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EXPERIMENTAL WALLEYE-PERCH MANAGEMENT IN A SMALL LAKE[1]

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[1]Contribution from Dingle-Johnson Study F-35-R-8, Michigan.

Abstract

The experimental walleye-yellow perch community of Jewett Lake was subjected to public angling in 1979-82. The characteristics of the fishery and of the fish populations were monitored and compared to modeled responses.

Fishing quality was on a par with other relatively low-yield coolwater fisheries. Anglers were able to harvest only 1.3-3.8 walleyes per hectare per year, far short of the quota of 7.0 which had been allotted in the model. Exploitation rate was 8.9% and natural mortality was 9-19%. Anglers took 50.5-64.0 perch per hectare per year in 1979-81, but harvest dropped to 11.6 in 1982. Only about 6% of the perch died from fishing, but this rate may have been excessive because natural mortality was very high, 88% per year. Apparently, high mortality of both juvenile and adult perch was due to walleye predation.

Compared to model predictions, rates of walleye fishing and natural mortality were low, resulting in a high standing crop, slow growth, and excessive predation on perch. The perch population was turning over too rapidly but will probably recover as dominant year classes of planted walleyes are gradually replaced by smaller classes of native walleyes. The community could have supported higher densities of planktivors and benthivors.

Introduction

Manipulation of fish communities to create balance (i.e., stable species populations containing satisfactory proportions of large fish) is a challenging and unpredictable part of fisheries management. Designing and constructing balanced communities is an even greater challenge.

One sign of imbalance in the fish community, found in many Michigan lakes, is an overabundance of yellow perch (Perca flavescens). They grow so slowly that few of them achieve a useful size before they die of natural causes. The remedy is to reduce the recruitment of small perch so that the survivors will be able to get more food and grow better. This can be done artificially by removal of some fish with toxicants or nets, but these techniques can be costly and are not likely to result in an enduring change in the perch population. The same remedy can sometimes be effected through natural means by manipulating fish communities so as to promote predation on small perch. The walleye (Stizostedion vitreum) can serve this function; furthermore it is a sport and food fish prized by anglers.

Experiments on the dynamics of yellow perch populations and communities were begun at Jewett Lake in 1966. To date, a series of four multi-year studies of increasing complexity have been conducted. In the first study, perch were the only fish in the lake (Schneider 1972); in the second, the fish community consisted of perch and minnows (Schneider 1972); in the third, of perch, minnows and walleye (Schneider 1979); and in the fourth study, the same perch-minnow-walleye community was subjected to angling exploitation (the subject of this report). The objectives of this last study were (1) to test if the populations and fisheries would be stable and respond as predicted, and (2) to demonstrate the practicality of managing small lakes for perch and walleye fisheries.

Results from the first study confirmed the need to control perch recruitment for satisfactory perch growth to be maintained. Results from the second study indicated that minnows could temporarily reduce the growth and recruitment of young-of-the-year perch, but the minnow population was quickly eliminated by adult perch predation. Results from the third study indicated that the addition of walleyes (stocked as fingerlings) could regulate perch recruitment and growth and that a fairly balanced community could be established. Results from the fourth (and present study) suggest the community can be destabilized by angling.

Jewett Lake is in the Rifle River Recreation Area, Ogemaw County, Michigan. Surface area is 5.2 ha and maximum depth is about 5 m. The light brown water has an alkalinity of 34 ppm. About 90% of the shoreline is rimmed by encroaching bog. The substrate is composed entirely of soft silt and peat except for very small, silty strips of sand at the water's edge.

Despite a lack of classical spawning habitat, walleyes spawned successfully every year from 1979 through 1982. This was evidenced by the collection of juvenile and sub-adult walleyes which either were born in years when hatchery-reared fingerlings had not been planted, or did not have identifying fin clips. Native fish also grew more rapidly than hatchery-reared fish. Furthermore, walleye eggs in the process of hatching were collected from the sand strips on May 4, 1982. The first year of successful natural reproduction (1979) corresponds to the time when the first walleyes planted in the lake (1975) probably first reached sexual maturity (age IV).

Methods

The perch-minnow-walleye community established in 1973-78 was the starting point for the present study, conducted in 1978-82. Methods described below were similar to those used in preceding studies except that public angling was permitted. A simple model based on previous survival and growth data was developed to predict walleye population response.

Fingerling walleyes averaging 86-179 mm (3.4-7.0 inches) total length were stocked each fall, 1975-80, at the rate of about 62 per ha (Table 1). All planted walleyes were given an identifying fin clip except those planted in 1976. Planting was discontinued because natural walleye recruitment seemed to be adequate.

The fish populations were sampled in September-October with 220-volt a-c electrofishing gear and trap nets. The Chapman modification of the Petersen mark-and-recapture method (Ricker 1975) was used to estimate numbers of fish through 1981. Perch were marked by clipping a lobe of the caudal fin; walleyes were marked either by clipping the caudal fin by inserting a numbered Floy Anchor tag at the base of the soft dorsal fin. Estimates were stratified by 25-mm size groups for perch and by fin clip (year class) for walleye to eliminate bias caused by size selectivity of the fishing gear. With the aid of scale samples and length-frequency measurements, estimates were stratified by both size and age for both species. About 75% of the large fish were actually handled during each population estimate.

Growth samples were collected through 1982. Average lengths of walleyes and young perch were calculated directly from empirical measurements; average lengths of older perch were derived, when possible, by weighting the empirical measurements with the population estimates to compensate for gear size selectivity.

Estimates of fish standing crops were calculated from estimates by age group, average lengths, and length-weight regressions.

The number of eggs produced yearly by the perch population was estimated by a slightly different method than that used before (Schneider 1979). (Earlier estimates for

1976-1978 have been revised accordingly.) Basically, the estimates were obtained by summing partial estimates stratified by age group and inch group. Steps in the calculation of partial estimates were as follows: (1) determine the number of perch present in the spring from fall population estimates and age-specific survival rates (except for 1978, when spring population estimates were made directly); (2) calculate the number and size distribution of females (assuming a 1:1 sex ratio and that females were the fastest growers in each year class); (3) multiply by the percentage of mature females (unpublished data from several perch populations); and then (4) multiply by the average number of eggs produced by a female of that inch group (Schneider 1972).

Some walleyes and perch were removed by angling in July 1978 to bring the community into better balance as the initial step in the present study (Schneider 1979). In 1979-82, public angling was allowed under a tightly controlled system. Free daily permits, one per fishing party, were issued by area personnel at the entrance to the Rifle River Recreation Area. After fishing, anglers were required to report back so their catch could be examined and their effort could be tabulated. In addition they were asked to rank fishing as either excellent, good, satisfactory, or poor. Out of the 701 permits issued, 80% provided complete information on catch and effort, 7% had incomplete information on effort, and 13% provided no information because the permittees did not report back (Table 2). This non-reporting probably did not cause a serious underestimate of the total catch because typical reasons for non-reporting were last-minute cancellation of the fishing trip or failure to catch anything. The total effort statistics may be low by about 15%.

Preliminary angling in 1978 suggested that the walleyes would be easy to catch and could be overexploited (Schneider 1979). Consequently, unusually restrictive regulations were established for public fishing in 1979-82. For walleyes, restrictions were an annual quota of 37, a minimum size limit of 14.0 inches (356 mm), and a daily limit of one per person. For perch, no quota or size limit was established but the daily limit was set at 10 per person. Use of bait minnows was prohibited. The fishing season was restricted to July 9 - Labor Day in 1979 and 1980, and to May 15 - Labor Day in 1981 and 1982. The quota of 37 walleyes was not taken by anglers in any of these years; consequently, in 1979 and 1980 quotas were completed during fall netting.

Population data collected since 1975 which were reported earlier (Schneider 1979), will be repeated here to fully illustrate the trends in the fish community.

Results and Discussion

Angling

Annual fishing pressures of 130 to 218 angler hours per hectare were logged at Jewett Lake during the 4 years of public fishing (Table 2). Most of the walleyes were caught early in the season, most of the perch in late summer. Despite this pressure and the small size of the lake, anglers were able to harvest only 7-20 walleyes per year instead of the 37 targeted for removal. Estimates made a month after the fishing season ended revealed that 75-109 legal-size walleyes remained (Table 3). Thus, anglers were able to harvest only a small fraction of the legal walleyes available. Based on first-year tag returns, exploitation averaged 8.9% in 1979-81. In 1978, very limited fishing had produced exploitation rates of 18% in May and 21% in July (Schneider 1979).

The catch rate for all sizes of walleyes was less than 0.1 per hour -- down considerably from the rates of 1.9 and 0.6 experienced during the test angling in 1978 (Table 2). This decline cannot be attributed to a decline in abundance. The numbers of walleyes larger than 254 mm (10.0 inches) were 297, 288, 272, 208, and 145 in 1977 through 1981, respectively (Table 3). The decline in fishing success was apparently due to selective harvest of more aggressive walleyes, or to increased wariness on the part of the survivors. This phenomenon has been reported for bass and certain other species before, but not for walleye (Goedde and Coble 1981; Schneider 1973).

Yellow perch, on the other hand, were highly exploited. Anglers removed 266-337 per year in 1979-81, but only 61 in 1982 (Table 2). The annual catch was of the same magnitude as the fall population of perch larger than 178 mm (7.0 inches) (Table 3); however, much of the harvest was comprised of relatively small perch which had grown to a harvestable size during August. Perch less than 178 mm long made up 39% of the harvest on the average, and as much as 54% in 1 year (Table 4). Few of the perch reached a length of 250 mm.

Most anglers ranked overall fishing quality as poor. Based on 541 interviews, 64% of the anglers ranked their fishing trip as poor, 24% as satisfactory, 10% as good, and 2% as excellent. The rankings were slightly higher in 1979 and 1980, years when catch rates were higher. Fishing rank was more strongly correlated (r=0.51) with total fish caught per angler hour than with any other indices of catch or effort. Comparable opinion surveys are not available for other fisheries, but the harvest rate of 0.1-0.4 fish per hour at Jewett Lake does not compare favorably with the 1.0 fish per hour of typical warmwater lakes (Schneider and Lockwood 1979). On the other hand, this harvest rate is close to that of some northern lakes in which coolwater species predominate (unpublished data).

<u>The walleye population</u>

The walleye population was composed of cohorts planted as fingerlings in 1975-80 plus native fish hatched in 1979-82. The 1976, 1975, and 1981 year classes were the strongest. The abundance of each cohort may be traced through time in Table 5 and Figure 1.

Mortality and subsequent success of the planted fingerlings varied greatly. Natural mortality during the first year of life in Jewett Lake was only 45% for the 1975 cohort and 30% for the 1976 cohort, but 92-97% for the 1977-80 cohorts (Table 6). The fingerlings planted in later years were at a disadvantage because they were small and predatory large walleyes were well established (Tables 1 and 3). Most of the first-year natural mortality took place soon after planting, though little was actually observed. Population estimates made 2 to 7 weeks after planting indicate daily instantaneous mortality rates were 0.0003, 0.057, 0.052, and 0.026 for the 1976-79 plants, respectively.

Mortality was low beyond the first year -- after a length of roughly 250 mm had been obtained. Natural mortality averaged 9-19% per year thereafter (Table 6).

Growth was rapid for small- to medium-sized walleyes but far below the desired rate (state average) for medium- to large-sized fish (Table 7). Legal length (356 mm) was usually reached during the third or fourth year of life, but growth of the strong 1976 year class was much slower. Tagging studies confirmed that many of those walleyes virtually ceased growing at 300-350 mm.

It is apparent that the population was not exploited enough to reduce intraspecific competition and bring growth into the desired pattern. Walleye standing crop remained higher than desired -- 15.3, 18.3, 17.4, and 12.2 kg per hectare in 1978-81, respectively (Table 8). The goal set in the model was 13.3 kg per hectare.

The yellow perch population

Recruitment of young perch varied considerably during the 7 years of observation. The number of age-0 perch in the fall ranged from 3,478 to 22,766 (Table 9) and their weight varied from 1.5 to 29.1 kg per hectare (Table 8). Average length of these perch progressively increased from 48 to 114 mm (Table 10). Slow growth in 1975, and to a lesser extent in 1976, was attributed to competition with planktivorous minnows (Schneider 1979); conversely, rapid growth in later years was attributed to low intra- and interspecific competition brought about by intensive walleye predation.

Growth of yearling and older perch was much above the state average (Table 10). This is in sharp contrast to the slow growth of perch before walleyes were introduced (Schneider 1972).

Total mortality was extremely high for all ages and sizes of perch (Table 11). For age 0-I perch, total mortality increased from 88 to 97% during the study. Some of this increase was due to angling harvest and hooking mortality but most of it must have been due to increased walleye predation. Morality of age I-II perch also increased, from 21% to over 90%, due in part to angling, but also to an increase in large walleyes capable of attacking relatively large perch. Scars were seen on the peduncles of these perch.

Angling harvest was a very small component of total perch mortality. The fishery was composed of some fast growing perch in their second summer of life (age interval fall 0 - fall I) plus older perch. Based on the estimates for age 0 and older perch in the preceding fall (Table 9), and the number of perch harvested the following summer (Table 2), expectation of death from fishing was only 3.7% in 1979, 2.2% in 1980, 3.1% in 1981, and 1.6% in 1982. Mortality caused by hook-and-release may have been of similar magnitude, judging from the catch data in Table 2. Total mortality averaged 94% during those years; thus about 6% of the perch died from harvest and hooking and about 88% died from natural causes.

This is not to say that anglers were ineffective at harvesting the perch available to them. Many of the perch present in the fall died before fishing began the next summer. For example, the perch harvested in July 1978 represented only 4.8% of the stock present in fall 1977, but about 30% of the perch actually present in July (Schneider 1979).

Perch natural mortality appeared to be evenly distributed throughout the year. Instantaneous daily natural mortality rates were calculated for overwinter and oversummer periods from population estimates made on September 28, 1977, May 18, 1978, and October 9, 1978 (Schneider 1979). For age 0-I (1977 year class), these rates were 0.0052 and 0.0059, respectively. For older perch (1976 and 1975 year classes combined), these rates were 0.0056 and 0.0046, respectively. The last figure, 0.0046, probably would have been higher if fishing had not also occurred in the summer of 1978.

Predicated versus observed responses

A model of a stable walleye population and fishery was developed at the beginning of the study from data collected prior to 1979 (Table 12). The model is of the Ricker (1975) type, in which changes in biomass are computed at each age from instantaneous rates of growth (G), natural mortality (M), and fishing mortality (F). Biomass figures are then converted to numbers of fish from average weights. The modeled population began with 0.94 kg per hectare of age-0 fall fingerlings, 127 mm long, to simulate the annual plantings of 325 fingerlings into Jewett Lake. It was judged that the Jewett Lake perch-walleye community could probably support a fall standing crop of about 13 kg per hectare of walleyes with the growth (state average lengths and weights -- Merna et al. 1981) and mortality rates given in Table 12. In simulating the fishery, it was assumed that exploitation would be intensive (F=0.7, equivalent to a exploitation rate of about 45% per year), and that with a 356-mm size limit (reached during age III) there would be a 10% hooking mortality on sublegal (age-II) walleyes.

Key features of the model were a fall biomass of 13.3 kg per hectare, an instantaneous natural mortality rate of 0.36 per year after fall of age I, and a predicted annual harvest of 4.12 kg per hectare and 7.0 walleyes per hectare (7.0 x 5.2 ha = quota of 37 set for entire lake in 1979-82). Observed features of the walleye population and fishery were different. Fall biomass was higher (12.2-18.3 kg per hectare), natural mortality of adults was lower (an average of 0.21 in 1979-80), and annual harvest was much lower (1.3-3.8 walleyes per hectare). The overestimation of natural mortality, plus the inability of anglers to harvest their quota of walleyes (especially before the end of the growing season), triggered a chain reaction which led to an excessive density of walleyes, slow growth, and excessive predation on perch. The decline in walleye biomass to 12.2 kg per hectare in 1981, and the modest rates of natural recruitment in recent years, may have signaled a better balance was being approached as the study ended.

Whether or not the perch population will be able to maintain stability remains to be seen. The population and harvest declined drastically by the end of the study. Sources of concern are the high mortality of adults, low density of spawners, and recruitment decline in 1981. Egg production declined at an alarming rate after 1978, and by 1982 it had fallen to 10% of its former level (Table 9). No relationship between number of eggs and number of fall fingerlings has been detected, however, the ability of the population to sustain recruitment has become questionable. Survival from egg to fall fingerling varied from 0.2% to 1.7% from 1975 to 1981.

Compared to an empirical model constructed to optimize the production of large perch in Jewett Lake (Schneider 1972 and 1979), the present perch population is not fully utilizing planktonic and benthic food resources. The rapid growth of young-of-the-year perch indicates that planktonic foods were plentiful and that the density of small perch (or other planktivors) could be increased to optimize fish production. However, maintaining a higher density of plankton feeders in the face of intense predation would be difficult. Populations of fathead and bluntnose minnows already have been virtually eliminated.

The low density and rapid growth of yearling and older perch suggest that benthic foods were underutilized and that the potential production of large perch was not being realized. However, small- to medium-sized walleyes were taking some of the excess benthos, judging from their surprisingly good growth and their food habits (Table 13). Young perch, originally expected to serve as the primary forage, grew so quickly that they soon passed through the size preferred by small walleyes.

Unexpectedly, perch apparently were unable to outgrow predation from large walleyes. Even adult perch suffered a high natural mortality rate -- 88% per year. In the absence of walleyes, adult perch mortality was about 41% (Schneider 1979); thus about 47% of the adult perch deaths can be attributed to walleyes.

Management strategies

The perch-walleye community in Jewett Lake was reasonably well balanced and was providing a specialized fishery fairly close to its biological potential. The dissatisfaction expressed by anglers is attributed to a combination of relatively low biological potential (as compared to more diverse communities dominated by bluegills and bass), inability to catch walleyes (they are notoriously difficult to catch in most waters), and unreasonably high expectations (fishing is expected to be good in a research lake).

Biological production could be improved some if the recruitment of young perch could be increased. Factors limiting the recruitment of perch in this situation are not precisely known, but an improvement in the rates of adult survival and egg production would add a safety factor. Under current conditions, the failure of two or three year classes would probably lead to extinction of the perch population. Furthermore, in order to generate a more desirable density of young perch, survival from egg to fall fingerling would have to be much higher than has been observed thus far--about five times the 1981 survival rate.

Biological production could also be improved some by establishing another planktivor-benthivor which would serve as prey for medium to large walleyes. Addition of bluegills (Lepomis macrochirus) to the community would fill the "open" niche, but they could overpopulate and interfere with the survival of walleye and perch fry. Golden shiners (Notemigonus crysoleucas) would also fill the niche (Beyerle 1977, Schneider 1979), but Jewett Lake has so little vegetation or other forms of cover that shiners might not be able to escape predation and maintain a population unless artificial cover were added.

Reduction, or complete elimination, of the 14-inch minimum size limit on walleyes would be an appropriate management strategy if conditions remained the same. If a lower size limit had been in effect in 1979-81, the harvest quota would have been met (Table 2), and perhaps some of the slowest growing walleyes would have been utilized. In addition, yield by weight would have been optimized. Because walleye growth was sub-standard, the critical size (the size at which growth balances natural mortality and fishing yields, by weight, are optimal) was less than expected, only about 13 inches. If growth had been equal to the state average, while natural mortality was as low as observed (M=0.21), then a 19-inch minimum size limit would have optimized yield to an intensive fishery. Thus, the ability to predict rates of growth and mortality is crucial to the selection of size limits (Schneider 1978).

Rather than introducing another species, more cover, or changing the walleye size limit, a wait-and-see strategy has been selected. This will allow the walleye population to stabilize and the community to adjust. It is anticipated that the dominant, slow-growing, 1975 and 1976 year classes of walleyes will soon be thinned out by natural mortality, and that recruitment (entirely natural) will probably continue at a modest level (less than 325 fall fingerlings per year). As a result, the total biomass of walleyes should decline to a better level (10-12 kg per hectare), year class strength should become more even, and growth should improve (approach the state average). Perch survival and recruitment should improve also, leading to a modest improvement in the fishery.

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Table 1. Walleyes planted in Jewett Lake, 1975-80.

Date	Fin clip	Number	Mean length (mm)
9/16/75	RV	329	141
9/02/76	None	325	179
9/15/77	LP	340	137
9/15/78	LV	325	135
8/23/79	RP	339	107
9/17/80	RV	325	86

Table 2. Angling catch (harvested fish and released fish) and effort for Jewett Lake in 1978 (sampling) and 1979-82 (public fishing under permit system).

	Year and date					
	1978 5/22- 5/24	1978 7/26- 7/27	1979 7/9- 9/2	1980 7/9- 8/31	1981 5/15- 9/7	1982 5/15- 9/5
Permits						
Issued	...	...	153	184	221	143
Incomplete	...	...	4	18	24	5
Not returned	...	...	3	22	43	20
Catch						
Walleyes						
Harvested	0	74	20	10	18	7
Released	61	0	65	26	32	41
Yellow perch						
Harvested	0	165	383	337	266	61
Released	27	0	469	493	378	36
Effort						
Angler hours	32	118	1,021	850	1,136	675
Hours/Trip	...	...	2.4	2.5	2.5	2.4
Catch per hour[a]						
Total						
Walleye	1.92	0.63	0.08 (0.15)	0.04 (0.06)	0.04 (0.06)	0.07 (0.06)
Yellow perch	0.85	1.40	0.78 (0.90)	0.98 (0.03)	0.57 (0.60)	0.14 (0.20)
Harvested						
Walleye	...	0.63	0.02 (0.03)	0.01 (0.01)	0.02 (0.04)	0.01 (0.01)
Yellow perch	...	1.40	0.33 (0.38)	0.40 (0.51)	0.23 (0.22)	0.09 (0.12)

[a] Simple ratios of total catch (harvested + released fish) divided by angler hours, or of harvested fish divided by angler hours, respectively. Catch per hour figures computed on a per trip basis are given in parentheses.

Table 3. Estimated numbers of walleye and yellow perch by size groups in fall, 1975-81.

Species, and size group (mm)	Year of estimate						
	1975	1976	1977	1978	1979	1980	1981
Walleye							
0-202	329[a]	174	138	94	137	5	250
203-253		107	75	10	4	2	8
254-304			131	156	26	16	5
305-355		180	118	91	169	83	65
356-405			43	39	61	75	54
406-456			5	8	14	18	14
457-507				1	1	9	6
508-584					1	7	1
≥356			48	48	77	109	75
Yellow perch							
0-101	6,369	22,766	5,366	8,019	14,412	2,239	785
102-177		409	3,051	770	310	5,972	2,883
178-280		344	380	296	216	349	100

[a] Actual number of fingerlings planted in early fall, 1975. Other figures for small walleyes are based on mark-and-recapture estimates made after planting.

Table 4. Size-frequency distribution in percent of yellow perch harvested by anglers, number of perch measured, and their mean length, 1979-82.

Size group (mm)	Percent in size group				
	1979	1980	1981	1982	1979-82
76-101			1		Tr
102-126	Tr[a]	Tr			Tr
127-151	12	9	5		9
152-177	11	45	35	8	30
178-202	29	23	33	62	29
203-228	27	15	20	20	20
229-253	19	5	4	8	9
254-278	1	2	2	2	2
279-305			1		Tr
Number measured	326	383	266	50	1,026
Mean length (mm)	193	178	188	188	191

[a] Tr = Trace less than 0.5%

Table 5. Estimated numbers of walleyes (in parenthesis are the actual number of different walleyes examined) in Jewett Lake, fall 1976 to fall 1982.

Year class and origin[a]	Year of estimate						
	1976	1977	1978	1979	1980	1981	1982
1975p	180 (80)	128 (97)	88 (68)	64 (48)	44 (34)	28 (19)	-- (2)
1976p	281 (167)	241 (161)	188 (115)	158 (102)	107 (88)	62 (52)	-- (5)
1977p		160 (63)	28 (22)	24 (21)	26 (23)	15 (12)	-- (1)
1978p			94 (75)	18 (15)	7 (6)	7 (5)	-- (0)
1979p				136 (32)	19 (13)	13 (10)	-- (1)
1979n				6 (5)	6 (5)	4 (3)	-- (0)
1980p					-- (0)	11 (10)	-- (4)
1980n					-- (5)	15 (13)	-- (5)
1981n						249 (90)	-- (13)
1982n							-- (18)

a p = planted as fingerlings; n = native

Table 6. Expectations of death (fishing-u, natural-v, and total-A, of walleyes in Jewett Lake based on the graphed population estimates and known harvest.

Year class, source, and type of mortality	Age group interval (fall to fall)					
	0-I	I-II	II-III	III-IV	IV-V	V-VI
1975p						
u	0	0	0.234	0.182	0.188	0.182
v	0.452	0.289	0.078	0.091	0.125	0.182
A	0.452	0.289	0.312	0.273	0.303	0.364
1976p						
u	0	0.199	0.016	0.067	0.159	
v	0.299	0.021	0.112	0.280	0.262	
A	0.299	0.220	0.128	0.347	0.421	
1977p						
u	0.003	0	0	0.292		
v	0.915	0.071	0.078	0.083		
A	0.918	0.071	0.078	0.375		
1978p						
u	0.006	0.167	0.300			
v	0.939	0.278	0.100			
A	0.945	0.445	0.400			
1979p						
u	0.006	0.053				
v	0.938	0.263				
A	0.944	0.316				
1980p						
u	0					
v	0.966					
A	0.966					
Average natural mortality(v)	--	0.184	0.092	0.123	0.194	0.182

p = planted as fingerlings.

Table 7. Mean total lengths (mm) at age (fall samples) for walleyes before and during periods of angling harvest (above and below the line, respectively). Also given are the averages for the angling period and the State of Michigan average.

Year class and origin[a]	Age group						
	0	I	II	III	IV	V	VI
1975p	141	324	351	360	385	433	416
1976p	179	279	291	327	353	358	381
1977p	137	274	327	356	368		
1978p	135	308	363				
1979p	107	295	340				
1979n	207	323	341				
1980p	86	234	348				
1980n	167	310	366				
1981n	128	312					
1982n	145						
Average during angling period	139	294	339	348	369	396	399
State average	180	264	353	401	447	488	523

[a] p = planted as fall fingerlings; n = native cohort.

Table 8. Estimated standing crops (kilograms per hectare) of walleyes, yellow perch, and minnows in Jewett Lake, fall 1975 - fall 1981.

Species and year class[a]	Year of estimate						
	1975	1976	1977	1978	1979	1980	1981
Walleye							
1975p	1.4[b]	9.3	8.6	5.9	6.1	6.7	3.4
1976p		2.8[b]	8.1	7.2	9.3	6.7	4.6
1977p			1.4[b]	0.9	1.5	1.9	1.1
1978p				1.3[b]	0.8	0.8	0.5
1979p					0.6[b]	0.8	0.8
1979n					..	0.3	0.3
1980p						0.2[b]	0.2
1980n						...	0.7
1981n							0.6
Total	1.4	12.1	18.1	15.3	18.3	17.4	12.2
Yellow perch							
1975p	1.5	8.2	7.0	2.2	0.4	0.1	
1976p		20.9	13.0	4.1	0.6	0.4	
1977n			7.0	4.4	0.6	0.2	0.1
1978n				8.6	4.2	0.7	0.2
1979n					20.2	7.9	0.4
1980n						18.4	2.5
1981n							6.7
Total	1.5	29.1	27.0	19.3	26.0	27.7	9.9
Minnow[c]							
Total	26.3	2.1	trace	trace	...	trace	...
Grand total	29.2	43.3	45.1	34.6	44.3	45.1	22.0

[a] p = planted as fall fingerlings; n = native

[b] Weight of fingerlings planted.

[c] Mostly fatheads (*Pimephales promelas*); a few bluntnose (*Pimephales notatus*) present in later years.

Table 9. Estimated numbers of yellow perch in Jewett Lake, fall 1975 to fall 1981.[a]

Year class	Year of estimate						
	1975	1976	1977	1978	1979	1980	1981
1975	6,369	768	609	99	13	1	
1976		22,766	2,822	277	22	8	
1977			5,366	681	31	4	2
1978				8,019	423	26	5
1979					14,922	672	20
1980						7,849	262
1981							3,478

[a] Estimated number of eggs deposited each spring were (in millions): 1975 - 3.0 (all stocked), 1976 - 3.1 (3.0 stocked), 1977 - 3.9, 1978 - 3.8, 1979 - 0.9, 1980 - 0.6, 1981 - 0.6, and 1982 - 0.4.

Table 10. Mean lengths (mm) at age (fall samples) for yellow perch before and during periods of angling harvest (above and below the line, respectively). Also given are the averages for the angling period and the State of Michigan average.

Year class	Age					
	0	I	II	III	IV	V
1975	48	171	176	207	248	282
1976	74	124	190	225	265	
1977	83	147	206	256	272	
1978	83	170	227	279		
1979	90	177	219			
1980	107	171				
1981	105	206				
1982	114					
Average during angling	100	174	210	242	262	282
State average	84	133	165	191	216	240

Table 11. Annual total mortality (A) of yellow perch based on the fall population estimates, before and during periods of angling harvest (above and below the line, respectively).

Year class	Age group interval (fall to fall)					
	0-I	I-II	II-III	III-IV	IV-V	V-VI
1975	0.879	0.207	0.837	0.869	0.923	1.0
1976	0.876	0.902	0.921	0.636	1.0	
1977	0.873	0.938	0.871	0.500		
1978	0.947	0.939	0.808			
1979	0.955	0.970				
1980	0.966					

Table 12. Predicted characteristics of a model walleye population and fishery for Jewett Lake, 1979.

Age[a]	Number per ha	Biomass (kg/ha)	Length (mm)	Weight (g)	Instantaneous rates[b] G	Instantaneous rates[b] M	Instantaneous rates[b] F	Harvest per ha Number	Harvest per ha Kilogram
0 F	62.5	0.94	127	15					
					0	0.6			
I S	34.0	0.51	127	15					
					2.38	0.6			
F	18.7	3.03	264	162					
					0	0.18			
II S	15.6	2.57	264	162					
					0.88	0.18	0.07		
F	12.1	4.74	353	392					
					0	0.18	0		
III S	10.2	4.00	353	392					
					0.39	0.18	0.7	4.6	2.24
F	4.2	2.42	401	577					
					0	0.18	0	0	0
IV S	3.5	2.02	401	577					
					0.33	0.18	0.7	1.6	1.12
F	1.6	1.28	447	803					
					0	0.18	0	0	0
V S	1.2	0.96	447	803					
					0.27	0.18	0.7	0.6	0.53
F	0.6	0.63	488	1,048					
					0	0.18	0	0	0
VI S	0.4	0.42	488	1,048					
					0.21	0.18	0.7	0.2	0.23
F	0.2	0.26	523	1,290					
					0	0.18	0	0	0
VII S	0.1	0.13	523	1,290					
Total		13.3 (fall)						7.0	4.12

[a] F = fall; S = spring

[b] Instantaneous rates: G = growth, M = natural mortality, and F = fishing mortality

Table 13. Frequency of occurrence (percent of all fish examined) of food items in the stomachs of walleyes of three size groups, 1977-82.

Food type	Walleye size group (mm)		
	112-155	156-300	301-432
Walleye			1
Yellow perch	6	7	7
Minnow[a]	12		1
Unidentified fish	6	29	22
All fish	25	36	32
Frog			2
Crayfish		7	4
Leech			
Chironomid	69	14	4
Other insects[b]		32	14
Amphipod	12		1
Zooplankton	94		
Plant		18	14
Unidentified		4	1
Number of fish	16	28	81
Number empty	0	12	40

[a] Fatheads, bluntnose, and sticklebacks (Gasterosteidae).

[b] Primarily dragonfly nymphs.

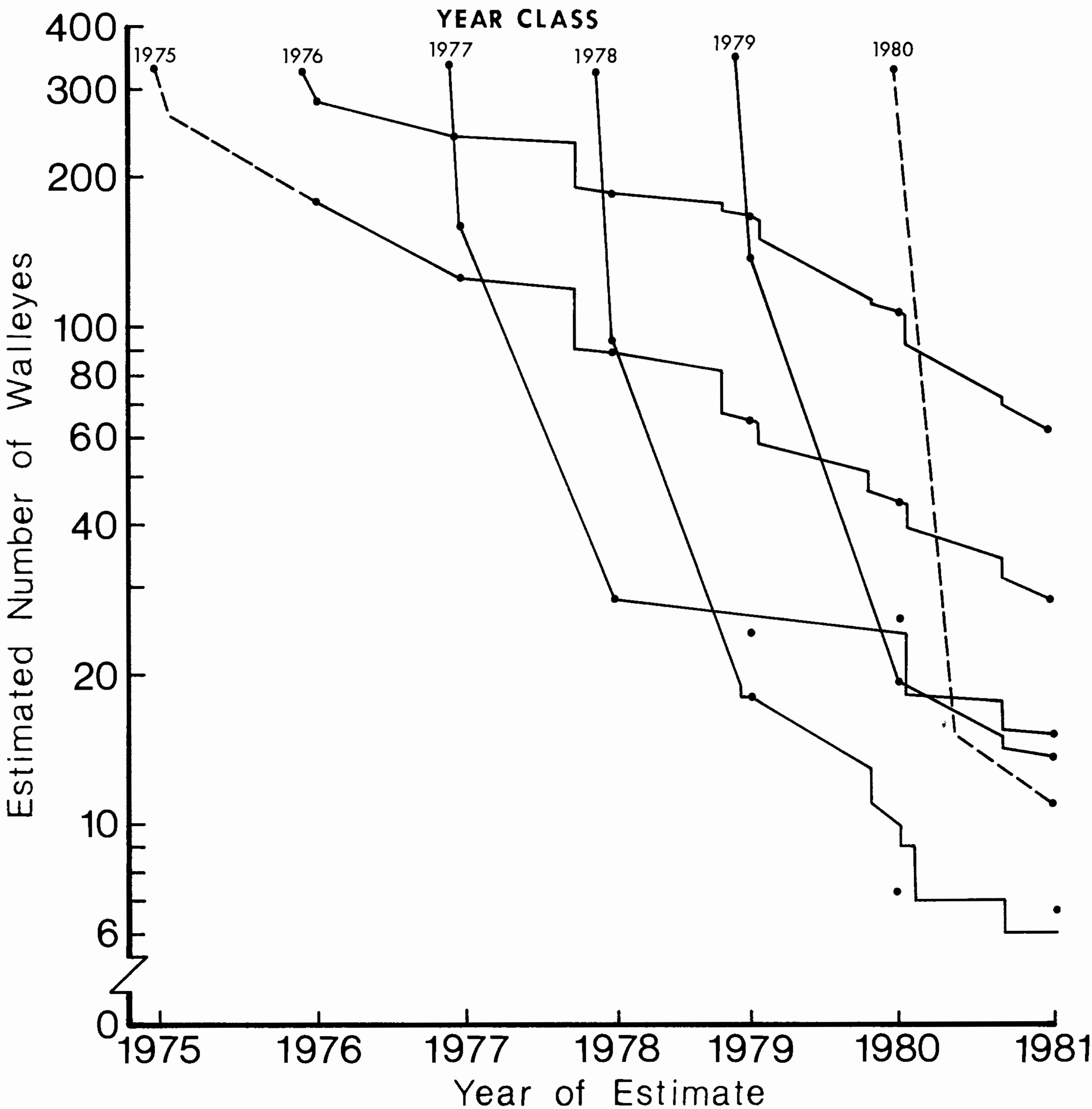

Figure 1.--Survival curves, based on fall population estimates, for fingerling walleyes planted in Jewett Lake in 1975-80. Dashed portions of the curves for the 1975 and 1980 year classes are assumed trends based on first-year survival of other year classes. Vertical drops indicate when known numbers of walleyes were harvested.

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