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Effects of Special Harvest Regulations on Largemouth Bass and Yellow Perch in Spruce Lake

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Abstract

The objectives of this study were to determine the effects of special harvest regulations on fishing pressure, largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) population density, growth, harvest, and yield in Spruce Lake. Following a 9-year fishing closure, experimental regulations (12-inch minimum length limit and bag limit of 2/day on largemouth bass and use of artificial baits only) were evaluated in Spruce Lake from 1 July 1986 to 31 October 1989. The average annual fishing pressure during this study was 28% lower than it was in the 1970s when there were no special regulations. Anglers harvested 91 largemouth bass in 1986 compared with an average annual harvest of 30 bass during 1987-89. The mean length and weight of largemouth bass harvested increased from 12.5 inches and 0.92 lb in 1986, to 13.3 inches and 1.15 lb in 1989. Limited population data for adult largemouth bass indicated that bass densities declined from 15.0/acre in 1986 to 3.9/acre in 1989, while yellow perch density increased over 650%, from 356/acre in 1986 to 2,678/acre in 1989. The bag limit regulation reduced the largemouth bass harvest during the first 2 years only. Limiting anglers to the use of artificial baits only reduced the yellow perch harvest, but did not contribute to the overabundance of yellow perch. Largemouth bass growth increased while yellow perch growth decreased. The special regulations improved the quality of the harvested largemouth bass from that of the years without regulations. However, the special regulations did not maintain a largemouth bass population large enough to control the yellow perch population.

Contents

Introduction

Wisconsin fish managers and anglers have largely taken bass for granted, directly managing largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) less than other large gamefish species (Klingbiel 1981). However, research has been conducted on the largemouth bass population and the remainder of the fish community of Spruce Lake since 1946. Kempinger (1969) summarized the results of the first 22 years of study on this lake in which the effects of 4 management procedures were studied: (1) elimination of angling season, size, and bag restrictions, (2) maintenance stocking of largemouth bass fingerlings and northern pike fry (*Esox lucius*), (3) closure to angling for a 3-year period, and (4) chemical reclamation and restocking with largemouth bass and northern pike. Kempinger concluded that neither the liberalized regulations nor the fishing closure improved the fishing quality on Spruce Lake, whereas chemical treatment and restocking greatly improved the fishery during the study period. These conclusions, along with largemouth bass and yellow perch (*Perca flavescens*) population data for 1978 on Spruce Lake contributed to the decision to treat the lake again with rotenone in 1978 (Hoff 1986*a*). When this treatment failed to eradicate the target species, particularly yellow perch, the lake was treated with rotenone and antimycin in 1980 (Serns and Hoff 1982). All of the piscicide treatments were failures at eradicating yellow perch. Thus, all subsequent improvements in the Spruce Lake fishery were short-lived (Hoff 1986*a*).

Following the 1980 chemical treatment, young-of-the-year largemouth bass were stocked at the rate of 250/acre in 1980 and 1982, and 238/acre in 1981. In addition, 2- and 3-year-old largemouth bass and various minnow species were stocked during 1981 (Hoff 1986*a*). None of the minnow introductions resulted in reproducing populations.

Hoff (1986*a*) concluded that the quality of the angling fishery for largemouth bass was greatest since 1946 immediately after lifting the fishing closure. Because of the positive effects of the fishing closure on the largemouth bass population, he suggested that restrictive regulations would be necessary to maintain a population of larger fish. Thus, Spruce Lake was opened to fishing on 1 July 1986 for the first time since autumn 1978 with experimental regulations restricting angling harvest. These regulations were use of artificial baits only, and a minimum 12-inch length limit and bag limit of 2/day on largemouth bass. The regulations were intended to protect largemouth bass large enough to effectively prey on yellow perch and to provide a quality bass and perch fishery. This study aimed to determine the effects of the special harvest regulations on fishing pressure and the population density, growth, harvest, and yield of largemouth bass and yellow perch.

Study Area

Spruce Lake is 1 of 5 lakes in the Northern Highland Fishery Research Area and is located in the Northern Highland State Forest in Vilas County, Wisconsin (Fig. 1). The lake is completely surrounded by state-owned land, covers an area of 16.5 acres, reaches a maximum depth of 13 feet, and has 0.6 miles of shoreline. It is an infertile seepage lake, having medium brown, slightly acid water of moderate transparency and a false bottom consisting chiefly of plant material. Ninety-nine percent of the shoreline is quaking bog. (Kempinger 1969). More detailed morphological and chemical data are found in Kempinger (1969) and Serns and Hoff (1982).

Methods

Sport Fishery Evaluation

A mandatory complete creel census was conducted on Spruce Lake through the use of a compulsory permit system. Each angler was interviewed by Department of Natural Resources personnel employed at a fisheries contact station located at the Northern Highland Fishery Research Area. For the purpose of this study the following information was used: (1) number of each species harvested, (2) fish total length (nearest 0.1 inch), (3) weight (nearest 0.01 lb), (4) number of marked (tag and/or fin clip) fish, and (5) angling hours.

Prior to fishing, anglers were asked to record the number of sublegal and legal-length largemouth bass caught and released. This information was provided at the completion of their trip. Scale samples were removed from all angler harvested largemouth bass.

The Spruce Lake angling regulations (12-inch minimum length limit and bag limit of 2/day on largemouth bass with use of artificial baits only) were posted at the Escanaba Lake contact station and at the Spruce Lake access.

Largemouth Bass

Largemouth bass were captured using fyke nets set for yellow perch and by catch-and-release angling. All bass captured were measured to the nearest 0.1 inch (total length), weighed to the nearest 0.01 lb, and a scale sample was removed for aging. Bass less than 9.0 inches were marked with a top-caudal fin clip, while those 9.0 inches and larger were marked with a Floy FD-67C anchor tag. To account for tag loss, each tagged fish was given a secondary mark by removing a distinct dorsal spine during each year of the study. The number of age I bass in 1985 (preregulation) was estimated from June-July and September fyke netting data by using the Schnabel method (Ricker 1975). The Petersen method (Ricker 1975), using fyke nets for marking and creel census for recapture, was used to estimate numbers of adult bass in 1986, 1987 and 1989. No estimate of adult largemouth bass was made in 1988 because no marked fish were recaptured.

Young-of-the-year largemouth bass were captured in autumn using 2.5-ft (1/4-inch square mesh) fyke nets. All young-of-the-year bass were marked with a top caudal fin clip, and a subsample of 50 fish were measured (nearest mm) and weighed (nearest g) each year. In 1986, 1987 and 1989 the number and standing crop of young-of-the-year bass were estimated using the Schnabel method. Estimates were not made in 1988 because marked fish were not recaptured.

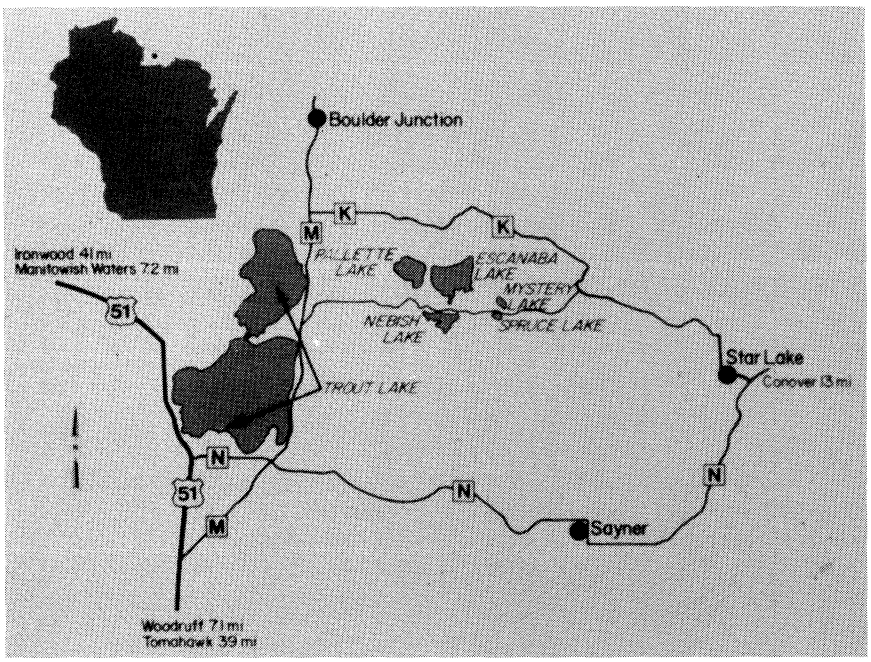


Figure 1. *Location of Spruce Lake.*

Stomachs from all harvested largemouth bass were removed and preserved in 70% ethanol. Stomach contents were later identified, counted, and volumetrically measured (nearest 0.1 ml) in a graduated centrifuge tube. Adult aquatic insects were pooled with terrestrial insects. Absolute (AI) and relative (RI) importance index values were calculated, using modifications of the indices developed by George and Hadley (1979), as follows:

AI_a = % frequency of occurrence + % of total numbers + % of total volume of food item a in all stomachs;

RI_a = 100 x AI_a/sum AI values for all food items.

Yellow Perch

Yellow perch were captured each spring using three 4-ft (3/8-inch square mesh) fyke nets and marked with a permanent, distinctive fin clip. Each year a random sample of perch were measured to the nearest 0.1 inch (total length) and sexed. Scale samples for aging were collected from 10 perch of each sex from each 0.5-inch group. Annually from 1986-88, the number of yellow perch were estimated by inch group using the Schnabel method (Ricker 1975) from mark and recapture during spring fyke netting. In 1989 the number of perch was estimated using the Bailey modification of the Petersen method (Ricker 1975). Exploitation rates were estimated by calculating the percentage of marked fish harvested by anglers and incorporating this into the formula R/M (Ricker 1975).

Results and Discussion

Fishing Pressure and Angler Harvest

When Spruce Lake was opened to fishing on 1 July 1986 for the first time since chemical treatment in 1978, anglers fished a total of 334.5 hours during open water. After the initial opening, fishing pressure declined as anglers only averaged 232.7 hours/year of fishing during the entire open-water seasons of 1987-89. Although 141 anglers fished during the shortened 1986 season, the mean number of anglers for all years combined was only 118 (Table 1). The mean angling hours/acre/year was 15.6 and the mean hours fished/angler was 2.2. Although Spruce Lake was open to fishing year around, there was no winter fishing for the duration of the study.

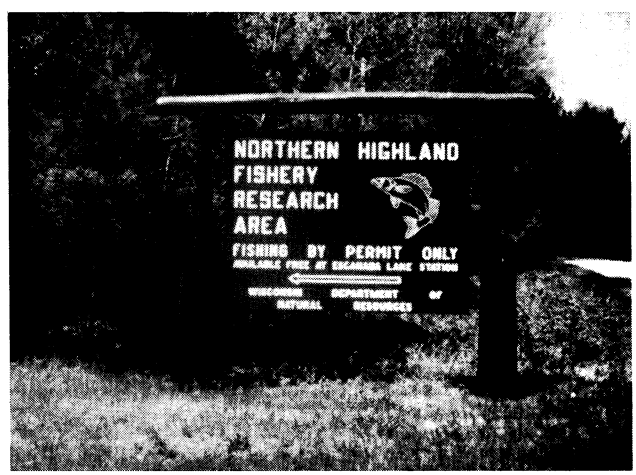
Most anglers expressed satisfaction with the special regulations and were eager to comply with the mandatory creel census. Some even were attracted by the regulations because they perceived a higher quality angling experience. The average annual fishing pressure on Spruce Lake from 1986-89 was 15.6 hrs/acre compared with 21.6 hrs/acre in the 1970s (S. Newman, Wis. Dep. Nat. Resour., unpubl. data) when there were no special regulations. Kempinger (1969) reported fishing pressure on Spruce Lake of 18.6 hrs/acre in the 1950s and 11.8 hrs/acre in the 1960s.

During 1986, anglers harvested 91 largemouth bass (55% of the 4-year bass harvest) averaging 12.5 inches in total length and 0.92 lb (Table 2). The majority of the 1986 bass harvest (73%) occurred during the first 15 days of the season. After this period, when fishing pressure and bass harvest were at their highest, the pressure and subsequent harvest remained stable for the

Table 1. *Fishing pressure on Spruce Lake during 1986-89.*

Year	Total Fishing		
Anglers	Hours	Hours/Acre	Total
1986[a]	334.5	20.3	141
1987	237.5	14.4	121
1988	295.0	17.8	119
1989	165.5	10.0	92
Mean	258.1	15.6	118

[a] Spruce Lake was opened to fishing on 1 July 1986 for the first time since chemical treatment in 1978.



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Fishing at The Northern Highland Fishery Research Area is allowed by special permit only.

remainder of the study. An average of 30 bass were harvested during the open water seasons of 1987-89 (Table 2). During 1954-59 after a 3-year fishing closure (1951-53) on Spruce Lake, an average of only 16 bass were harvested annually (Kempinger 1969). Thus, the special regulations in this study appeared to have little effect on the total bass harvest.

Anglers harvested an average of 0.18 bass/hour compared with 0.05/hour during 1954-59. However, anglers harvested 0.79 and 0.34 bass/hour in the 1960s (Kempinger 1969) and the 1970s (S. Newman, Wis. Dep. Nat. Resour., unpubl. data), respectively. A total of 245 sublegal and 167 legal-length bass were caught and released during 1986-89. Most of these sublegal (48%) and legal-length (65%) bass were caught and released in 1986 (Table 2).

The mean total length and weight of harvested largemouth bass during the study period was 13.1 inches and 1.04 lb, compared with 8.3 inches and 0.31 lb in the 1960s (Kempinger 1969) and 9.7 inches and 0.49 lb in the 1970s (S. Newman, Wis. Dep. Nat. Resour., unpubl. data). The largest bass harvested during this study was 15.2 inches in length. However, during 1954-59, after a 3-year fishing closure, bass up to 19 inches in length were taken, the average bass weighing 1.7 lb (Kempinger 1969).

The 1986 largemouth bass harvest consisted exclusively of age VI fish, whereas the harvest from the other years consisted of at least 6 year classes (Table 3). The same year class that constituted the entire 1986 harvest also made up 80% of the total 1987 harvest. The total annual harvest and yield of bass was composed of younger fish each year, as age groups less than VI constituted 8% of the harvest and 6% of the yield in 1987, 31% of the harvest and 26% of the yield in 1988, and 65% of the harvest and 59% of the yield in 1989 (Table 3). The highest yield of bass was 5.05 lb/acre in 1986 and the lowest yield was 1.72 lb/acre in 1987.

Only 25 yellow perch were harvested during the entire study and 15 of those were taken in 1988. Of the remaining perch harvest, 2 were taken in 1986, 1 in 1987 and 7 in 1989. During 1954-59, after a 3-year fishing closure, anglers harvested an average of 83 perch annually (Kempinger 1969). Anglers either were dissatisfied with the size of the majority of Spruce Lake perch, or the perch were too difficult to catch with artificial baits during this study.

Population Development and Exploitation Rates

Largemouth Bass. In 1985, prior to the opening of fishing on Spruce Lake, the population size of age I largemouth bass was estimated at 357 (21.6/acre) in July and 73 (4.4/acre) in September, which indicated a mortality rate of 80% from July to September 1985 (Table 4). The population size of age VI bass on 3 June 1986 was estimated at 247 (15.0/acre). In June 1987, the same cohort of age VI bass in 1986 was estimated to be 77 (4.7/acre) at age VII. In September 1989 the population size of ages III, V, and VII bass were estimated at 45 (2.7/acre), 11 (0.7/acre), and 8 (0.5/acre), respectively. Population estimates of bass in other age groups and in 1988 could not be calculated because marked fish were not recaptured. Kempinger (1969) reported population estimates during 1965-67 ranging from 208 (12.6/acre) to 1,878 (113.8/acre). Population estimates during 1954-59 after a 3-year fishing closure were not made.

During 1986-89 the average annual exploitation rate of Spruce Lake largemouth bass was 22% (Table 4). The highest exploitation rate was 36% in 1986, the initial year of this study. This exploitation rate was only for age VI fish because this was the only age group known to be legal length (12 inches) during the 1986 season. However, 76% of this exploitation occurred during the first 10 days of the 1986 season (1-10 July). Bass exploitation during that season could have been much higher under a bag-limit regulation allowing harvest of more than 2 bass/day because anglers caught and released 108 legal-length bass this season. Of the total bass caught and released in 1986, 96 were caught during the first 10 days of the season. The exploitation rate of Spruce Lake largemouth bass was 18% in 1987 and 11% in 1989 (Table 4). Despite the relatively low bass exploitation in 1989, ages VII and IX bass were exploited at 33% and 100%, respectively (only 1 age IX bass was marked). No exploitation estimates were made in 1988 because only 3 bass were marked in spring and none of those were harvested.

The number of young-of-the-year largemouth bass in Spruce Lake was estimated at 466 in 1986, 4,065 in 1987 and 2,113 in 1989 (Table 5). Although 162 young-of-the-year bass were captured in 1988, no estimate could be calculated because no marked fish were recaptured. However, visual observations in autumn indicated that large numbers of young-of-the-year were present.

Table 2. *Mean length and length distribution of angler-harvested largemouth bass, and number of angler-caught-and-released largemouth bass.*

	1986	1987	1988	1989
Total number harvested	91	25	39	26
Mean length ± SD (inches)	12.5 ± 0.3	13.3 ± 0.7	13.4 ± 0.8	13.2 ± 0.9
Length range (inches)	11.9-13.4	11.8-14.9	12.1-15.1	11.8-15.2
Mean weight (lb)	0.92	1.14	1.15	1.15
No. and % >13.0 inches	10(11)[a]	18(72)	23(59)	15(58)
No. and % >14.0 inches	0	2(8)	11(28)	5(19)
No. and % >15.0 inches	0	0	2(5)	1(4)
No. released				
Sublegal	118	36	70	21
Legal	108	8	45	6

[a] Percent in parenthesis.

Table 3. *Age distribution, mean weight, and total weight of largemouth bass harvested from Spruce Lake, 1986-89.*

			Weight (lb)		
Year	**Age**	**Number Harvested**	**Mean ± SD**	**Total**	**Yield (lb/acre)**
1986	VI	91	0.92	83.38	5.05
1987	IV	1	0.72	0.72	0.04
	V	1	0.95	0.95	0.06
	VI	1	0.96	0.96	0.06
	VII	20	1.14 ± 0.14	22.88	1.39
	IX	1	1.39	1.39	0.08
	X	1	1.54	1.54	0.09
Total		25	28.44	1.72	
1988	II	1	0.93	0.93	0.06
	III	1	0.95	0.95	0.06
	IV	7	0.96 ± 0.08	6.71	0.41
	V	3	1.01 ± 0.12	3.03	0.18
	VI	10	1.19 ± 0.23	11.93	0.73
	VII	8	1.23 ± 0.25	9.82	0.60
	VIII	9	1.29 ± 0.16	11.59	0.70
Total		39	44.96	2.73	
1989	III	5	0.95 ± 0.22	4.73	0.29
	IV	3	0.96 ± 0.44	2.88	0.17
	V	9	1.11 ± 0.13	9.99	0.61
	VI	3	1.49 ± 0.14	4.47	0.27
	VII	2	1.26 ± 0.10	2.52	0.15
	VIII	1	1.00	1.00	0.06
	IX	1	1.65	1.65	0.10
	X	1	1.69	1.69	0.10
Unknown[a]		1	1.04	1.04	0.06
Total		26	29.97	1.81	

[a] Could not be aged because of scale regeneration.

Yellow Perch. The population size of yellow perch in Spruce Lake increased from 5,873 (356.0/acre) in April 1986 to 44,181 (2,677.6/acre) in April 1989 (Table 6). The primary population explosion of perch occurred during 1987-88 when the population increased in size over 49 times. However, despite the large increase in perch density during 1986-89, the perch size structure has changed little. Each year over 83% of the perch were less than 4.3 inches in length except in 1987 when only 39% were less than 4.3 inches. Relatively few perch (less than 1.0%) were greater than 8.2 inches in length in any year.

Annual angler exploitation rates of yellow perch were generally low. The exploitation rate for perch greater than 8.2 inches ranged from 13% in 1986 to 50% for those greater than 8.8 inches in length in 1987 (only 2 perch were marked in 1987) (Table 7).

Growth Rates

Largemouth Bass. Mean length at annulus formation of age III-VII largemouth bass increased an average of 0.4-0.6 inches annually during 1987-89 (Table 8). Largemouth bass grew relatively slowly in Spruce Lake; however, age I-III fish actually grew faster than average when compared with similar age bass from other northern Wisconsin lakes (Fig. 2). The mean length of a 3-year-old Spruce Lake bass was 10.8 inches during this study compared with 9.9 inches for the average 3-year-old bass from 40 lakes in northwestern Wisconsin (Snow 1992) and 9.2 inches from 13 additional lakes in northern Wisconsin (Snow 1969). After age V, Spruce Lake largemouth bass growth rates began to decline, and by age VII they were far below average with a mean length of only 13.3 inches, compared with mean lengths of 17.1 inches in northwest Wisconsin (Snow 1992) and 16.5 inches in 13 northern Wisconsin lakes (Snow 1969).

Considering the large number of perch available in Spruce Lake, the poor growth of bass after age V was probably due to bass food preference, prey location, productivity of Spruce Lake, or a combination of the 3, rather than lack of forage. It is possible, given the general lack of cover in Spruce Lake, that the largemouth bass are reluctant to move away from the security of the bog margin to actively feed on perch.

Yellow Perch. Mean length at annulus formation of all ages of male and female yellow perch declined annually during 1987-89, directly corresponding to the increase in perch density during the same years (Table 9). However, male and female perch showed an average length increase of approximately 1.0-1.7 inches at each age during each year of the study.

Food Habits of Adult Largemouth Bass

Despite yellow perch densities ranging from 82-1,641/acre, the most important largemouth bass food items during 1986-88, based on relative importance index values (RI), were odonates, dipterans and terrestrial insects (Table 10). According to Kempinger (1969) and Hoff (1986*b*) insects also were the most important food items of Spruce Lake largemouth bass in 1969 and during 1981-82. Insects were not an important bass food item in Murphy Flowage, Wisconsin, where they only constituted 8.3% of the total number of food items found in bass stomachs (Snow 1971). Not until 1989, when the perch density reached 2,678/acre, did they become the most important food item for largemouth bass (RI = 39.2).

A 12.0-inch length limit for largemouth bass has previously been studied on largemouth bass-bluegill lakes. Several researchers (Farabee 1974, Johnson and Anderson 1974, Rasmussen and Michaelson 1974) reported that a 12-inch length limit for largemouth bass resulted in stockpiling of bass under 12 inches and reduced bluegill populations. None of these studies resulted in substantial increases of large largemouth bass. However, according to Ming and McDannold (1975), a 12-inch length limit in a Missouri impoundment resulted in substantial increases of sublegal and legal-length bass. In Spruce Lake, stockpiling of bass under 12 inches was not a problem, probably because of the above-average growth rates for 1-3 year-old bass and the stable reproduction and recruitment of the bass population. Hoff (1986*b*)

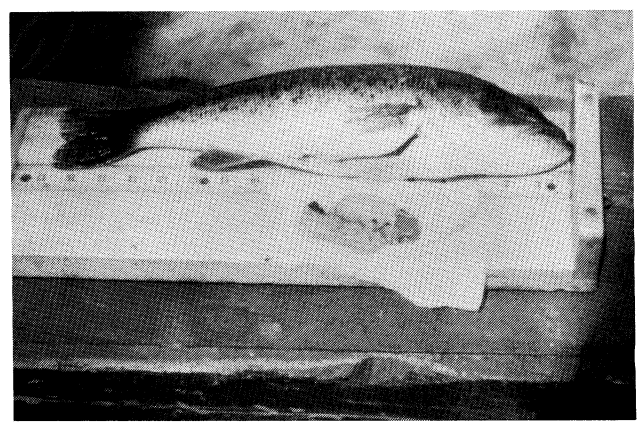

PHOTO: SERNS AND HOFF

Stomach contents of angler-harvested largemouth bass were analyzed.

Table 4. *Population estimates and exploitation rates of selected age largemouth bass present in Spruce Lake, 1985-87 and 1989.*[a]

Month-Year	Age	Population Estimate	95% Confidence Interval	Density (no./acre)	Exploitation Rate
Jul 1985	I	357	259-427	21.6	[b]
Sep 1985	I	73	36-2,500	4.4	[b]
Jul 1986	VI	247	174-347	15.0	0.361
Jun 1987	VII	77	35-210	4.7	0.180
Sep 1989	III	45	19-87	2.7	0.070
	V	11	8-22	0.7	0.330
	VII	8	6-13	0.5	0.200
	IX	–	–	–	1.000[c]
Total					0.114

[a]No estimates could be made for other age groups because no marked fish were recaptured.
[b]No angling was allowed during this study until 1 July 1986.
[c]Only 1 (age-IX) largemouth bass was marked and it was harvested.

Table 5. *Population and standing crop estimates of largemouth bass young-of-year, autumn 1986, 1987, and 1989.*[a]

Year	Population Estimate	95% Confidence Interval	Density (no./acre)	Standing Crop (lb/acre)
1986	466	220-1,074	28.2	0.22
1987	4,065	1,921-9,382	246.4	1.09
1989	2,113	998-4,876	128.1	0.54

[a]Marked fish were not recaptured in 1988 so no population estimate could be calculated.

Table 6. *Estimated number of yellow perch, by inch group, from 1986-89.*

Total Length Range (inches)	1986		1987		1988		1989	
	Number	% Total	Number	% Total	Number	% Total	Number	% Total
<4.3	5,732(347.4)[a]	97.6	533(32.3)	39.1	26,348(1,596.8)	97.3	36,886(2,235.5)	83.5
4.3-5.2	52(3.2)	0.9	419(25.4)	30.7	168(10.2)	0.6	4,258(258.1)	9.6
5.3-6.2	53(3.2)	0.9	320(19.4)	23.5	251(15.2)	0.9	1,640(99.4)	3.7
6.3-7.2	7(0.4)	0.1	54(3.3)	3.9	178(10.8)	0.7	562(34.1)	1.3
7.3-8.2	5(0.3)	0.1	38(2.3)	2.8	90(5.5)	0.3	481(29.1)	1.1
>8.2	24(1.5)	0.4	–	–	48(2.9)	0.2	354(21.4)	0.8
Total	5,873(356.0)		1,364(82.7)		27,083(1,641.4)		44,181(2,677.6)	

[a]Density (no./acre) in parenthesis.

Table 7. *Yellow perch exploitation rates, 1986-89.*

Year	Length Group (inches)	Number Marked (M)	Number Recaptures (R)	Exploitation Rate
1986	>8.2	15	2	0.133
1987	>8.8	2	–	0.500
1988	6.8-7.2	64	–	0.016
	>8.2	24	8	0.292
1989	7.3-8.2	135	4	0.030

also reported above-average growth through the third year of life for the 1980 year class of Spruce Lake largemouth bass.

Limited research has been performed to assess largemouth bass bag limits. Latta (1974) showed that a bag limit of 5 largemouth bass/day in Michigan was ineffective in limiting the catch. On Spruce Lake, the bag limit regulation of 2 bass/day had the greatest effect in 1986. Because anglers caught and released many legal-length bass during this period, the total exploitation rate may have been significantly higher if not for the 2 bass/day bag limit. In 1988 the total bass exploitation probably would have been higher if not for the bag limit. However, the bag limit regulation had little effect in 1987 and 1989 when very few legal-length bass were released.

Although the regulation requiring the use of artificial baits did not appear to affect the angling pressure on Spruce Lake during this study, it did have an effect on the yellow perch harvest. Nearly all perch harvested from other lakes in the Northern Highland Fishery Research Area are taken with live bait alone or in combination with artificial bait. Thus, without this regulation the perch harvest from Spruce Lake would have been higher during this study. However, because of the infertile water, the high reproductive rate and the slow growth of perch in Spruce Lake, not enough of them would have been harvested to prevent their overpopulation of Spruce Lake.

Note that there may have been a natural decrease in the Spruce Lake fish populations since the end of this study. Nonquantitative fyke netting in 1991 suggested a decline in the yellow perch population, and quantitative creel census data during 1990-92 suggested a decline in the largemouth bass population. The cause of these possible declines is unknown. Further discussion and conclusions presented here are based only on quantitative data collected during this study.

The special regulations were ineffective, at least through October 1989, at controlling the yellow perch population. There is some evidence, however, that largemouth bass might finally begin to affect the growth of the perch population, because in 1989 they began preying more heavily on perch than on insects for the first time during this study. However, given the history of the predator-prey relationship between Spruce Lake largemouth bass and yellow perch, bass seem incapable of controlling the perch population in Spruce Lake. Previous studies on Spruce Lake indicated that for largemouth bass to exhibit good growth, along with reproduction and recruitment

Table 8. *Mean total length and age, at capture, of largemouth bass captured with fyke nets and by angling, 1986-89.*

			Total Length (inches)[a]		
Year	Age	Number	Mean	Range	SD
1986	II	8	4.9	3.9-6.4	0.8
	III	19	10.2	9.7-10.8	0.3
	IV	–	–	–	–
	V	–	–	–	–
	VI	83	12.5	11.8-13.6	0.4
1987	III	2	7.7	7.6-7.7	0.1
	IV	2	9.2	7.0-11.4	3.1
	V	–	–	–	–
	VI	1	11.6	–	–
	VII	11	12.7	12.4-13.2	0.3
1988[b]	II	1	8.0	–	–
	III	3	10.7	10.3-11.5	0.7
	IV	7	11.4	10.7-11.9	0.4
	V	3	12.4	10.7-13.7	1.5
	VI	10	13.4	12.8-14.1	0.5
	VII	8	13.7	12.4-15.1	0.8
	VIII	9	13.8	13.3-14.1	0.3
1989[b]	III	19	11.7	10.7-12.7	0.5
	IV	8	11.9	11.1-12.5	0.5
	V	11	13.0	12.2-13.7	0.4
	VI	8	13.7	12.8-14.7	0.7
	VII	6	13.8	13.2-14.7	0.5
	VIII	2	13.2	12.9-13.5	0.4
	IX	1	14.4	–	–
	X	1	15.2	–	–

[a] Length at annulus formation of bass harvested during the growing season in 1988 and 1989 was determined by back-calculation of scale samples.

[b] Age data includes fish captured by researchers during the catch-and-release angling marking period, and sportsmen during the angling season.

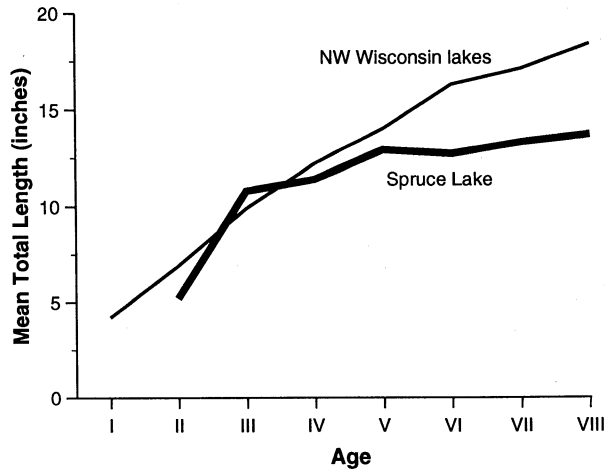

Figure 2. *Growth rates of largemouth bass from Spruce Lake, 1986-89, compared with growth of bass from northwestern Wisconsin lakes (northwestern Wisconsin data from Snow 1992).*

Table 9. *Mean total length by age for male and female yellow perch captured during April, 1986-89.*[a]

Age	1986			1987			1988			1989		
	Number	Mean	SD	Number	Mean	SD	Number	Mean	SD	Number	Mean	SD
Males												
I	24	3.3	0.3	21	3.6	0.3	40	3.3	0.5	21	3.3	0.2
II	41	5.0	0.5	33	5.0	0.6	22	4.9	0.4	30	4.7	0.6
III	4	6.6	0.6	23	6.6	0.7	47	6.3	0.8	26	5.4	1.0
IV	10	7.7	0.5	2	8.2	1.3	11	7.9	0.3	29	7.3	0.9
V				5	7.7	0.8	1	9.6	–	10	8.5	0.5
VI							2	9.7	1.3	1	10.5	–
Females												
II	10	5.7	0.5	29	5.6	0.6	16	6.2	0.5	37	4.7	0.5
III	3	8.7	0.3	27	8.7	0.6	42	7.2	0.8	27	6.6	0.9
IV	9	9.1	0.8	–	–	–	17	8.6	0.8	27	8.4	0.7
V	1	11.3	–	1	9.2	–	1	11.2	–	5	8.8	0.8
VI				1	9.5	–	1	10.0	–	1	11.7	–
VII							1	13.3	–			

[a] Units in inches.

Table 10. *Frequency of occurrence (FO) and absolute (AI)*[a] *and relative (RI)*[b] *importance index values for food items in the stomachs of angler-harvested largemouth bass during 1986-89.*

Taxon	1986			1987			1988			1989		
	%FO	AI	RI	%FO	AI	RI	%FO	AI	RI	%FO	AI	RI
Annelids												
Hirudinea	2.1	5.5	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arachnida	0.0	0.0	0.0	8.0	10.6	2.7	2.6	4.9	1.3	0.0	0.0	0.0
Crustaceans												
Hydracarina	2.1	3.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aquatic insects												
Ephemeroptera	8.5	10.5	2.5	0.0	0.0	0.0	2.6	3.3	0.9	0.0	0.0	0.0
Odonata	68.1	142.8	33.6	44.0	73.1	18.8	25.6	42.8	11.6	0.0	0.0	0.0
Hemiptera	6.4	7.7	1.8	0.0	0.0	0.0	15.4	21.0	5.7	3.8	6.3	1.9
Trichoptera	2.1	2.4	0.6	4.0	4.2	1.1	2.6	3.6	1.0	7.6	26.8	7.9
Coleoptera	2.1	2.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	3.8	6.3	1.9
Diptera	34.0	51.6	12.1	48.0	131.3	33.9	12.8	22.8	6.2	7.6	18.5	5.5
Terrestrial insects												
Insecta[a]	40.4	51.8	12.2	24.0	40.8	10.5	41.0	96.2	26.0	30.8	54.1	16.0
Unidentified insect remnants	6.4	7.2	1.7	0.0	0.0	0.0	5.1	6.5	1.8	11.5	18.5	5.5
Pelecypoda	0.0	0.0	0.0	4.0	4.6	1.2	2.6	3.3	0.9	0.0	0.0	0.0
Vertebrates												
Amphibia	4.3	5.1	1.2	8.0	8.5	2.2	15.4	36.4	9.9	0.0	0.0	0.0
Reptilia	6.4	43.1	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chelonia	0.0	0.0	0.0	0.0	0.0	0.0	2.6	18.4	5.0	0.0	0.0	0.0
Mudminnow	0.0	0.0	0.0	4.0	4.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth bass	0.0	0.0	0.0	8.0	12.8	3.3	0.0	0.0	0.0	0.0	0.0	0.0
Yellow perch	25.5	65.7	15.4	20.0	77.4	20.0	12.8	48.1	13.0	42.3	133.0	39.2
Unidentified fish remnants	17.0	25.9	6.1	16.0	20.3	5.2	28.2	62.0	16.8	30.8	74.7	22.1

[a] AI = % of total number of food items + % frequency of occurrence + % of total volume.
[b] RI = 100 x AI/sum AI.
[c] Includes the adult stage of aquatic insects, if present.

near or at the levels of the mid 1960s (Kempinger 1969), the perch population must not be allowed to reach the size it had prior to the rotenone treatment in 1978 (Hoff 1986*a*). Unfortunately by 1989, the perch density again was over 2,600/acre, the level it was prior to chemical treatment in 1978 (Hoff 1986*a*). Despite numerous management procedures to prevent overpopulation of perch and to enhance the population of bass in Spruce Lake, the perch density reached 4,654/acre prior to chemical treatment in 1960 (Kempinger 1969) and 2,615/acre prior to chemical treatment in 1978 (Hoff 1986*a*).

Conclusions

1. The average annual fishing pressure on Spruce Lake during this study was 28% lower than it was during the 1970s when there were no special regulations.
2. The 2 largemouth bass/day bag limit was beneficial at reducing bass harvest during the first 2 years of this study, but had little effect during the last 2 years.
3. Although the artificial bait regulation reduced the yellow perch harvest, it did not contribute to the overpopulation of yellow perch in Spruce Lake. This regulation had little effect on the largemouth bass harvest.
4. The 12.0-inch length limit was successful at increasing the average size of harvested largemouth bass, and did not result in stockpiling of fish under 12.0 inches. However, the average size of harvested bass did not reach its potential.
5. The special regulations appeared to have little effect on the total number of largemouth bass harvested. Also, the regulations did not maintain a largemouth bass population large enough to control the yellow perch population. Because the yellow perch density has reached over 2,600/acre, it is highly unlikely that the largemouth bass and yellow perch populations will again become balanced without drastic remedial action. Periodic yellow perch removal or chemical treatment probably is necessary to maintain a quality yellow perch population in Spruce Lake regardless of the largemouth bass regulations.
6. The quality of largemouth bass harvested from Spruce Lake improved during this study. However, higher length limits would more likely be successful at improving angling and population quality.
7. Despite extremely high yellow perch densities, insects were the most important largemouth bass food item in Spruce Lake during 1986-88. In 1989, for the first time during this study, perch were the most important food item for the largemouth bass in Spruce Lake.

Management Implications

Special regulations like those implemented on Spruce Lake (12-inch length limit and bag limit of 2 for largemouth bass and use of artificial baits only) would improve the quality of the bass caught (harvested or released) from similar small lakes but probably would not result in a balanced population of largemouth bass and yellow perch, if bass and perch were the only gamefish present in the lake. However, these regulations would not, under similar conditions, result in a high-quality largemouth bass fishery in which bass up to 18 inches in length would be consistently produced. Given the growth rates of bass under these conditions, even more stringent regulations would be necessary to maintain a high quality largemouth bass fishery. If higher quality is desired, a minimum length limit of 16 inches with a bag limit of 1 or 2 is recommended under these conditions. If growth rates are higher than that found on Spruce Lake, a minimum length limit of 18 inches and bag limit of 1 or 2 is recommended.

A bag limit regulation of 2 largemouth bass/day appears to be a viable management alternative in reducing bass harvest in some years. However, we believe a bag limit of 1 would be most effective at consistently reducing largemouth bass harvest.

Limiting anglers to the use of artificial baits only on Spruce Lake appeared to have little effect on the total fishing pressure and the largemouth bass harvest during this study. However, it would not be beneficial to implement a regulation such as this if substantial panfish harvest is desired.

Because largemouth bass failed to control yellow perch in Spruce Lake during this study, a different management approach probably would be necessary to maintain a stable largemouth bass-yellow perch community in similar small dystrophic lakes in northern Wisconsin where perch density is a problem. We recommend periodic yellow perch removals. Large numbers of perch can easily be removed with fyke nets during their spring spawning season in small lakes. Chemical treatment should only be used as a last resort.

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