smallmouth bass declined as perch shifted from small to large average sizes and the numerical density of walleye increased. Some of the population changes were attributed to predation, competition, and the effects of weather on the recruitment of young fish.

It was recommended that managers rear more large fingerling walleyes if they can be produced for less than 8¢ each or less than twice the cost of small fingerlings. Large fingerlings should be selected over small ones for maintenance stocking into communities already close to carrying capacity. Returns can be optimized by stocking every second or third year, rather than consecutively, at average rates not to exceed 12 large or 30 small fingerlings per acre per year.

INTRODUCTION

Since the early 1970's Manistee Lake, Kalkaska County, has been intensively studied to determine (1) the survival, growth, and returns of walleyes (Stizostedion vitreum) stocked at various sizes and (2) the effect of walleye stocking on abundance, growth, mortality, and stability of the other fish populations. The results of stocking large (about 6-inch) fingerling walleyes in 1973–78 were given by Laarman (1980, 1981). Laarman and Ryckman (1980) analyzed the selectivity of the trap nets in use throughout the study. This report will give the results from stocking small (about 2-inch) fingerlings and review all the stocking and population data collected through 1984, the last scheduled year of study.

Manistee Lake is in the north central part of the Lower Peninsula of Michigan. It is large (860 acres) and shallow (maximum depth of 18 feet). Spawning habitat for walleye appears to be of poor quality, consisting of sandy shoals with small amounts of gravel. Nevertheless, a substantial amount of successful reproduction must have occurred through the mid-1950's to produce the good population and fishery which existed up through the early 1960's.

Walleyes apparently were not native to the lake even though the species had free access via the Manistee River drainage. The earliest reports on file, from 1926–30, indicate northern pike (Esox lucius) and small yellow perch (Perca flavescens) predominated. Largemouth bass (Micropterus salmoides) and pumpkinseed (Lepomis gibbosus) were common and rock bass (Ambloplites rupestris), bullheads (Ictalurus sp.), some large bluegills (Lepomis macrochirus), and a great variety of forage fish were present. Smallmouth bass (Micropterus dolomieui) and walleye had reportedly just become established from stocking. Official stocking records show that small numbers of walleye fry were stocked in 1903–1910, but there are no records available from 1915–1932, when the more successful plantings of walleye and smallmouth bass apparently took place. Frequent stocking of walleye fry at the rate of about 0.5 million per year continued up until 1946.

The walleye population expanded, became dominant, then declined. A conservation officer observed seven walleyes in the 1931 sport catch. Census records taken by conservation officers show that by the mid-1930's walleyes comprised 10% of the sport catch, and by the late 1950's they had increased to about 50% of the sport catch. However, by 1976–78, walleyes had declined to only 1–4% of the total catch (Laarman 1980).

Other marked changes occurred in the fish community through the years. Northern pike declined greatly and by 1976–78 they comprised less than 1% of the sport catch. White sucker (Catostomus commersoni) were not reported in 1930, but by the 1970's they made up 35% of the total fish biomass (Laarman 1980). Bullheads became very rare. Bluegills were usually sparse and large sized, and yellow perch were usually abundant and small sized; however, these patterns reversed dramatically in some years.

METHODS

In the period 1968–84, Manistee Lake was stocked with walleye fry, large fingerlings (mean lengths, 4.3–6.7 inches, usually fin clipped), and small fingerlings (mean lengths, 2.5–2.7 inches) (Table 1). No walleyes were stocked in 4 years, and the relative strength of corresponding year classes plus the fin clips on some stocked fish allowed us to evaluate the magnitude of natural reproduction. The large fingerlings, specially reared, were mostly stocked in fall, 1972–80, at rates of 0.3 to 8.8 per acre per year. The small fingerling were stocked in summer, 1981–83, at rates of 4.9 to 28.1 per acre per year. These small fish were typical products of the Fisheries Division's current pond-rearing program which now produces, statewide, about 4 million small fingerlings annually.

Sampling methods in 1981–84 were identical to those described by Laarman (1980) for the 1973–78 period. Standard trap nets, with 3 ft x 5 ft x 8 ft pots of 1.5-inch stretched mesh, were fished from mid-September to mid-October. Nets were lifted 6 days per week for 5 weeks. Three nets were used in each quadrant of the lake; one was moved daily to a randomly picked site.

Fish captured in the nets were given a caudal fin clip and released. Mark-and-recapture population estimates were calculated with the Schumacher-Eschmeyer formula. Estimates were stratified by species and, when possible, by inch group to reduce bias caused by gear selectivity (Laarman and Ryckman 1980). Often size groups were pooled to improve the precision of the estimates. Laarman (1980) reported examples of confidence limits.

About 30 scale samples per inch group per species were collected for age determinations. Mean growth indices were calculated (Laarman et al. 1981a). The mean growth index for a species was the mean deviation in length of represented age groups from the October statewide average for Michigan. Only age groups containing at least five fish were used.

Walleyes proved to be difficult to age accurately beyond age V due to a slowdown in their growth. This became increasingly apparent as known-age walleyes were tracked through the years. For example, in the 1984 collection only three to eight annuli could be seen on scales of walleyes which were known to be age IX or XI (RV fin clip). For age-VII walleyes (RP fin clip), 42% were correctly aged and 58% were underestimated by one to three annuli.

Biomass estimates, stratified by inch groups, were calculated from the size group estimates, length-frequencies of the net catches, and state average length-weight relationships (Laarman et al. 1981b).

Age-specific population estimates were calculated for walleye, smallmouth bass, bluegill, pumpkinseed, black crappie (Pomoxis nigromaculatus), northern pike, rock bass, and yellow perch from length group estimates and scale samples. The percent contribution of each age group to the length group sample was multiplied by the length group estimate to give age estimates stratified by size. These were then summed to give the total estimate for each age group.

Annual survival rates of adult fish were determined from the age-specific estimates by a different method than the one used earlier (Laarman 1980). The new method obscures possible age differences in survival but it is not biased by weak or strong year classes. For each species except northern pike, the number of age-III and older fish in year 2 was divided by the number of age-II and older fish in year 1 to obtain the average survival for age-II+ fish between year 1 and 2. These calculations were repeated for years 2 and 3, and each other pair of intervals. A grand mean survival was then computed, based on as many as 9 yearly averages (years in which population estimates were inadequate or survival estimates exceeded 100% were excluded). For northern pike, which had more inconsistent age estimates, an average number was calculated for each age group, then a linear regression was fit by the least squares method to the logarithms of these averages.

An index of year-class strength was obtained as follows. First, a typical age distribution for each species was calculated from the grand mean survival rate and the average estimated number of age-III fish (this age group had the most precise estimates). Second, each age group estimate was compared to the typical age distribution by calculating its percent deviation. Third, the deviations for ages II to V were averaged for each cohort to provide a single index of relative year-class strength. The indices were used for determining the contribution of stocked walleyes to the walleye population and for the analyses mentioned below.

Possible relationships among annual indices of recruitment, growth, adult density, and environmental temperature were explored for each species of fish by means of regression and correlation analyses. The data set spanned the 1968–84 period, but only temperature data were available for each of the 17 years. The smallest sample size, 10 years, was for growth. Recruitment was represented by the index of year-class strength. Growth was represented by the mean growth index at age III. Adult density was represented by a 4-year moving average of the population estimates. Temperature was expressed as deviations from the mean, April to August or October, in various monthly or weekly combinations. Lacking direct measures of lake temperature, we substituted air temperature at the U. S. Weather Station in Grayling, 18 miles east of the lake.

RESULTS

Walleye

The population of walleyes 11 inches and larger varied between 0.9 and 6.7 fish per acre and 1.5 and 7.2 pounds per acre (Tables 2 and 3, Fig. 1). The number of legal-sized walleyes (13.0 inches and larger in 1973–75 and 15.0 inches and larger in 1976–84) varied from 0.5 to 3.6 per acre. They supported a small to modest fishery, averaging 0.3 walleye per acre per year in 1976–78. (Laarman 1980). However, in fall 1984 an unusually high number of small walleyes were present and they reportedly bolstered the fishery in 1985 and 1986 (J. Fenske, personal communication). These fish belonged to the 1983 year class (Table 4), the one which had been supplemented with the largest number of small fingerlings (Table 1). Earlier, in 1978, a small boost in walleye fishing was documented as a result of stocking large fingerlings (Laarman 1980).

The annual survival of age-II and older walleyes averaged 0.58 for the 1973–84 period (Table 5). This is higher than the unweighted mean of 0.44 calculated previously (Laarman 1980). The previous analysis had suggested that survival rate decreased beyond age V, but that could have been due to underestimating the age of scales from old fish. At 0.58, survival of adult walleyes in Manistee Lake is on a par with most estimates in the literature (Schneider 1978).

First-year survival of stocked walleyes was estimated less directly from population estimates at age I, stocking rates, and estimates of the amount of natural recruitment. For large marked fingerlings stocked during the 1970's, Laarman (1980) estimated survival from time of stocking (summer or fall, age 0) to fall age I at 25%, 27%, 21%, and 30% for the 1974, 1975, 1976, and 1977 cohorts, respectively (mean 26±5%). Survival from the very small plants in 1972 and 1973 was too low to estimate, thus a weighted estimate of first-year survival of large fingerlings stocked in summer or fall is about 24%. Fingerlings stocked during the 1980's were not given a unique mark so it was not possible to distinguish them from native walleyes. Assuming natural recruitment averaged 2.5%, the same as in 1973–78, then survival to fall age I was 28% for the 1980 cohort (large fingerlings stocked in spring, age I), and 21%, 11%, and 16% for the 1981, 1982, and 1983 cohorts, respectively (small fingerlings stocked in summer, age 0). Thus, survival of large spring yearlings was the highest (28%), survival of large summer-fall fingerlings was intermediate (24%), and survival of small summer fingerlings was the lowest (14%).

A typical walleye age distribution was calculated based on the average survival of 58% and an average population of 314 age-III walleyes (Table 4). It was then used as a standard for computing an index to year-class strength for the 1968–83 cohorts (Table 6). The highest index, +352%, was for the 1968 cohort. This one was not supplemented by stocking and it was the last native cohort of consequence. The native cohorts in 1970 and 1979 had low indices, about -20%. Fry plants in 1971 and 1972 were total failures (indices of -64 and -74) as suspected from earlier surveys (Laarman 1980). The 1969 cohort, also supplemented with fry, was moderately strong (index +150%), but this was most likely due to carry-over of some natural reproduction.

The strength of the other cohorts was related to stocking rate (Fig. 2). Also, because of higher survival the first year in the lake, fewer large fingerlings than small fingerlings were required to produce a year class of a given strength. The difference became more pronounced at higher stocking rates.

Although the correlations are high ($r = 0.89$ and 0.95), there is considerable scatter in the data. For example, similar plantings in 1975–78 of 6,000 to 8,000 large fingerlings resulted in indices ranging from +89 to +309. The scatter is not clearly related to stocking month or length, or to mortality rate observed right at stocking. However, the relatively high survival of the 1977 planting was followed by relatively poor survival of the 1978 planting. Studies at other lakes indicate that a large year class often suppresses the following one (Schneider 1969).

Growth of walleyes changed markedly during the study (Table 7). It was good relative to the Michigan state average in the 1970's, but growth of age-groups II to IV declined during the 1980's. Consequently, about an extra year was required for the fish to reach a length of 15 inches.

This decrease in growth was correlated with a twofold increase in the numbers of 11.0-inch and larger walleyes during the 1980's ($r = 0.97$, $P<0.05$) and year-class strength index ($r = 0.33$), and also with the growth patterns of smallmouth bass (similar) and yellow perch (opposite). However, it was not related to total walleye biomass (compare Table 7 and Fig. 1).

<u>**Smallmouth bass**</u>

The lake supported a modest, fluctuating, smallmouth bass population and fishery. The standing crop of 9.0-inch and larger fish averaged 2.1 pounds per acre (Table 3, Fig. 1). The average population of 12.0 inches and larger bass was 0.7 fish per acre (Table 2), and the average annual sport catch in 1976–78 was 0.12 bass per acre. The fluctuations in the population do not relate to the change in the minimum size limit from 10 to 12 inches in 1976 (Laarman 1980).

Old and large fish were relatively sparse due to a relative low survival rate of 0.32 (Tables 5 and 8). Growth was below the state average in most years (Table 9). Growth was density related, being correlated with year class index ($r = -0.72$, $P<0.05$) and to average number of adult bass ($r = -0.54$). Recruitment was variable and paralleled that of rock bass ($r = 0.76$, $P<0.05$) and walleye—if years of walleye stocking are discounted (Table 6). Both smallmouth bass and rock bass recruitment were correlated to relatively warm August temperatures ($r = +0.52$ for each species). This was the highest correlation we found between temperature indices and year-class strength of smallmouth bass over the months April through October, and combinations thereof. In many other northern populations of smallmouth bass, large year classes strongly correlate with warm weather in summer or fall (MacLean et al. 1981). The largest bass year class occurred in 1968, which had a relatively warm fall; however a weak year class occurred in 1971, which had the warmest fall.

Northern pike

The pike population and fishery were modest. The average density of legal-sized pike (20.0 inches and larger) was 1.0 per acre and the average annual sport catch in 1976–78 was 0.12 per acre (Table 2 and Laarman 1980). However, because of their large average size, pike standing crop estimates sometimes exceeded those of other piscivors—up to 8.2 pounds per acre in 1976 (Table 3, Fig. 1). Annual survival was 0.41 (Tables 5 and 10). Growth was consistently above the state average (Table 11).

Largemouth bass

Largemouth bass did not enter the nets readily; consequently, poor population estimates were obtained (Tables 2 and 3). The population was clearly smaller than those of the other fish, and the sport catch in 1975–78 averaged just 0.08 largemouth bass per acre per year (Laarman 1980). Growth was much above average (Table 12).

Bluegill

The bluegill was the predominate species in some years (Table 2). Estimates of 6.0-inch and larger fish varied tenfold, from 5.4 to 47.0 per acre, with a definite peak in 1976–78. Sport harvest during the peak years was 6.6 bluegills per acre per year (Laarman 1980). Standing crop varied from 1.8 to 12.8 pounds per acre (Table 3, Fig. 1).

Adult survival rate averaged 0.36, which was very similar to the rates for most other centrarchids (Tables 5 and 13). Growth was much above the state average throughout the study (Table 14), but declined somewhat in the years of high adult density, as expected ($r = -0.66$). The increase in density can be attributed to the large 1973 year class (Table 6). Slightly above normal June and August temperatures, plus unknown factors, may have boosted fry survival that year (Fig. 3).

Pumpkinseed

Pumpkinseeds were as abundant as bluegills in some years. The density of 6.0-inch and larger pumpkinseeds ranged from 2.1 to 31.7 fish per acre and 1.1 to 11.6 pounds per acre, with a peak in 1976–78 (Tables 2 and 3, Fig. 1). Sport harvest in those years averaged 2.6 pumpkinseeds per acre per year (Laarman 1980).

The population trends and characteristics of pumpkinseed and bluegill were nearly identical. Survival of adults was 0.32, on the average (Tables 5 and 15). Some pumpkinseeds exceeded 9 inches in length because their growth was very good (Table 16). Growth was strongly dependent on the density of adults ($r = -0.91$, $P<0.05$) but was only weakly correlated with year-class strength ($r = -0.25$). Recruitment of pumpkinseeds closely paralleled that of bluegills ($r = +0.93$, $P<0.05$), and both produced exceptionally large year classes in 1973 (Table 6).

Yellow perch

A remarkable transformation in the perch population was documented. The abundance of adults (7.0 inches and larger) increased one hundredfold, mostly during the 1980's when perch became the predominate species in the lake (Table 2). Estimates of number per acre were 0.6 in 1974, 8.5 in 1978, 51.8 in 1981, 62.8 in 1982, and 53.1 in 1984. Estimates of pounds per acre increased from less than 1 to over 20 (Table 3, Fig. 1). Smaller perch were not adequately sampled by the trap nets, but observations indicate that they declined correspondingly. The annual sport catch in 1975–78 averaged just 2.3 perch per acre. Census data were not taken in the 1980's, but the lake's reputation did not improve proportionately because the perch seemed difficult for the anglers to catch. Perch over 12 inches long had become common by 1984.

These changes were brought about by increases in both growth and recruitment. Survival may have increased also, but that cannot be documented (Table 17). The average survival of adults was 0.55 (Table 5). The big improvement in growth occurred in the younger age groups, I-IV (Table 18). Surprisingly, growth was positively and highly correlated with adult density ($r = +0.96$, $P<0.05$) and was not correlated with year-class strength ($r = -0.01$). Thus, there was no indication that growth was density dependent. Moderately strong year classes originated in 1973, 1974, and 1976–79 (Table 6). These years were relatively cool from May through August ($r = 0.60$, $P<0.05$).

Black crappie

The density of 7.0-inch and larger crappies was modest and relatively stable. It varied from 1.2 to 5.4 fish per acre and from 1.0 to 2.9 pounds per acre (Tables 2 and 3). The annual sport catch in 1976–78 averaged 0.8 crappie per acre (Laarman 1980).

Survival rate was 0.53 (Tables 5 and 19). This relatively high rate, coupled with excellent growth (Table 20), resulted in the production of some 13-inch crappies. Growth was not significantly correlated to indices of density. The strongest year classes originated in 1969, 1973, and 1974, without any clear relation to temperature (Table 6, Fig. 3).

Rock bass

Rock bass, like black crappie, maintained a low and relatively stable population. The density of 6-inch and larger rock bass ranged between 0.7 and 4.2 fish and 0.3 and 1.2 pounds per acre (Tables 2 and 3). Annual sport catch in 1975–78 averaged 0.3 per acre (Laarman 1980).

The survival rate of rock bass was 0.31, which was very similar to the rates for smallmouth bass, bluegill, and pumpkinseed (Tables 5 and 21). Growth was equal to state average the first 2 years of life, then increased (Table 22). It depended somewhat on adult density ($r = -0.44$). The strongest year classes originated in 1968, 1969, and 1981 (Table 6). Strong natural year classes of walleye, smallmouth bass, and pumpkinseed also occurred in 1968 and 1969. There was a correlation between year-class index and average August temperature for rock bass ($r = +0.52$), as for those other species.

White sucker

The sucker population was quite stable from 1973 to 1984 (Table 2, Fig. 1). The density of 9.0-inch and larger (age-I and older) suckers varied from 3.5 to 7.9 fish per acre and from 9 to 22 pounds per acre (Table 3). None were harvested by anglers (Laarman 1980). Growth was rapid and an average length of 20 inches was reached late in age IV (Table 23).

DISCUSSION

Walleye stocking

First-year survival of large yearling walleyes stocked in the spring was the highest (28%), survival of large fingerlings stocked in summer or fall was intermediate (24%), and survival of small fingerlings stocked in summer was the lowest (14%). This result agrees with the general axiom that the highest survival and returns are obtained from stocking larger, older fish (Laarman 1978).

There are two basic methods for culturing walleye fingerlings: extensive and intensive. In extensive culture, relatively low densities of walleye fry are stocked into natural ponds or winterkill lakes which have few other fish and are naturally rich in zooplankton, insects, and minnows. Large numbers of large-sized fingerlings can be produced economically because of low density, diverse food types, and low capital outlay and maintenance costs. In intensive culture, relatively high densities of walleye fry are stocked into ponds (usually drainable) which have no other fish and zooplankton production is promoted by artificial fertilization. These ponds can produce large numbers of small-sized fingerlings economically, but few large-sized fingerlings because they lack enough insects and minnows.

In Minnesota and Wisconsin, many large fingerling walleyes are raised extensively and are stocked out in fall when temperatures are most favorable for handling (Schupp 1985; Klingbiel 1985). Schupp estimated these large fingerlings cost slightly more per fish, but 75% less per pound, than small fingerlings reared intensively in drainable ponds. In Michigan, nearly all walleyes are reared intensively and are stocked out in late June-early July at a total cost of 4¢ each (Schneider 1985). This strategy minimizes rearing cost on a per-fingerling basis but increases the risks of handling mortality and in-lake mortality, and reduces the probability of these fish eventually contributing to the anglers' catch. Given the relative survival rates above, then large fall fingerlings would be better if they can be reared for less than 8¢ each, as in Minnesota (Schupp 1985). Michigan managers should seek opportunities for less costly extensive walleye culture among our natural ponds and winterkill lakes.

Figure 2 may be used to predict the stocking rates needed to produce large or small year classes in Manistee Lake. In order to produce a relatively strong year class with an index of +300, and a correspondingly moderately good fishery, plants of either 10,000 large fingerlings or 26,000 small fingerlings are required (12 or 30 per acre).

Average long-term returns to the Manistee Lake angler from stocking small or large fingerling walleyes were predicted. The computations are based on the 1984 growth rate, the first-year survival rates above, and a total mortality of 42% for age-I and older, of which for age-III and older, 17% was due to fishing and 25% was due to natural causes. We predict that eventually 1.9% of the small fingerlings would be harvested. At a production cost of 4¢ each, then each harvested walleye would cost $2.08, or $1.29 per pound. The return rate for large fingerlings was projected to be 3.3%, which agrees with the previous projection of 3.5% (Laarman 1980).

These results are in line with those from other studies. Returns from maintenance stocking were 0.1% to 1% for Fife Lake and 0.3% to 7.1% for Bear Lake; many other Michigan lakes were less successful and very few were more successful (Schneider 1969). Small lakes, intensively managed for walleyes, may give higher returns (8%) initially (Schneider 1985). The experiences of other states have been similar (Laarman 1978, Schupp 1985, Klingbiel 1985). Generally, survival and returns are highest for the initial stocking and decline with each successive stocking (Schneider 1969). This has prompted Wisconsin's recommendation that fingerlings not be stocked in consecutive years (Klingbiel 1985).

Walleye recruitment

The causes for the rise and fall of natural walleye recruitment in Manistee Lake and the corresponding fluctuations in the walleye fishery remain obscure. Since walleyes were not stocked from 1946 to 1969, the good walleye fishing reported in some of those years was mainly due to good spawning success and high survival of native walleyes. Scale samples taken during periodic management surveys indicate that some natural recruitment occurred each year from 1951 to 1954 and from 1962 to 1969. These data and comments about fishing quality suggest that recruitment was poor in the late 1940's and in 1950, very good in 1952–54, probably low in the late 1950's, and low in 1962–69. Data presented in this report indicate that natural recruitment was modest in 1968 and low from 1969 to 1983. Thus, the good walleye fishing reported in the 1950's and 1960's was largely due to strong natural recruitment in the early 1950's. Possible explanations for irregular recruitment include: (1) changes in water quality, (2) weather fluctuations, and (3) changes in the fish community.

No obvious decline in water quality can be documented which might explain poor walleye spawning success since the early 1950's. However, because the spawning substrate appears to be of such marginal quality, subtle changes in eutrophication or siltation could have had a significant effect on survival of walleye eggs. Surveys as far back as 1930 noted that submergent vegetation was abundant due to the lake's shallowness and organic substrate. The lake is still weedy, but there seems to be considerable year-to-year variation in weed density—as it is true in many other lakes. Secchi disk transparency, an index of plankton production and other suspended materials, was measured in 1930, 1955, and 1974. It has ranged between 6 and 8 feet, without trend.

Nutrient loading, boating, and fishing probably have not increased significantly since the early 1950's. Already in 1930 Manistee Lake was a popular fishing lake. Only six cottages and one hotel (all on the east shore) and a county park were noted on a 1930 map. A 1937–38 map shows 24 cottages and 1 hotel. By 1955, the lake supported 165 cottages, 1 hotel, 8 resorts, and 4 boat liveries. Relatively few dwellings have been added to the lake shore since then. On the other hand, there are more year-around residents now and, consequently, a greater potential for nutrients to seep into the lake from septic sewage systems.

Weather during the period when walleye eggs are incubating and hatching and larval walleyes are starting to feed has been correlated with spawning success for some walleye populations (Koonce et al. 1977; Busch et al. 1975). For Manistee Lake this critical period would be from mid-April to mid-May—the exact date depending on ice-out and the rate at which the water warms. Weather conditions which would probably favor good egg survival and hatching success in Manistee Lake are: (1) above normal or steadily rising temperatures (eggs would hatch quickly, reducing their exposure to siltation, anoxia, disease, and predators) and (2) low winds (eggs are not silted over or displaced to poor locations). After hatching, it is important that weather conditions help trigger a plankton "bloom" so that larval walleyes have a good supply of zooplankton to eat. Later, the fingerling walleyes need a good supply of small perch or minnows. Survival through each of these stages is enhanced by low populations of predatory or competitive fishes. Poor conditions at any one stage could cause a weak year class.

Weather conditions alone did not seem to explain the pattern of weak and strong walleye year classes observed at Manistee Lake. Lacking data on actual dates of walleye spawning and water temperatures, we examined air temperatures from April 15 to May 14 as far back as 1946 (Fig. 3). For the early 1950's, when exceptionally good recruitment occurred, the correlation is mixed: 1952 and 1955 were very warm, but 1953 and 1954 were normal and a severe cold spell occurred in May 1954. No exceptional year classes were produced in 1960, 1964, 1970, and 1977 even though they were exceptionally warm. The moderately strong 1968 year class originated during average spring temperatures. Data on wind are not adequate to judge if it influenced walleye recruitment.

Community structure and dynamics

Large changes have occurred in the fish community of Manistee Lake over the last 60 years. Between the 1920's and the 1950's, walleye replaced northern pike as the dominant piscivor and white sucker increased. However, the demise of the walleye in the 1960's and 1970's apparently was not counterbalanced by major shifts in pike or other species. Since 1973, suckers have been stable at about 31% of the total fish community biomass. That density is probably not high enough to seriously affect walleye, yellow perch, or other species (Schneider and Crowe 1980; Schneider 1981).

Total fish community biomass was relatively stable over the 12-year study period despite shifts in species population (Fig. 1). The large decreases in bluegills, pumpkinseeds, and northern pike were offset by the increase in yellow perch. As a result, total standing crop was within 12% of the mean (47 pounds per acre) in 8 out of 10 years (Table 3). Piscivor (walleye, pike, and bass) biomass was also fairly stable, from 19 to 30% of the total. Generally lakes with a ratio of 20% or more are "balanced" and provide satisfactory fishing (Schneider 1981). This stability suggests that the community was rather closely regulated, most likely by means of intra- and interspecific competition and predation.

Evidence for intraspecific competition was mixed. It should have been reflected in negative correlations between growth and year-class density and between growth and adult density. The correlations should have been strongest for slower-growing species because they were probably more food limited. The correlations were negative, as expected, for bluegill, rock bass, pumpkinseed, smallmouth bass, and walleye, but only the correlations for the latter three species were strong enough to be meaningful. The correlations for black crappie, northern pike, and yellow perch were counter to expectations—especially for perch ($r = +0.96$ between growth and average adult density). However, crappie and pike were fast growing. A similar positive correlation has been noted for perch before (Anderson and Schupp 1986), but generally perch growth is density dependent (Schneider 1971 and 1972).

Evidence for interspecific competition and predation is scanty. The decline in growth of smallmouth bass late in the study seems to be related to the decrease in walleye growth and the increase in numbers of walleyes. The change in growth of both species was likely due to the shift in the perch population to sizes too large to serve as optimum forage (Parsons 1971; Schneider 1975 and 1983). This shift in perch may have been triggered, in part, by reduced pike predation on adult perch after 1978. Similar interactions between pike and adult perch, among walleye, pike, and bass populations have been observed at other lakes. Anderson and Schupp (1986) and Laarman (1978) review other examples.

Variable recruitment had a very strong effect on the structure of the fish community. The year classes produced in 1968 and 1969 (smallmouth bass, pumpkinseed, rock bass, native walleye), 1973 (bluegill and pumpkinseed), and 1976–79 (yellow perch) had the greatest effect. These were probably triggered by a combination of favorable weather and food supply at a critical stage during the first year of life, coupled with suitable densities of spawning adults and moderate to low densities of potential competitors and predators. Once established, relative year-class strength tends to carry through a life span (often up to 10 years) and cause corresponding variations in adult density. A large year class tends to suppress subsequent cohorts and may effect the recruitment of other species as well.

The recruitment patterns of walleye, smallmouth bass, and rock bass tended to be similar, as did those of bluegill and pumpkinseed. Large year classes of smallmouth bass, rock bass, and pumpkinseeds tended to be produced in relatively warm Augusts (Fig. 3)—even though these species can thrive in colder habitats than Manistee Lake. A correlation for smallmouth bass year classes and summer and/or fall temperatures has been noted before for more northern Michigan lakes (Clady 1975), and is characteristic of smallmouth bass populations in northern latitudes (MacLean et al. 1981; Serns 1982). The 1973 year class of bluegill and pumpkinseed, the largest observed, originated in the second warmest summer since 1968. Conversely, yellow perch year classes tended to be larger in years of relatively cool May-August temperatures ($r = -0.60$, $P<0.05$). But this alone probably does not account for the phenomenal improvement in the abundance and growth of perch. Contributing factors were probably: (1) walleye stocking, which may have increased predation on small perch and released surviving perch from intraspecific competition; (2) a natural downswing in the abundance of large pike, which may have improved the survival of large perch; and (3) a natural dip in the populations of bluegill and pumpkinseed, which may have released potential invertebrate food resources. Once established, the large perch population probably hindered recruitment of perch and other species, causing a shortage of suitable-sized prey fish for walleyes. This scenario accounts for the observed decline in walleye growth and the lack of a significant improvement in walleye biomass despite the gains in numerical abundance brought about by stocking.

RECOMMENDATIONS

Managers should seek waters, such as winterkill lakes, where large fingerling walleyes can be reared extensively for less than 8¢ each. These larger fish are better than small fingerlings for maintenance stocking into lakes already containing populations of walleyes and other fish close to carrying capacity. Fry stocking is most suitable for introduction into fishless waters; small fingerlings are most likely to succeed in waters with relatively few fish.

Plantings should be made every second or third year instead of every year at average rates not to exceed 12 large or 30 small fingerlings per acre per year. This procedure should generate modest populations and fisheries in suitable lakes. Suitable lakes should have little or no natural walleye production, native walleyes (if present) should be growing well, food should be plentiful and of the right size and type when planting occurs, and predators and competitors should be low—i. e., there is an open niche. Stocking should be discontinued or adjusted in 5 years pending results from monitoring growth, survival, and overall success.

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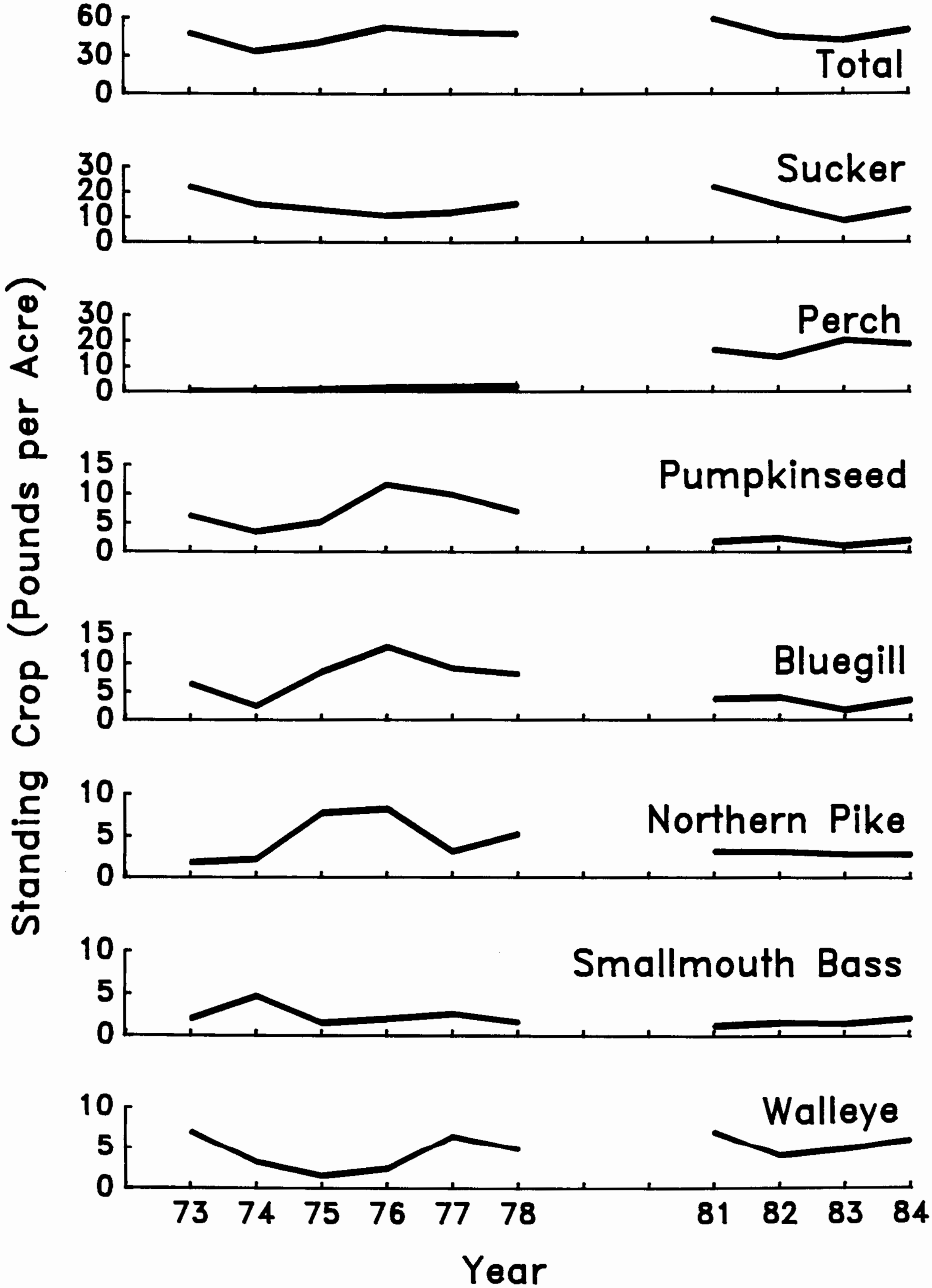

Figure 1. Trends in standing crop of total fish and of the major fish species, Manistee Lake, 1973–78 and 1981–84.

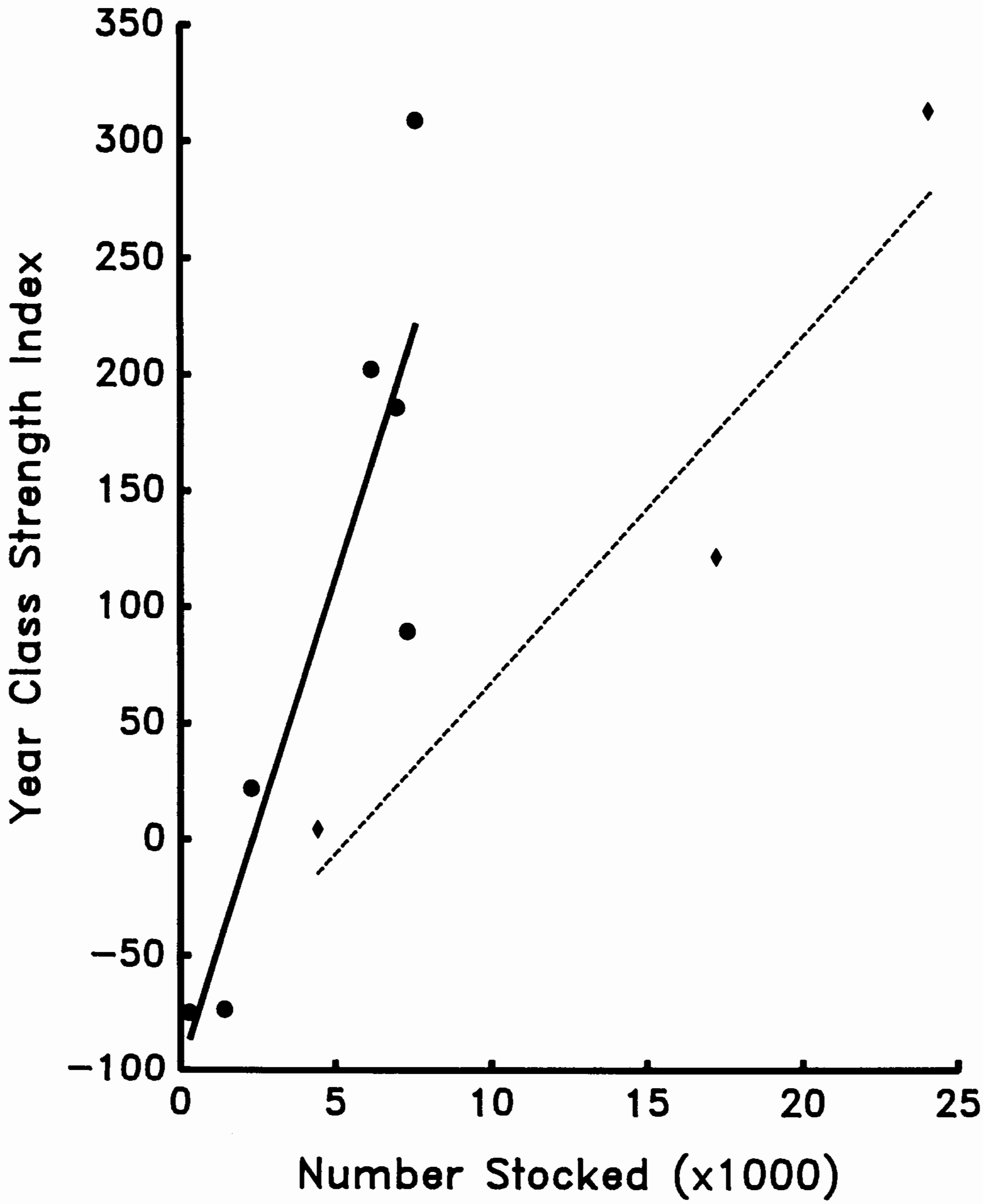

Figure 2. Year-class strength index versus number of large fingerlings (dots) or small fingerlings (diamonds) stocked in Manistee Lake.

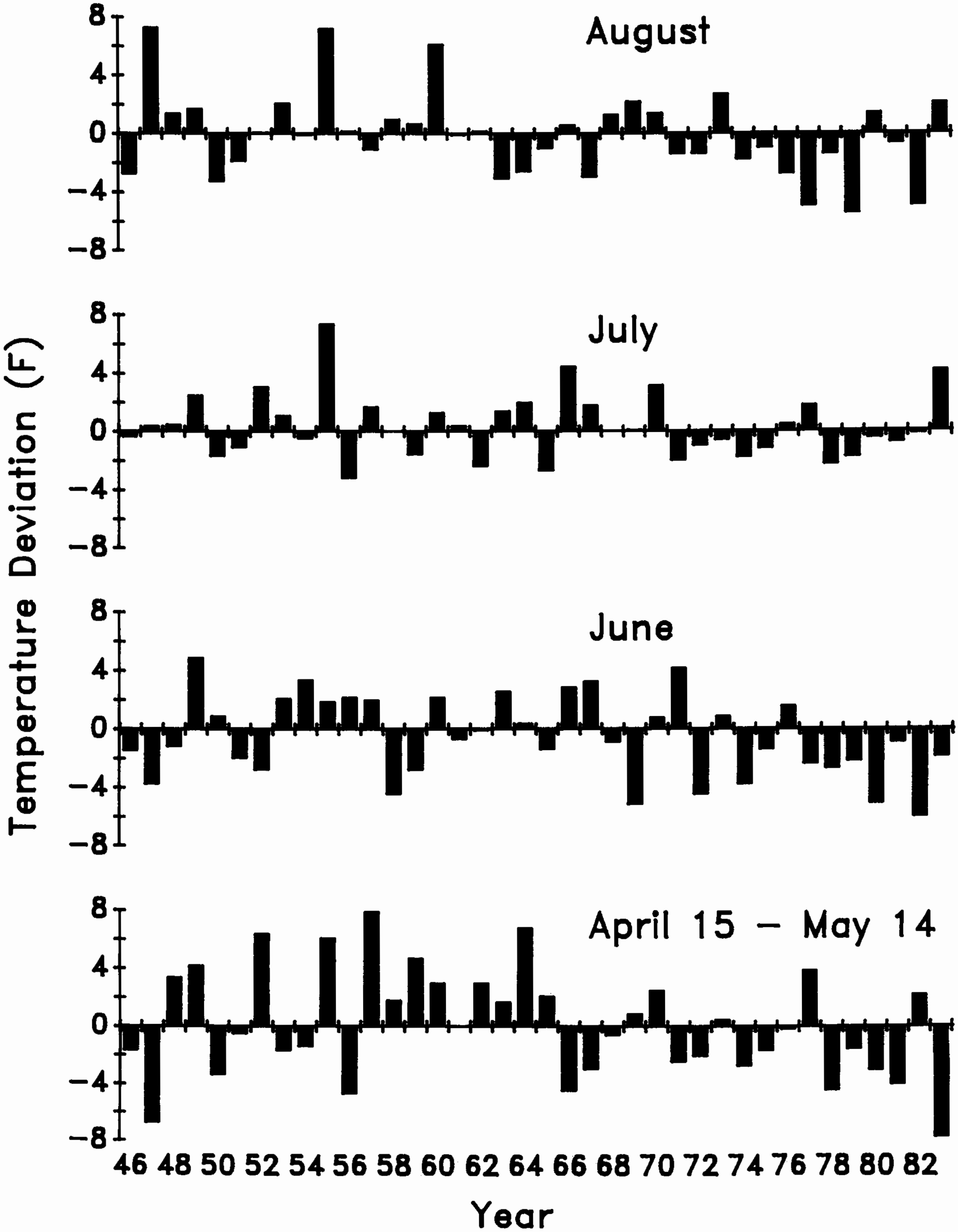

Figure 3. Deviations of monthly air temperatures at Grayling, Michigan, from average (adjusted to 1974–82 base), 1946–83.

Table 1. Walleyes planted in Manistee Lake, 1968-84.

Supplemented year class	Number stocked (net)[1]	Total length (inches)	Planting clip
1968	0	—	—
1969	1,000,000	fry	—
1970	0	—	—
1971	1,000,000	fry	—
1972	1,000,000	fry	—
1972	1,400	4.3	LV
1973	297	4.3	RV
1974	2,329	5.4	LV
1975	6,960	5.2	RV
1976	6,145	6.7	LV
1977	7,583	5.3	RP
1978	7,270	5.1	LV
1979	0	—	—
1980	4,176[2]	5.3	—
1981	4,432	2.7	—
1982	17,270[3]	2.7	—
1983	24,149	2.5	—
1984	0	—	—

[1] Net number stocked for 1972-78 was determined by Laarman (1980) by correcting for the fingerlings which died during stocking.

[2] Stocked as yearlings in spring 1981.

[3] Stocking mortality was estimated to be 1,000.

Table 2. Estimated number of fish in Manistee Lake by species and length group, 1973–78 and 1981–84.

Species and length (inches)	1973	1974	1975	1976	1977	1978	1981	1982	1983	1984
	Year of estimate									
Walleye										
11.0+	2,523	1,178	813	2,343	3,586	3,323	4,709	2,470	3,745	5,789
13.0–14.9	0	15	205	380	1,049	415	466	235	900	1,132
15.0+	2,523	1,163	373	458	1,496	1,913	3,063	1,501	1,329	1,141
Smallmouth bass										
9.0+	1,562	4,202	1,921	2,603	2,187	1,309	1,332	2,591	2,213	2,946
10.0–11.9	354	1,737	1,020	1,102	1,165	457	739	673	1,088	1,720
12.0+	745	—	—	—	1,185	727	336	124	—	270
Largemouth bass										
9.0+	—	—	126	129	—	164	319	—	—	—
12.0+	—	—	—	—	—	29	—	—	—	—
Northern pike										
18.0+	395	377	2,022	2,555	1,002	1,449	1,140	920	917	1,236
20.0+	395	506	1,671	1,865	646	673	912	866	551	891
Bluegill										
5.0+	18,997	10,350	49,442	54,086	38,062	28,810	13,379	12,008	5,130	13,814
6.0+	18,169	6,520	10,367	40,395	22,905	27,819	9,377	11,160	4,672	11,133
Pumpkinseed										
5.0+	13,525	6,537	27,243	52,055	49,145	21,696	6,212	8,448	3,860	10,170
6.0+	13,199	5,211	3,986	25,861	27,292	18,230	2,675	3,986	1,763	2,903
Yellow perch										
7.0+	—	517	2,761	5,090	6,726	7,340	44,512	54,016	43,895	45,669
Black crappie										
7.0+	1,363	1,175	3,953	3,455	2,936	2,572	4,644	2,308	1,058	1,512
Rock bass										
5.0+	3,439	2,578	1,266	2,720	4,395	2,654	1,552	1,525	2,241	4,582
6.0+	2,418	1,518	585	1,696	1,162	1,884	788	670	1,094	3,613
White sucker										
9.0+	6,831	4,758	—	3,978	4,777	4,737	6,762	4,893	2,998	4,436

Table 3. Standing crop (pounds per acre) of fish in Manistee Lake, 1973–78 and 1981–84.[1]

Species and length (inches)	Year of estimate										
	1973	1974	1975	1976	1977	1978	1981	1982	1983	1984	Mean
Walleye 11.0+	7.1	3.2	1.5	2.4	6.6	4.9	7.2	4.0	4.8	5.9	4.8
Smallmouth bass 9.0+	2.0	4.7	1.5	2.0	2.6	1.6	1.2	1.6	1.5	2.2	2.1
Largemouth bass 9.0+	—	—	0.1	0.1	—	0.2	0.3	—	—	—	0.1
Northern pike 8.0+	1.8	2.2	7.7	8.2	3.1	5.2	3.1	3.1	2.8	2.8	4.0
Bluegill 5.0+	6.4	2.5	8.5	12.8	9.1	8.1	3.7	4.0	1.8	3.6	6.0
Pumpkinseed 5.0+	6.3	3.5	5.2	11.6	9.9	7.0	1.8	2.4	1.1	2.1	5.1
Yellow perch 7.0+	0.3[2]	0.3	0.9	1.6	1.9	2.2	16.4	13.5	20.1	18.5	7.5
Black crappie 7.0+	1.2	1.2	1.9	2.0	2.2	1.9	2.9	1.6	1.0	1.0	1.9
Rock bass 5.0+	0.6	0.7	0.3	0.7	0.8	0.7	0.5	0.4	0.6	1.2	0.6
White sucker 9.0+	22.1	15.2	13.0[3]	10.8	12.1	15.5	22.1	14.8	8.6	13.1	14.7
Total	47.8	33.5	40.6	52.2	48.3	47.3	59.2	45.4	42.3	50.4	46.8

[1] Estimates for 1973–78 were calculated by a slightly different method than those in the previous report (Laarman 1980).

[2] Assumed to be the same as in 1974.

[3] Mean of the two adjacent estimates.

Table 4. Walleye age-specific population estimates for 1973–78 and 1981–84, and a typical age distribution calculated from the average number of age-III walleyes (314) and the average survival rate (0.58).

	Age					
Year	I	II	III	IV	V	VI+
1973	0	0	101	424	479	1,521
1974	15	14	120	207	284	538
1975	647	7	41	88	109	129
1976	1,830	467	38	55	60	15
1977	1,093	1,953	527	93	86	57
1978	2,183	903	938	300	63	126
1981	1,197	352	724	903	660	875
1982	950	324	150	262	528	454
1983	1,876	852	334	181	204	719
1984	3,848	1,302	167	189	111	667
Typical	930	540	314	182	106	145

Table 5. Mean annual survival rate (s), based on 5 to 9 yearly averages, 1973–84, for age II and older or age III and older fish.

Species	Age	Survival rate	Number of years
Walleye	II+	0.58	8
Smallmouth bass	II+	0.32	9
Bluegill	III+	0.36	9
Pumpkinseed	III+	0.32	9
Yellow perch	III+	0.55	5
Black crappie	II+	0.53	9
Rock bass	III+	0.31	9
Northern pike[1]	I+	0.41	—

[1]The survival rate for northern pike was obtained by regressing age against $\log_e$ of average number (pooled years) of pike per age.

Table 6. Relative year-class strength expressed as average percent deviation of population estimates from the typical age distribution. Number of age-group estimates included in average is given in parentheses.

	Species						
Cohort	Walleye	Smallmouth bass	Blue-gill	Pumpkin-seed	Yellow perch	Black crappie	Rock bass
1968	+352 (1)	+339 (1)	+12 (1)	+187 (1)	— —	-39 (1)	+210 (1)
1969	+150 (2)	+50 (2)	-67 (2)	+95 (2)	-99 (1)	+253 (2)	+172 (2)
1970	-17 (3)	+45 (3)	-7 (3)	-23 (3)	-94 (2)	+59 (3)	+34 (3)
1971	-64 (4)	-36 (4)	-38 (3)	-69 (3)	-75 (3)	-83 (4)	-42 (3)
1972	-74 (5)	-70 (4)	-63 (3)	-83 (3)	-36 (3)	-88 (4)	-67 (3)
1973	-75 (5)	+1 (4)	+400 (3)	+735 (3)	+119 (3)	+159 (4)	-6 (3)
1974	+22 (4)	+7 (3)	-80 (2)	+26 (2)	+164 (2)	+163 (3)	-5 (2)
1975	+186 (3)	+6 (2)	+57 (1)	+11 (1)	-19 (1)	-63 (2)	+16 (1)
1976	+203 (3)	-63 (2)	-100 (1)	-81 (1)	+68 (1)	-4 (2)	+1 (1)
1977	+309 (3)	-79 (2)	-99 (2)	-77 (2)	+86 (2)	+71 (2)	-73 (2)
1978	+89 (3)	-66 (3)	-71 (3)	-84 (3)	+97 (3)	+67 (3)	-79 (3)
1979	-21 (4)	-68 (4)	-20 (3)	-93 (3)	+93 (3)	+39 (4)	-26 (3)
1980	0 (4)	+66 (3)	-94 (2)	-94 (2)	-10 (2)	-62 (3)	-17 (2)
1981	+4 (3)	-1 (2)	-98 (1)	-88 (1)	— —	-75 (2)	+141 (1)
1982	+121 (2)	+14 (1)	— —	— —	— —	-82 (1)	— —
1983	+312 (1)	— —	— —	— —	— —	— —	— —

Table 7. Deviations (inches) of walleye average length at age from the Michigan state average.

	Age								
Year	0	I	II	III	IV	V	VI	VII	VIII
1973	—	—	—	+1.2	-0.1	-0.1	-0.9	-0.4	-0.3
1974	—	+3.1	—	+1.3	+0.5	+0.3	-0.8	-1.1	—
1975	+1.1	+1.4	—	+1.8	+1.0	+0.6	+0.4	+0.6	—
1976	+1.1	+1.7	+1.9	+2.9	+3.0	+3.2	+3.1	—	—
1977	+1.5	+1.2	+0.5	+2.0	+1.9	+1.6	—	—	—
1978	+0.6	+0.9	+0.6	+1.0	+1.1	+0.6	+0.3	—	—
1981	+1.7	+1.6	+0.3	-0.3	-0.8	-0.4	-1.3	-0.2	—
1982	—	+1.2	+0.5	-0.3	-0.4	-0.9	-1.4	-1.2	—
1983	+0.3	+1.0	+0.2	-0.8	-0.9	-1.7	-1.5	-1.2	-0.8
1984	0	+0.9	-0.1	-0.2	-1.0	—	—	-3.4[1]	—
State average	7.1	10.4	13.9	15.8	17.6	19.2	20.6	21.6	22.4

[1]Known age walleyes with RP fin clips.

Table 8. Smallmouth bass age-specific population estimates for 1973–78 and 1981–84, and a typical age distribution calculated from the average number of age-III smallmouth bass (559) and the average survival rate (0.32).

Year	Age II	Age III	Age IV	Age V	Age VI	Age VII	Age VIII+
1973	576	566	141	250	76	0	0
1974	1,473	1,297	551	126	294	42	0
1975	1,814	79	44	15	0	7	7
1976	1,723	753	39	23	34	11	56
1977	1,475	459	171	0	64	11	42
1978	227	713	252	40	7	13	7
1981	802	160	44	35	44	18	9
1982	3,377	103	29	10	3	10	0
1983	1,634	878	62	33	14	33	28
1984	1,986	582	264	16	0	24	0
Typical	1,747	559	179	57	18	6	3

Table 9. Deviations (inches) of smallmouth bass average length at age from the state average.

	Age								
Year	0	I	II	III	IV	V	VI	VII	VIII
1973	—	+0.1	-0.8	0.0	+0.4	+0.9	+0.5	+0.3	—
1974	—	+0.3	-0.3	0.0	+0.4	—	+0.7	—	—
1975	—	-0.4	-0.4	+1.0	+0.5	—	—	—	—
1976	—	-0.1	-0.7	0.0	—	—	—	—	+1.3
1977	—	0.0	-1.0	-0.4	-0.1	—	+0.7	—	—
1978	—	+0.1	-0.6	-0.6	-1.0	+0.1	—	—	—
1981	—	+0.3	0.0	+0.9	-0.1	—	+0.2	—	—
1982	—	-0.8	-1.2	-0.2	+0.2	—	—	—	—
1983	+1.2	-0.2	-1.2	-1.3	—	—	—	—	—
1984	—	+0.1	-0.7	-1.0	-1.8	—	—	—	—
State average	3.8	7.5	10.8	12.6	14.4	15.3	16.3	17.3	18.1

Table 10. Northern pike age-specific population estimates for 1973–78 and 1981–84.

Year	Age							
	I	II	III	IV	V	VI	VII	VIII+
1973	—	29	208	93	36	0	7	21
1974	45	32	150	110	32	6	0	0
1975	1,134	99	247	295	247	0	0	0
1976	1,149	297	772	238	60	20	0	20
1977	426	453	68	27	14	0	0	14
1978	202	573	379	219	59	8	8	0
1981	508	707	25	0	0	0	0	0
1982	—	440	264	166	20	20	10	0
1983	338	256	204	119	0	0	0	0
1984	705	312	190	81	14	0	13	0
Average	563	320	251	135	48	5	4	5

Table 11. Deviations (inches) of northern pike average length at age from the state average.

Year	Age 0	I	II	III	IV	V
1973	—	—	—	+0.6	+2.2	+3.1
1974	—	+2.3	+1.9	+1.7	+1.6	+3.9
1975	+0.9	+3.2	—	+1.5	+1.8	+3.5
1976	—	+2.4	+1.9	+2.3	+1.9	—
1977	—	+2.3	+3.5	+5.8	—	—
1978	—	+3.3	+1.9	+1.9	+3.3	+2.8
1981	—	+1.3	+1.9	+2.7	+4.7	—
1982	—	—	+0.9	+2.5	+2.6	—
1983	—	+1.5	+1.9	+1.5	+3.9	—
1984	—	+1.0	+1.8	—	—	—
State average	11.7	17.7	20.8	23.4	25.5	27.3

Table 12. Deviations (inches) of largemouth bass average length at age from the state average.

Year	Age 0	I	II	III	IV
1973	—	—	+0.9	—	+1.6
1974	—	+1.0	+1.3	—	—
1975	—	+1.0	+1.9	—	—
1976	—	+1.2	+1.9	—	—
1977	—	+1.2	+1.6	—	—
1978	—	+0.7	+1.2	+1.0	—
1981	+0.9	+1.7	+1.6	—	—
1982	—	—	+1.4	—	—
1983	+1.1	+1.0	+1.5	+1.2	—
1984	—	+1.1	+1.4	+0.6	—
State average	4.2	7.1	9.4	11.6	13.2

Table 13. Bluegill age-specific population estimates for 1973–78 and 1981–84, and a typical age distribution calculated from the average number of age-III bluegills (11,762) and the average survival rate (0.36).

	Age					
Year	III	IV	V	VI	VII	VII+
1973	18,736	1,738	1,714	380	522	0
1974	5,866	2,023	376	198	66	13
1975	4,639	3,825	1,120	53	177	0
1976	51,680	2,178	694	70	29	0
1977	3,082	19,331	312	295	17	0
1978	18,454	574	9,208	366	133	0
1981	4,141	43	0	835	75	43
1982	10,242	963	15	45	460	208
1983	498	3,085	464	0	111	143
1984	280	400	1,200	20	10	0
Typical	11,762	4,234	1,524	549	198	106

Table 14. Deviations (inches) of bluegill average length at age from the state average.

Year	Age						
	I	II	III	IV	V	VI	VII
1973	—	-0.1	+0.6	+1.3	+1.2	+1.6	+1.7
1974	0.0	0.0	+0.4	+1.2	+1.4	+1.8	+1.6
1975	—	+0.8	+0.9	+0.9	+1.1	—	+1.7
1976	+0.8	-0.2	+0.5	+1.2	+1.2	+1.5	—
1977	—	+0.1	+0.4	+0.5	+0.9	+1.0	—
1978	—	—	+0.5	+0.1	+0.6	—	—
1981	—	+0.8	+1.7	—	—	+1.4	+1.4
1982	—	—	+1.0	+1.5	—	—	+1.6
1983	+0.1	+0.9	+0.7	+1.1	+1.8	—	—
1984	+0.1	+1.3	+1.9	+1.5	+1.5	—	—
State average	3.8	5.0	5.9	6.7	7.3	7.8	8.2

Table 15. Pumpkinseed age-specific population estimates for 1973–78 and 1981–84, and a typical age distribution calculated from the average number of age-III pumpkinseed (8,079) and the average survival rate (0.32).

Year	Age					
	III	IV	V	VI	VII	VIII+
1973	6,143	4,045	2,376	702	0	0
1974	2,560	1,272	1,931	609	0	0
1975	2,255	494	883	218	0	0
1976	47,163	385	354	100	43	0
1977	9,840	20,019	59	30	22	0
1978	9,003	3,347	9,496	55	21	0
1981	1,221	606	153	374	329	97
1982	808	526	197	60	333	103
1983	803	164	106	87	87	31
1984	998	81	34	95	47	25
Typical	8,079	2,585	827	265	85	39

Table 16. Deviations (inches) of pumpkinseed average length at age from the state average.

Year	Age I	II	III	IV	V	VI	VII
1973	—	+0.1	+0.6	+1.5	+1.6	+1.7	—
1974	0.0	+0.1	+0.6	+1.3	+1.7	+1.7	—
1975	-0.2	+0.3	+1.3	+1.3	+1.8	+1.8	—
1976	0.0	0.0	+0.9	+1.7	+1.8	+1.9	+1.7
1977	—	+0.1	+0.6	+0.8	+1.7	+1.6	+1.5
1978	0.0	—	+0.4	+0.5	+0.9	+1.5	—
1981	0.0	+0.4	+1.8	+1.5	+1.6	+1.4	+1.5
1982	—	+0.4	+1.3	+1.7	+1.9	—	+1.4
1983	+0.1	+0.6	+1.4	+1.7	+1.7	+1.5	+1.6
1984	-0.1	+0.8	+1.6	+2.1	+1.2	+1.6	+1.9
State average	3.8	4.9	5.6	6.2	6.6	7.1	7.5

Table 17. Yellow perch age-specific population estimates for 1974–78 and 1981–84, and a typical age distribution calculated from the average number of age-III yellow perch (14,263) and the average survival rate (0.55).

Year	Age					
	III	IV	V	VI	VII	VIII+
1974	45	71	53	125	0	0
1975	5,343	4,459	533	100	29	26
1976	12,840	9,208	833	140	47	8
1977	29,880	10,501	1,635	54	4	0
1978	11,613	24,992	18,666	162	90	54
1981	22,670	15,092	7,233	1,462	364	121
1982	21,293	12,416	7,764	4,493	1,370	197
1983	10,422	11,469	11,788	7,841	1,717	0
1984	—	8,402	12,229	5,730	1,661	501
Typical	14,263	7,845	4,315	2,373	1,305	—

Table 18. Deviations (inches) of yellow perch average length at age from the state average.

Year	Age							
	I	II	III	IV	V	VI	VII	VIII
1973	—	—	-0.2	—	+2.3	+1.8	—	—
1974	—	—	-0.9	+0.1	+1.7	+1.4	—	—
1975	—	-0.8	-1.1	-0.9	-0.3	+0.1	+0.3	+0.6
1976	—	-1.1	-1.2	-0.6	+0.6	+0.4	+1.4	—
1977	—	-0.9	-1.3	-0.5	+0.1	+1.2	—	—
1978	—	—	-1.4	-2.1	-1.7	-0.7	-0.1	—
1981	-0.4	-0.4	+0.2	+0.8	+1.0	+1.2	—	—
1982	+0.4	0.0	+0.7	+1.4	+1.0	+1.2	+0.6	—
1983	+0.1	0.0	+0.7	+1.0	+1.5	+0.9	+1.0	—
1984	+0.4	+0.4	+0.7	+1.5	+1.2	+0.6	-0.3	—
State average	5.2	6.5	7.5	8.5	9.4	10.3	11.1	11.6

Table 19. Black crappie age-specific population estimates for 1973–78 and 1981–84, and a typical age distribution calculated from the average number of age-III crappies (590) and the average survival rate (0.53).

	Age						
Year	II	III	IV	V	VI	VII	VIII+
1973	58	145	1,054	101	4	0	0
1974	138	100	210	613	24	0	0
1975	3,789	26	53	53	61	0	0
1976	2,036	1,330	19	46	27	3	0
1977	434	1,808	617	42	15	19	0
1978	936	204	939	457	5	20	6
1981	2,273	1,070	488	179	294	325	2
1982	531	730	468	308	13	206	26
1983	37	201	368	280	119	10	31
1984	201	284	97	179	173	97	7
Typical	1,113	590	313	166	88	47	—

Table 20. Deviations (inches) of black crappie average length at age from the state average.

Year	Age I	II	III	IV	V	VI	VII
1973	+0.4	+1.3	+1.4	+1.7	+2.0	—	—
1974	+0.2	+1.4	+1.7	+1.9	+1.7	—	—
1975	+0.1	+1.4	+2.0	+2.1	+2.1	+2.3	—
1976	+0.1	+1.3	+1.7	+2.4	+2.3	+2.0	—
1977	+0.2	+1.3	+1.6	+1.9	+2.0	—	—
1978	0.0	+1.4	+1.7	+1.6	+1.8	—	+1.5
1981	-0.1	+0.7	+1.4	+2.0	+1.8	+1.9	+1.6
1982	—	+0.9	+1.3	+1.7	+1.9	—	+1.5
1983	+0.8	+1.6	+1.3	+1.6	+1.8	+1.7	—
1984	+0.9	+1.8	+1.0	+1.0	+1.2	+1.3	+1.1
State average	6.0	7.5	8.6	9.4	10.2	10.8	11.4

Table 21. Rock bass age-specific population estimates for 1973–78 and 1981–84, and a typical age distribution calculated from the average number of age-III rock bass (1,202) and the average survival rate (0.31).

Year	Age					
	III	IV	V	VI	VII	VIII+
1973	1,825	1,204	360	19	19	0
1974	1,245	584	256	61	19	0
1975	310	151	109	42	5	16
1976	1,371	172	36	42	10	0
1977	982	426	33	25	8	0
1978	1,390	405	64	0	0	0
1981	299	122	117	65	9	0
1982	943	84	26	19	24	2
1983	765	126	18	6	6	10
1984	2,893	385	129	19	15	0
Typical	1,202	373	116	36	11	5

Table 22. Deviations (inches) of rock bass average length at age from the state average.

Year	Age I	II	III	IV	V	VI	VII
1973	—	—	-0.2	+0.2	+0.5	—	—
1974	-0.2	-0.1	+0.2	+0.7	+0.5	+0.5	—
1975	—	-0.1	+0.4	+0.7	+0.8	+0.6	—
1976	-0.1	0.0	+1.0	+1.1	+1.3	+1.0	—
1977	—	-0.1	+0.2	+0.8	—	—	—
1978	—	-0.1	+0.5	+1.0	+0.4	—	—
1981	-0.3	+0.3	+1.2	+1.4	+1.5	+1.2	—
1982	—	-0.1	+0.7	+1.5	+1.3	+1.2	+1.1
1983	—	0.0	+0.8	+1.5	+1.4	—	—
1984	0.0	+0.3	+0.9	+1.3	+1.2	—	—
State average	3.9	5.1	6.1	6.9	7.8	8.6	9.3

Table 23. Average length (inches) of white suckers in 1973–78.

	Age						
Year	I	II	III	IV	V	VI	VII
1973	—	12.6	16.9	21.4	22.3	—	—
1974	9.7	13.6	17.0	21.5	21.4	—	—
1975	10.2	14.2	18.4	20.3	20.7	—	—
1976	12.7	14.1	17.3	19.8	21.3	—	—
1977	10.7	14.8	17.7	20.5	22.3	—	—
1978	9.7	13.6	17.5	19.5	21.0	21.4	23.7
Mean	10.6	13.8	17.5	20.5	21.5	21.4	23.7

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