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GROWTH AND SURVIVAL OF NORTHERN PIKE IN TWO SMALL LAKES CONTAINING SOFT-RAYED FISHES AS THE PRINCIPAL SOURCE OF FOOD [1]

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ABSTRACT

Fingerling northern pike were stocked for 3 years in two small lakes, one containing only minnows and the other containing minnows and young coho salmon. Pike stocked at a rate of 46 fingerlings per acre, in 3 years produced mean standing crops of 52 pounds per acre. In the pike-minnow lake an adequate supply of small minnows throughout the study resulted in high survival of all year classes of pike. Moderate growth of pike occurred, but pike longer than 15 inches exhibited slow growth, presumably because of a lack of larger food items. In the pike-minnow-salmon lake, survival of all three year classes of pike was relatively low, because very few small minnows were available to each year's crop of fingerling pike. However, the inclusion of salmon as a forage presumably increased the growth of larger pike to the extent that pike of age-group II averaged 2.6 inches longer in the pike-minnow-salmon lake than in the pike-minnow lake.

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Introduction

Frost (1954) found that in Windermere northern pike (Esox lucius) tended to consume the largest of available food items. Similar results have been obtained with pike confined in aquaria with prey fishes of various size (Ivlev, 1961). Other studies of food selectivity by pike in aquaria (Beyerle and Williams, 1968) have shown that, when given a choice, pike will eat soft-rayed minnows and chubsuckers rather than spiny-rayed centrarchids and percids. Thus it may be hypothesized that maximum growth of pike would be realized in waters containing an abundance of soft-rayed fishes of a wide variety of sizes. Most southern Michigan lakes contain bluegills (Lepomis macrochirus) as the predominant fish species, with relatively minor populations of soft-rayed fishes. To test the efficiency of pike as predators in such lakes, populations of northern pike and bluegills were maintained in two small lakes for 3 years (Beyerle, 1971). Here large populations of pike did not prevent excessive survival of bluegills, and growth of both pike and bluegills was far below potential.

In the present study I wanted to compare the growth and survival of northern pike in two lakes which contained forage supplies of only soft-rayed fishes--minnows in one lake, minnows and salmonids in the second lake. The second lake was to be stocked the first year with pike and minnows, and the succeeding 2 years with pike and the salmonid. For this study, hatchery personnel provided 60,000 young-of-the-year and yearling coho salmon (Oncorhynchus kisutch). A secondary justification for planting the salmon was to determine how well they would survive in a small and warm inland lake.

The two lakes used in this study previously had contained pike-bluegill populations. Thus direct comparisons could be made of growth and survival of pike in the two situations--one with the bluegill as a forage species, the other with minnows and small salmonids as forage.

Procedure

Daggett Lake in T. 3 N., R. 10 W., Sec. 1, Barry County, is 14.0 acres in area[2] and has no inlet or outlet when water level is normal. Maximum depth is 15 feet, and average depth is 7 feet. The bottom is muck and peat. A moderate growth of Elodea sp. occurs in patches over about 50% of the bottom. A moderately dense growth of water lilies (Nymphaeaceae) covers about 20% of the lake. Methyl orange alkalinity averages 17 ppm.

About 70 pounds of adult golden shiners (Notemigonus crysoleucas) and fathead minnows (Pimephales promelas) were stocked in Daggett Lake in October 1966. Production by these fishes resulted in a substantial minnow population from 1967 through 1969. In the spring of 1967, 675 fingerling northern pike (48 per acre) were stocked in Daggett Lake. This stocking rate is identical with that used in the previous study in Daggett Lake (Beyerle, 1971). Identical plantings of pike were made again in 1968 and 1969.

In September 1969, a sample of northern pike was collected by angling and electrofishing to determine feeding habits. Daggett Lake was then treated with rotenone and all pike and the majority of minnows were recovered. I then determined the growth and survival of the three year classes of pike, and the standing crop of minnows.

Emerald Lake in T. 2 S., R. 8 W., Sec. 14, Calhoun County, is 5.6 acres in area. Maximum depth is 9 feet and average depth is 6 feet. Because the lake was treated periodically with Aquathol-plus (endothal plus silvex) and with copper sulfate, aquatic vegetation was essentially non-existent during the study. The lake received water both from springs, and from an adjacent lake via a pipeline. There is no outlet. Methyl orange alkalinity averages 114 ppm.

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[2] During the study, excessive precipitation caused Daggett Lake to increase in area by 1.7 surface acres, from 12.3 acres to 14.0 acres. To preserve continuity, all calculations in this study are based on a surface area of 14.0 acres.

In May 1969, 40 pounds of fathead minnows and 30 pounds of common shiners (Notropis cornutus) were stocked in Emerald Lake. In September 1969, about 10 pounds of golden shiners were stocked and in May 1970, an additional 20 pounds of golden shiners and fathead minnows were stocked. From May through November 1970, about 9,000 young-of-the-year coho salmon were stocked each succeeding month; the total was 35,500 salmon weighing 754 pounds. In 1971, 8,160 yearling salmon (450 pounds) and 18,000 young-of-the-year salmon (105 pounds) were stocked. In May 1969, 250 fingerling northern pike (45 per acre) were stocked, and identical plantings of pike were made in 1970 and 1971. As with Daggett Lake, the stocking rate for pike in Emerald Lake was identical to that used in the previous study in Emerald Lake (Beyerle, 1971). In September 1971, a sample of pike was collected by angling to determine feeding habits. Emerald Lake was then treated with rotenone and all pike and other fishes were recovered. Growth and survival of the three year classes of pike were determined, and the standing crop of prey fishes was calculated. During the study, both Daggett and Emerald lakes were closed to fishing.

Results and Discussion

For pike taken from Daggett and Emerald lakes by electrofishing and/or angling prior to chemical treatment, stomach contents are shown in Table 1. Pike in Daggett Lake were feeding as much on tadpoles and mature frogs as on minnows. This tendency of pike to feed heavily on frogs was even more pronounced during the pike-bluegill studies on both Daggett and Emerald lakes. The fact that very few food items of preferred sizes, including tadpoles, were available in Emerald Lake when the pike were sampled is reflected in the paucity of food found in stomachs.

Percentage survival of the three year classes of northern pike in Daggett Lake at time of poisoning is shown in Table 2. As expected,

the first year class stocked (1967) had the highest survival (54.7%). Subsequent plantings in 1968 and 1969 survived at relatively lower rates (35.5 and 16.1, respectively). In Emerald Lake (Table 3) percentage survival of all three year classes, 1969-1971, was relatively much lower (31.6, 11.2, and 4.4, respectively). These values for survival in lakes containing soft-rayed prey fish can be compared (Table 4) with average percent survival of 52.2, 1.8, and 5.4 for comparable age groups in the two lakes with the pike-bluegill combination (Beyerle, 1971). Pike of ages 0 and I had much higher survival with minnows as food than with bluegills as food. There was a good supply of small minnows in Daggett Lake when pike were stocked there in 1968 and 1969. The abundance of small food items in Daggett Lake in 1969 was also reflected in the survival of 761 age-0 pike which in this instance were produced by natural reproduction (Table 2). In contrast, the low survival of age-0 and age-I pike in the pike-bluegill lakes is attributed to a lack of food (no bluegill reproduction) in one lake, and the under utilization of small bluegills in the other lake.

A large unexplained die-off of minnows occurred in Emerald Lake only 3 weeks before the initial stocking of pike (1969 year class). This fact may explain the relatively poor survival of age-II pike. Low survival of age-0 and age-I pike (1970 and 1971 year classes) in Emerald Lake was attributed to the absence of small minnows when these pike were stocked as fingerlings. The coho salmon stocked in 1970 and 1971 (Table 5) tended to cruise the shoreline in schools, and it is assumed that they rapidly decimated the small minnows.

Initial survival of stocked coho salmon appeared to be high, with the exception of the fish stocked in July 1970, when high water temperature caused almost complete mortality. However, indications were that most salmon did not survive more than about 3 months from the date they were stocked. There is no evidence that any salmon survived over the winter of 1970-1971. A relatively small population of large golden shiners was present in Emerald Lake at the time of poisoning (Table 6). Obviously

some shiners were available as food for pike at all times throughout the study. A small number of adult largemouth bass, bluegills, and green sunfish infiltrated Emerald Lake and were discovered spawning in the spring of 1970. Despite a concerted effort to control these species, some reproduction and survival of centrarchids occurred in 1970 and again in 1971 (Table 6). The extent to which these centrarchids were utilized as food by the pike is not known, but it is probable that some predation on centrarchids occurred during winter and other periods when few soft-rayed fishes were available. It is also quite probable that some of the coho salmon were eaten by largemouth bass.

Growth of pike in Daggett Lake is shown in Table 2. Age-II pike (1967 year class) averaged only 1.6 inches longer than age-II pike in the pike-bluegill lakes (Table 4). Growth of age-0 and age-I pike was almost identical in both populations. Age-II pike (1969 year class) in Emerald Lake averaged 22.8 inches, or 4.2 inches longer than age-II pike in the pike-bluegill lakes, and 2.6 inches longer than pike in Daggett Lake (Table 4). Age-0 pike in Emerald Lake averaged 2.1 inches shorter, and age-I pike were 1.5 inches longer, than pike in the pike-bluegill lakes. One reason for the slow growth of pike in Daggett Lake was the scarcity of forage minnows over 4 inches in length. Less than 1% (141 fish per acre) of the minnows collected from Daggett Lake were over 4 inches long (Table 6). In addition, growth of age-0 and age-I pike was probably inhibited somewhat because of high population density and a high degree of competition for available food. In Emerald Lake relatively rapid growth of age-I and age-II pike compensated to a large extent for low survival (Table 4). The paucity of soft-rayed fishes less than 4 inches in length (Table 6) is reflected in the very slow growth and poor survival of age-0 pike.

The standing crops of pike in Daggett Lake and Emerald Lake are compared with data from the pike-bluegill lakes (Table 4). Standing crops of prey fishes are shown in Table 6. Surprisingly, the standing crop of age-II pike in Daggett Lake was only slightly larger than in the pike-bluegill lakes. This again reflects the fact that there was undoubtedly a shortage of larger minnows in Daggett Lake, at least during the last year

of the study. Because the standing crops of pike of ages 0 and I were considerably larger in Daggett Lake, the total standing crop of pike in Daggett Lake was 60% greater than the average of the pike-bluegill lakes. In Emerald Lake the standing crop of age-II pike, expressed as fish per acre, was only 55% as great as in the pike-bluegill lakes. However, because of the larger size attained by the pike in Emerald Lake, the standing crop by weight was 15% higher. The standing crop of age-I pike in Emerald Lake was higher than in the pike-bluegill lakes, but considerably less than in Daggett Lake. Age-0 pike were relatively insignificant in Emerald Lake. The total standing crop of pike in Emerald Lake was 5.3 pounds per acre less than in Daggett Lake, but 15.3 pounds per acre more than in the pike-bluegill lakes.

In these studies pike stocked at a rate of 46 fingerlings per acre produced mean standing crops of 52 pounds per acre in 3 years. However in Daggett Lake the prey-predator ratio was reduced to only 1.9 pounds of minnows to 1 pound of pike (Tables 4 and 7). The standing crop of large minnows was severely depressed and growth of larger pike was slow. Thus it seems apparent that Daggett Lake cannot sustain a fast-growing population of pike at about 50 pounds per acre without supplemental stocking of larger soft-rayed prey fishes. If the test had been continued beyond the third year without supplemental stocking, it is feasible that lower survival rates plus slower growth would have depressed the standing crop of pike considerably. I would predict a reduction to about 25 pounds per acre, which would be a more realistic figure on carrying capacity for pike. Assuming a total carrying capacity of 150 pounds per acre for all fish, a figure consistent with available data for Daggett Lake, the lake should have a standing crop of minnows or other forage species of some 125 pounds per acre. If fishing were permitted, the weight of pike removed by angling would be compensated by a combination of increased growth of the remaining older pike, increased survival of young pike, and a higher standing crop of prey species.

Only 54 pounds per acre of prey fishes, of a size edible to pike, were collected from Emerald Lake, and 69% of these fishes

were centrarchids (Table 7). The ratio of prey weight to predator weight was 1.1 to 1. Indications are that supplementary stocking of coho salmon had the desired effect of stimulating the growth of the pike stocked in 1969.

It is unlikely that the lesser numbers of pike in Emerald Lake, as compared with Daggett, could account entirely for the larger size and greater standing crop observed in Emerald. The size attained by age-II pike averaged 2.6 inches larger in Emerald than in Daggett, and likewise the standing crop (weight) of age-II pike was over 15% greater in Emerald than in Daggett. Survival of age-II pike was only 53% as great in Emerald Lake as in Daggett Lake, but the food supply for these pike, other than stocked salmon, was only half as plentiful in Emerald as in Daggett. It appears that the reduction in numbers of pike in Emerald Lake was accompanied by a reduction in minnow supply, and the observed growth increase can be attributed to the stocked salmon.

The combination of salmon and/or young bass completely decimated the young minnows produced in 1970 and 1971, resulting in poor survival of pike stocked in those years. Obviously a soft-rayed fish that is mainly piscivorous is not a wise choice for supplemental stocking in pike-minnow lakes. Some species of sucker or chubsucker would probably be better as a prey fish of larger size.

Two ways of managing populations of northern pike and soft-rayed prey fishes in small lakes are suggested by this study. One procedure would be to abandon the supplemental stocking of prey species, accept the slower growth rate by the pike, and set a low size limit of 16 to 18 inches (or no size limit at all) to compensate for the slow growth. Relatively high survival and fast growth of young pike would mean a steady recruitment into the fishery each year.

The second procedure would be to employ supplemental stocking of large prey fish, so that pike could be expected to grow relatively rapidly beyond 20 inches in length, and standing crops of 50 pounds per acre would be produced. In such a situation, the existing 20-inch size limit would be appropriate, or a "trophy" fishing lake could be established, with a 24-inch or larger, size limit.

Table 1.--Stomach contents of northern pike taken by electrofishing or angling from Daggett Lake and Emerald Lake

	Lake	
	Daggett	Emerald
Total pike captured	33	16
Length range (inches)	8.3-21.3	20.0-25.2
Stomachs with food	19	3
Stomachs empty	14	13
Stomach contents	Number	
Minnows	5(2 1/2-3 in.)	0
Centrarchids	0	0
Largemouth bass	0	1(2 1/2 in.)
Unidentified fish	4	2(1 1/2-3 1/2 in.)
Frogs	8(2-4 in.)	0
Tadpoles	4(3-4 in.)	0
Crayfish	0	1
Unidentified remains	1	0

Table 2.--Growth, survival, and standing crop of northern pike in Daggett Lake

Year class, event	Date of event	Number of pike	Pike per acre		Mean length (inches)	Percent survival
			Number	Pounds		
1967						
Stocked	6/8/67	675	48.2	...	3.2	...
Examined	10/13/67	21	...	...	15.7	...
Examined	6/27/68	13	...	...	18.3	...
Collected	9/9/69	369	26.4	36.8	20.2	54.7
1968						
Stocked	5/21/68	675	48.2	...	3.4	...
Collected	9/9/69	240	17.1	15.8	17.6	35.5
1969						
Stocked	5/21/69	675	48.2	...	3.3	...
Collected	9/9/69	109	7.8	2.2	12.3	16.1
Collected	9/9/69	761*	54.4	3.0	6.3	?

* Natural reproduction.

Table 3.--Growth, survival, and standing crop of northern pike in Emerald Lake

Year class, event	Date of event	Number of pike	Pike per acre		Mean length (inches)	Percent survival
			Number	Pounds		
1969						
Stocked	5/21/69	250	44.6	...	3.3	...
Collected	9/13/71	79	14.1	42.4	22.8	31.6
1970						
Stocked	6/10/70	250	44.6	...	3.5	...
Collected	9/13/71	28	5.0	6.6	18.8	11.2
1971						
Stocked	6/7/71	250	44.6	...	3.8	...
Collected	9/13/71	11	2.0	0.5	10.2	4.4

Table 4.--Comparative standing crops, mean lengths, and percent survival of three consecutive age groups of northern pike in two pike-bluegill lakes, in a pike-minnow lake, and a pike-minnow-salmon lake

Species and lake	Standing crop		Mean length (inches)	Percent survival
	Fish per acre	Pounds per acre		
Pike-bluegill (two lakes)				
Age group 0	2.4	0.7	12.3	5.4
I	1.0	1.2	17.3	1.8
II	25.6	32.3	18.6	52.2
Total	29.0	34.2	...	...
Pike-minnow (Daggett)				
Age group 0	7.8	2.2	12.3	16.1
I	17.1	15.8	17.6	35.5
II	26.4	36.8	20.2	54.7
Total	51.3	54.8	...	...
Pike-minnow-salmon (Emerald)				
Age group 0	2.0	0.5	10.2	4.4
I	5.0	6.6	18.8	11.2
II	14.1	42.4	22.8	31.6
Total	21.1	49.5	...	...

Table 5.--Summary of coho salmon stocked in Emerald Lake during 1970-71

Date	Number of salmon stocked		Length (inches)		Weight
	Total	Fish per acre	Mean	Range	Pounds per acre
1970					
May	9,000	1,607	2.8	2-4	14.8
July	9,000	1,607	3.2	2-5	20.7
September	9,000	1,607	...	3-6	42.9
November	8,500	1,518	4.5	...	56.2
1971					
April	8,160	1,457	5.2	...	80.4
June	18,000	3,214	2.0	...	18.8
Total	61,660	11,010	...	...	233.8

Table 6.--Standing crops of fishes other than northern pike in Daggett Lake and Emerald Lake at end of experiment

Species and length or year class	Pike-minnow lake (Daggett)		Pike-minnow-salmon lake (Emerald)	
	Fish per acre	Pounds per acre	Fish per acre	Pounds per acre
Golden shiner and fathead minnow				
Under 4 inches	19,604	94.2	...	...
Over 4 inches	141	8.8	287	16.7
Coho salmon	...	...	...	...
Largemouth bass				
Adult (9-16 inches)	...	...	16	14.4
Yearling (5.5-6.5 inches)	...	...	17	1.7
Young-of-the-year (2.5-3.5 inches)	...	...	1,181	11.2
Bluegill and green sunfish				
Over 6 inches	...	...	1	0.8
4-6 inches	...	...	457	20.8
Under 4 inches	...	...	2,119	26.5
Total	...	103.0	...	92.1

Table 7.--Comparison of standing crops of prey fish of edible size in two pike-bluegill lakes, in a pike-minnow lake (Daggett), and a pike-minnow-salmon lake (Emerald), at end of experiment

Fish combination	Prey species	Fish per acre		Mean length (inches)
		Number	Pounds	
Pike-bluegill (two lakes)	Bluegill	15,376	164	2.8
Pike-minnow (Daggett)	Minnows	19,745	103	2.6
Pike-minnow-salmon (Emerald)	Largemouth bass	1,181	11	2.8
	Bluegill and green sunfish	2,119	26	2.8
	Golden shiner	287	17	5.5
	Coho salmon	0	0	...
	Sub-total	3,587	54	...

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