Experimental management of Spruce Lake, a small bog lake in northeastern Wisconsin. Report 40 1969

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RESEARCH REPORT 40

EXPERIMENTAL MANAGEMENT OF SPRUCE LAKE, A SMALL BOG LAKE IN NORTHEASTERN WISCONSIN

By

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ABSTRACT

The effects of four management procedures have been studied for 22 years on Spruce Lake, a bog lake in northeastern Wisconsin with an overcrowded panfish population: liberalized regulations, maintenance stocking, closed seasons, and chemical reclamation and restocking.

Neither the liberalized regulations nor the 3-year closed season improved the fishing quality on Spruce Lake. In contrast, chemical treatment and restocking produced a greatly improved fishery, with double the rate of angling success.

ACKNOWLEDGEMENTS

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SPRUCE LAKE

INTRODUCTION

Many lakes in Wisconsin are characterized by large populations of discouragingly small slow-growing fish. One of the earliest attacks on this problem was initiation in 1946 of a research project on a group of five Vilas County lakes to determine primarily if liberalized angling regulations would result in reduced fish numbers and increased growth of the remainder.

This project was started by the Wisconsin Conservation Department at the request of the Vilas County Sportsmen's Club, indicating an early awareness by fishermen of the need for research at a time when fishery research was still virtually in its infancy. In asking the Department to set up this study, the Club said: "Control of the fish populations on these experimental lakes would be first attempted by special regulations covering the angling therein and if necessary then by additional measures biologists may deem advisable such as the heavier planting of control fishes, transfer of too numerous sizes or species to other nearby waters, etc."

This report summarizes the results of a 22-year study of one of the five lakes, 16.5-acre Spruce Lake. During the period 1946-1967, the effects of four management procedures have been studied on this small bog lake: (1) liberalization of angling regulations--no size or bag limits and no closed season; (2) maintenance stocking of largemouth bass fingerlings and northern pike fry; (3) closure to angling for a 3-year period; and (4) chemical reclamation and restocking with largemouth bass and northern pike.

DESCRIPTION OF LAKE

Spruce Lake, Vilas County (T41N, R7E) is 0.2 mile long by 0.1 mile wide and has an area of 16.5 acres and a maximum depth of 13 feet. The lake is entirely surrounded by state-owned land and access to it is provided by a graded road that passes within 100 feet of the lake. Ninety-nine percent of the 0.6 miles of shoreline is quaking bog and the chief bottom type consists of material of plant origin that creates a false bottom.

There are no tributary streams but an intermittent outlet flows during periods of high water, usually only in early spring. The water is brown-stained and infertile, having a methyl orange alkalinity range of 1.6 to 5.0 parts per million. Fish inhabiting the lake prior to chemical treatment in 1960 were mudminnow (Umbra limi), northern pike (Esox lucius), northern black bullhead (Ictalurus melas), largemouth bass (Micropterus salmoides), pumpkinseed (Lepomis gibbosus), and perch (Perca flavescens). Physical and chemical characteristics of the lake are presented in Table 1.

HISTORY OF SPRUCE LAKE

Spruce Lake is one of a group of five lakes, (Escanaba, Mystery, Nebish and Pallette), on which all size, season and bag limits were removed in 1946 (Oehmcke and Waggoner, 1956), to evaluate the effects of liberalized angling regulations. In 1944-45 and 1949-50 the lake was stocked on a maintenance basis with largemouth

TABLE 1

Physical and Chemical Characteristics
of Spruce Lake

Date and Depth (Ft.)	Condition	Temp. (°F)	Conductivity 77°F (mmhos)	pH	Methyl Orange Alkalinity (ppm)	Dissolved Oxygen (ppm)
Feb. 5, 1964	Ice	33.5	23.0	6.0	1.6	11.5
Surface						
4		38.0	20.5	6.2	1.6	9.0
8		38.0	19.1	6.2	1.6	8.8
11		38.0	18.4	6.2	1.6	9.0
Apr. 2, 1964		33.5	25.3	6.2	3.0	9.6
Surface						
4		39.0	21.6	6.0	3.0	6.4
8		39.0	21.6	6.0	5.0	5.0
11		39.5	21.6	6.0	5.0	3.4
May 6, 1964	Openwater	60.5	19.1	6.2	2.5	9.4
Surface						
4		60.5	18.2	5.9	2.5	9.1
8		60.0	17.1	5.7	2.5	9.4
11		57.0	22.8	5.7	2.5	9.4
July 16, 1964		77.5	19.8	5.8	4.0	7.2
Surface						
4		77.0	19.1	5.2	4.0	6.2
8		73.0	19.1	5.2	4.0	6.9
11		72.5	19.8	5.4	5.0	6.4
Aug. 31, 1964		65.5	18.8	6.2	3.0	8.6
Surface						
4		65.5	19.4	6.0	4.0	8.0
8		65.5	21.7	5.6	3.0	8.0
11		65.0	25.1	5.4	3.0	6.7

Date	PO_4(T)	PO_4(D)	NH_3-N	K-N	NO_3-N	CL	SO_4	Ca	Mg	Na	K	Fe
May 20, 1960*	0.1	0.01	0.1	1.3	0.2	0.1	1.0	1.5	1.0	1.0	0.5	0.25

*Expressed in ppm; analysis by Ronald J. Poff

bass fingerlings and northern pike fry, respectively. In 1951, Spruce Lake was closed to all fishing for 3 years. In 1954 the lake was again opened to liberalized fishing regulations. In 1960 the lake was chemically treated to remove the entire fish population and restocked the same year with largemouth bass fingerlings. The following summer largemouth bass and northern pike adults and northern pike fry were stocked. The lake was again opened to liberalized fishing regulations in 1961.

METHODS

Creel Census

From 1946 to 1967 all persons fishing Spruce Lake were required to obtain a free fishing permit, which was available at the checking station located at the boat landing of Escanaba Lake, (Fig. 1). From 1946 to 1950 the checking station was manned 24 hours a day from June 20 to September 13. After September 13, permits were issued by personnel located at Trout Lake Forestry Headquarters approximately 5 miles distant. From 1954 to 1967 there was a complete creel census, during which period fishing was allowed from 4:00 a.m. to midnight during the open water season and 6:00 a.m. to 8:00 p.m. during the winter months.

Hours fished, species caught and data on angler characteristics were obtained from the creel census records. Total length to the nearest tenth inch and weight to the 0.01 pound were recorded for each fish. Representative scale samples were taken for aging, and after chemical treatment fish stomachs were collected for food analyses.

Marking

In 1960, the year of chemical treatment, perch, pumpkinseed and northern pike were captured with fyke nets. All fish were measured, marked by fin removal and released. After treatment, dead fish were collected, measured, weighed and examined for marks. The population and standing crop was estimated by the Petersen method.

In 1963, a 230-volt AC boom shocker was used to capture fish. During the 1965-67 period, fyke nets were set from "ice out" to June 1 when angling pressure began. Fish captured were measured, scales taken for aging, marked by fin removal and released. Fish populations were estimated and exploitation rates determined through the complete creel census.

Stocking

The fish species native to Spruce Lake are unknown, but it is known that for years lakes of this type were stocked. Stocking records date back to 1944 when 150 largemouth bass fingerlings were stocked (Williamson, 1947). In 1945 another 300 were stocked. Previous to 1944 it is reported that northern pike were introduced, but no information is available on the number or date of stocking. In 1949 and 1950, 7,000 and 3,000 northern pike fry were stocked, respectively. No further stocking took place until 1960 after the lake was chemically treated. Thirty-one days after treatment, 3,100 bass fingerling were stocked.

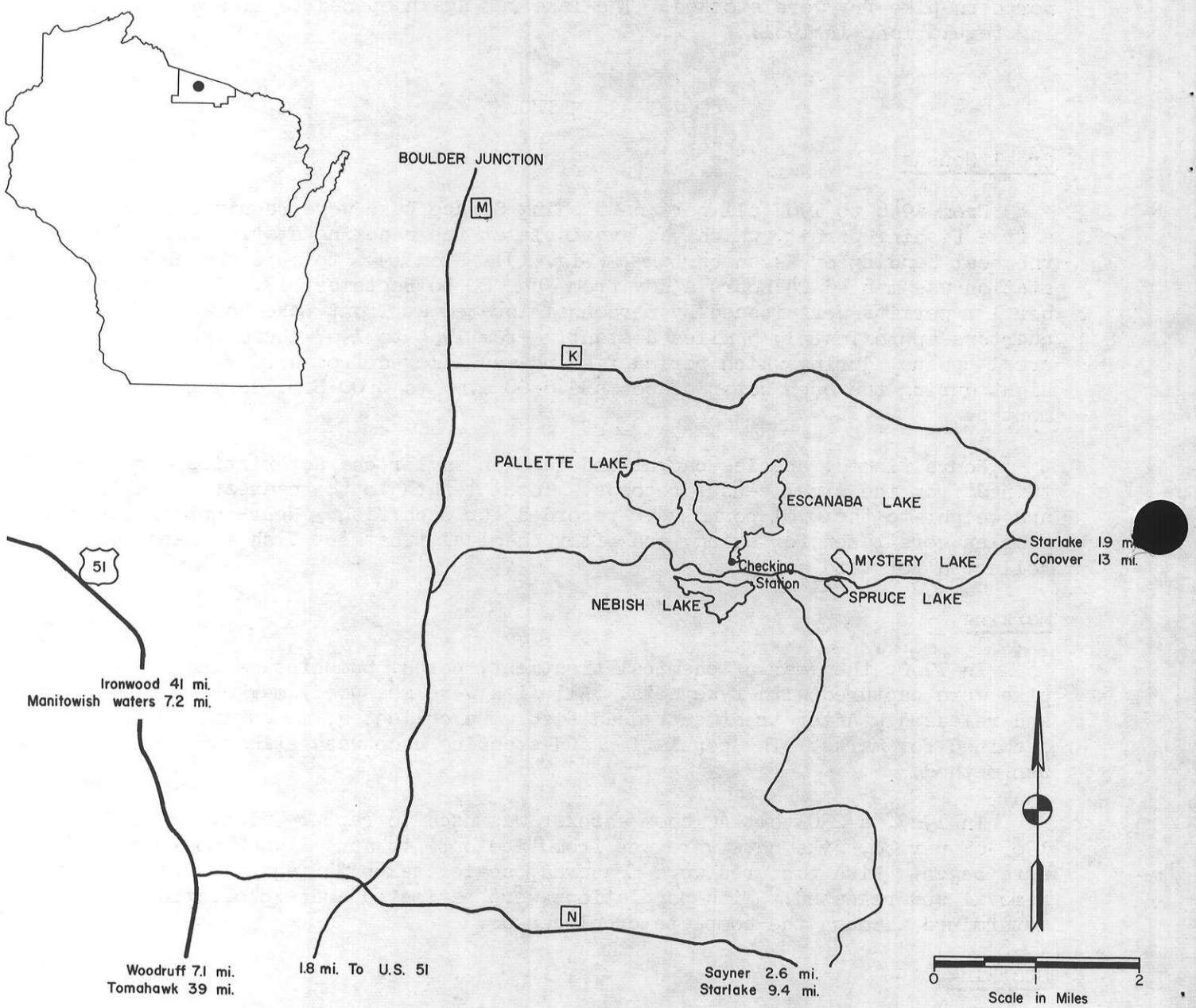

FIGURE 1. Map showing location and environs of Spruce Lake, one of the five study lakes in the Northern Highland Research Area, Vilas County.

The fish weighed a total of 19.6 pounds and averaged 2.3 inches. The following spring, March 10, 1961, 16 adult northern pike averaging 19.7 inches were stocked. On June 3, 1961, 7,500 northern pike fry weighing 2.4 pounds were stocked. The final stocking took place June 4, 1961, when 22 adult largemouth bass averaging 7.6 inches were stocked. The known Spruce Lake stocking record is shown in Table 2.

TABLE 2

Known Stocking Record for Spruce Lake

Date	Species	No.	Age	Total Length (in.) Range	Total Length (in.) Avg.	Weight (lbs.)
1944	LMB	150	Fingerling	-	-	-
1945	LMB	300	Fingerling	-	-	-
1949	NP	7000	Fry	-	-	-
1950	NP	3000	Fry	-	-	-
August 10, 1960	LMB	3100	Fingerling	-	2.3	19.6
March 10, 1961	NP	16	Adult	14.7-29.7	19.7	-
June 3, 1961	NP	7500	Fry	0.75-1.25	-	2.4
June 4, 1961	LMB	22	Adult	6.0-16.0	7.6	-

All adult largemouth bass and northern pike stocked in 1961 were marked by removal of the left pectoral fin.

Chemical Treatment

On July 6, 1960, Spruce Lake was chemically treated with approximately 1 ppm of emulsifiable rotenone (Churchill, 1961). The lake was stratified at that time, having a temperature of 78°F at the surface, and 56°F at the 10-foot level. To assure penetration of the toxicant to all levels, a second application of rotenone was applied in the hypolimnion while the epilimnion was still toxic. Fish were collected immediately after treatment to estimate the population and standing crop. To test the effectiveness of the treatment, fish were held in cages at several points in the lake.

RESULTS

Liberalized Fishing Regulations, 1946-1950

During the first five years of the project, anglers fished 427 hours and caught 138 fish that weighed 105 pounds (Table 3). The number of fish caught per hour was 0.32. Annual average catch was 1.3 pounds per acre during this period.

Only 53 perch were caught so liberalization of fishing regulations was apparently ineffective in increasing the harvest of this species.

Fishing Success After Three Closed Seasons, 1954-1959

Fair fishing for two weeks resulted from the closing of Spruce Lake for three years to all fishing. During the first 14 days of the 1954 season anglers fished 121 hours and caught 21 northern pike and 33 largemouth bass at the rate of 0.45 fish per hour.

During the entire 1954-1959 period 560 anglers fished 1,838 hours and caught 711 fish or 0.39 fish per hour (Table 4). The total catch weighed 465 pounds (annual average of 4.7 pounds per acre). During this period 496 perch were caught. Many of the perch caught were small and undesirable, so closing the lake to all fishing for three years did not produce a quality fishery. The most desirable fish caught was the occasional largemouth bass. During this period 94 bass were caught and of this total 66 measurements are available for 1954, 1955, and 1958, shown in Figure 2. Average total length of bass caught during these three years

TABLE 3

Fishing Success Under Liberalized Fishing Regulations, 1946-50

	1946	1947	1948	1949	1950	Totals
No. hours fished	180	54	51	111	31	427
Species caught						
Largemouth bass						
No.	2		5	36	9	52
Wt. (lbs.)	4		6	39	14	63
Northern Pike						
No.	8	1	1	1	1	12
Wt. (lbs.)	19	3	2	3	3	30
Perch						
No.	0	0	36	17	0	53
Wt. (lbs.)	-	-	6	3	-	9
Pumpkinseed						
No.	0	0	1	20	0	21
Wt. (lbs.)	-	-	0.15	3	-	3.15
Total Fish	10	1	43	74	10	138
Total Weight	23	3	14	48	17	105
Fish/Hour	0.06	0.02	0.85	0.87	0.32	0.32

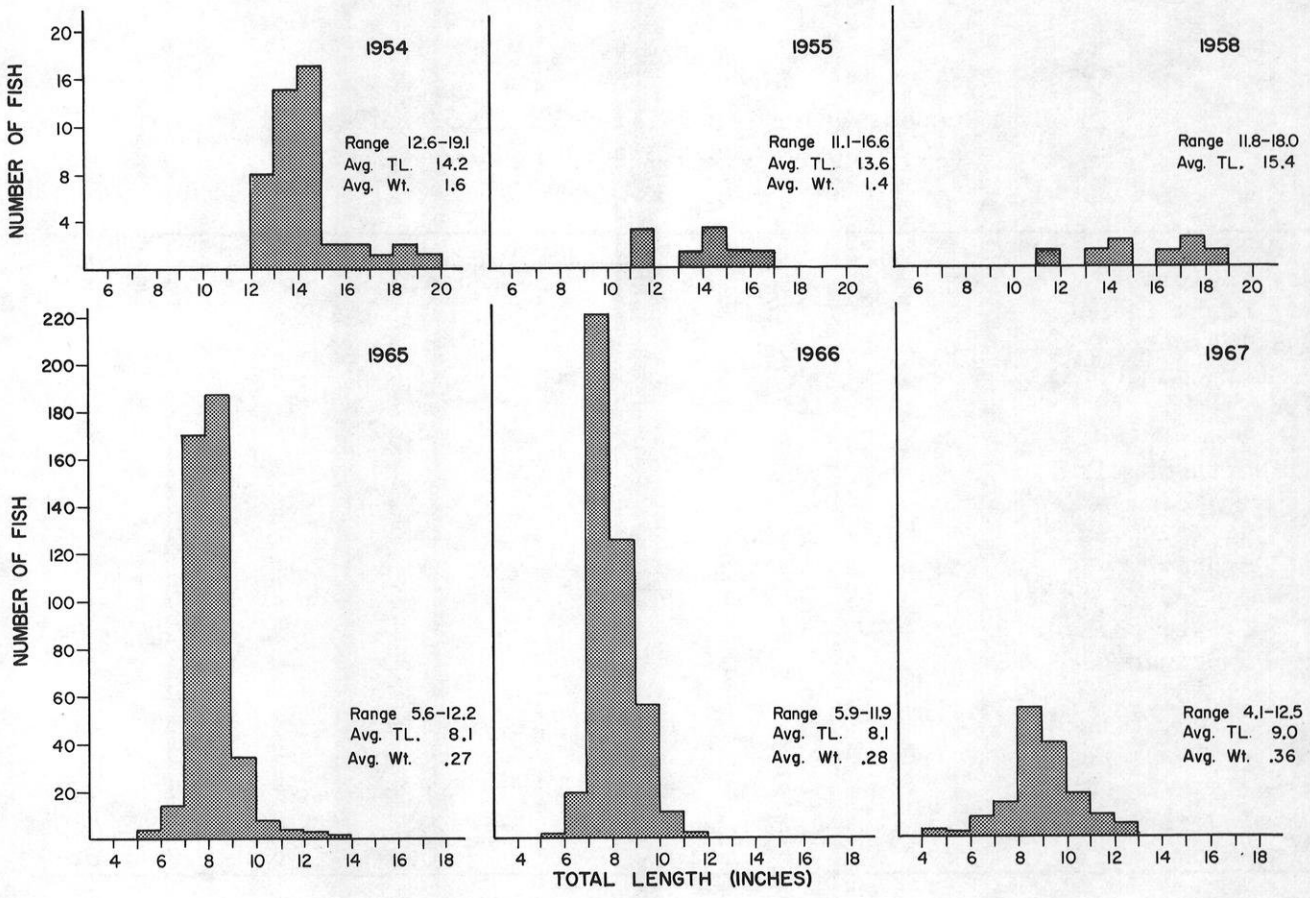

FIGURE 2. Length distribution of Spruce Lake largemouth bass catch.

was 14.3 inches. Again during this period there was definite evidence of poor reproduction and survival of young bass.

Maintenance Stocking of Largemouth Bass Fingerlings and Northern Pike Fry

The fingerling bass stocked in 1944 and 1945 would have been Age II and Age I, respectively, in 1946 and would have entered the fishery after the creel census began. The exact number of stocked bass caught is unknown since the fish were unmarked; however, only 52 bass were caught during the whole period. As reflected in the total catch, survival of the 450 largemouth bass fingerlings stocked in 1944 and 1945 was poor. Natural reproduction or survival of young bass during the first five years of the project was also poor.

Only 68 northern pike were caught by anglers (Table 4). Survival of the 10,000 northern pike fry stocked in 1949 and 1950 was poor.

The four stockings, two each of largemouth bass fingerlings and northern pike fry, did not augment the respective fish populations.

TABLE 4

Fishing Success Under Liberalized Fishing Regulations
After Three Closed Seasons, 1954-59

	1954	1955	1956	1957	1958	1959	Totals
No. anglers	191	53	77	113	67	59	560
No. hours fished	614	137	283	407	232	165	1838
Species caught							
Largemouth bass							
No.	48	9	10	18	8	1	94
Wt.(lbs.)	78	12	10	38	17	4	159
Northern pike							
No.	28	4	13	13	4	6	68
Wt. (lbs.)	106	8	48	42	9	19	232
Perch							
No.	10	120	133	56	68	109	496
Wt. (lbs.)	1	15	18	7	8	15	64
Pumpkinseed							
No.	2	0	17	24	2	8	53
Wt. (lbs.)	0.5	-	3	4	0.38	2	10
Total Fish	88	133	173	111	82	124	711
Total Weight	185.5	35	79	91	34.38	40	465
Fish/Hour	0.14	0.97	0.61	0.27	0.35	0.75	0.39

Evaluation of Chemical Treatment and Restocking

Fish populations. During the pretreatment marking period, 95 percent of the 2,398 fish captured and marked were perch (Table 5). Dead perch collected after treatment accounted for 92 percent of the 4,351 fish recovered. The population was estimated at 76,784 perch weighing 1,680 pounds. The overcrowded perch populations resulted in slow-growing fish. Age VI perch in Spruce Lake were 5.9 inches compared to 10.0 inches for fish the same age in Escanaba Lake (Table 6).

Only 102 pumpkinseed were marked (Table 5). After treatment, 338 pumpkinseed were recovered, 44 being marked fish. The pumpkinseed population was estimated at 783 and the standing crop at 38 pounds.

Eight northern pike were marked before treatment (Table 5). Based on 11 northern pike recovered, one being a marked fish, the population was estimated at 88 fish. Average weight of 11 northerns recovered was 2.5 pounds and the standing crop was estimated at 220 pounds.

Since no largemouth bass were marked, it was impossible to estimate the population. Seventeen bass were recovered that weighed an average of 2 pounds each. Average recovery rate of largemouth and smallmouth bass after chemical treatment in Nebish Lake, 1966 was 26 percent. Based on this 26 percent recovery rate, the largemouth bass population was estimated at 68 fish and total standing crop at 136 pounds.

Total standing crop of the four fish species combined in Spruce Lake prior to chemical treatment was 2,074 pounds or 125 pounds per acre. Fyke net surveys later revealed that mudminnows and northern black bullheads survived the chemical treatment.

TABLE 5

Population Estimates and Standing Crop at Pretreatment, 1960

	Perch <3.5"	Perch >3.5"	Pumpkinseed	Total Panfish No.	Total Panfish Percent	Northern Pike	Largemouth Bass	Total Game Fish Number	Total Game Fish Percent
Marked	1671	617	102			8	0		
Recovered	2881	1132	338			11	17		
Recaptures	73	71	44			1	0		
Estimated Population	69947	6837	783	77567	99.8	88	68	156	0.2
Estimated Weight(lbs)	1116	564	38	1718	83.0	220	136	356	17.0
Pounds/Acre	68	34	2	104		13	8	21	

TABLE 6

Average Growth of Perch in Escanaba and Spruce Lakes

Age	Sample Size Spruce Lake	Years 1	2	3	4	5	6
I	85	2.8*					
II	90		3.6 (6.4)**				
III	90			5.0 (7.3)			
IV	80				5.2 (8.0)		
V	85					5.7 (9.4)	
VI	45						5.9 (10.0)

* Average total length of Spruce Lake perch at the time of chemical treatment.
**Average total length of perch during a 9-year period in Escanaba Lake, 1956-64.

Angler success, 1961-67. The first seven years after treatment, 460 anglers fished 1,362 hours and caught 1,101 fish that weighed 380 pounds (Table 7). The average annual catch was 3.3 pounds per acre. The bulk of the catch was composed of largemouth bass, and only 28 northern pike were recorded. Four of the northerns caught had been stocked as adults. Twenty-three were from the 1961 year class which was either natural reproduction from the stocked adults or from the 1961 fry stocking. Only one northern pike was caught from a year class later than 1961. All northern pike caught were in generally poor condition.

Largemouth bass reproduction from adults stocked in 1961 brought about year classes that created an improved fishery. During the first three years (1961-63) after treatment only 17 bass were caught (Table 7); thirteen of these fish had been stocked as adults. Through 1967, 18 of the 22 adult bass stocked had been caught by anglers. Because fingerling bass were the only fish stocked in 1960 it was possible to determine stocking success. Only three of the 3,100 fingerling stocked have been caught by anglers. Since chemical treatment, naturally reproduced bass have comprised 98 percent of the bass caught by anglers. During the 1965-67 seasons anglers caught 1,021 bass at the rate of 0.92 fish per hour. Annual harvest was 5.9 pounds per acre during the last three years.

TABLE 7

Fishing Success After Chemical Treatment, 1961-67

	1961	1962	1963	1964	1965	1966	1967	Totals
No. anglers	6	26	16	42	124	115	131	460
No. hours fished	12	72	45	133	360	412	331	1,362
Species caught								
Largemouth bass								
No.	2	13	2	34	432	443	146	1,072
Wt. (lbs.)	1.5	14.5	3.5	25	116.5	123	52	336
Northern Pike								
No.	2	5	8	9	5	0	0	28
Wt. (lbs.)	1.5	4	12.5	15	11	-	-	44
Total fish	4	18	10	43	437	443	146	1,101
Total weight	3	18.5	16	40	127.5	123	52	380
Fish/hour	0.25	0.26	0.22	0.32	1.21	1.08	0.44	0.81

Size distribution and growth rates. Angler catch of bass in 1965-67 was 1,021, only 2 of which were stocked fish. Average length of bass caught by anglers during this three-year period was 8.1, 8.0 and 8.9 inches, respectively (Fig. 2). Average weight of bass caught the same years was 0.27, 0.28 and 0.35 pounds. Growth rate of the few naturally reproduced fish caught during the first three years after treatment was better than the period when they became abundant in the years 1965-67 (Table 8). Average rate of growth during 1965-67 for Age I through Age IV was 6.5, 8.0, 9.3 and 10.9 inches. Average length of bass caught by the anglers in 1967 was greater, but growth rate was comparable to 1965 and 1966. Growth rate of bass is compared with Browns Lake, Wisconsin bass Mraz (1964) in Table 9.

TABLE 8

Growth of Largemouth Bass in Spruce Lake, 1962-67

Age	Growth in Inches					
	1962	1963	1964	1965	1966	1967
I	8.1(1)*	4.8(3)	6.7(5)	6.4(15)	6.6(2)	6.5(16)
II		12.0(1)	9.7(7)	8.1(364)	7.9(297)	8.0(30)
III			11.1(18)	9.4(30)	9.3(59)	9.3(80)
IV				11.5(7)	10.8(2)	10.9(18)

*Number of fish.

TABLE 9

Average Growth of Largemouth Bass in Browns and Spruce Lakes

Age	Sample Size Spruce Lake	Years						
		1	2	3	4	5	6	7
0		(3.6)*						
I	15		6.5** (6.6)					
II	663			8.0 (8.8)				
III	81				9.3 (10.5)			
IV	4					11.0 (12.0)		
V							(14.2)	
VI								(15.4)

* Average total length of 1948 Browns Lake bass.
**Average total length of 1965-67 angler-caught Spruce Lake bass.

The average size of bass captured in fyke nets during 1965-67 is shown in Table 10.

TABLE 10

Average Size of Bass, 1965-67

Year	Sample Size	Range (Inches)	Avg. (Inches)
1965	92	6.3 - 11.9	7.5
1966	17	5.3 - 8.3	7.1
1967	48	6.9 - 11.8	9.1

Population and exploitation rates. The most successful method used to sample the fish population in Spruce Lake was fyke netting. However, with the soft bottom characteristically found along the shoreline of bog lakes few nets could be set. Electroshocking with a 230-volt AC boom shocker was almost completely unsuccessful due to the soft water.

Using fyke nets in the spring of 1965, 8 northern pike were captured. Anglers during the summer caught 5 northern pike, 4 of which had been marked in the spring. Netting during the springs of 1966-67 produced only one northern pike in 1966 and none in 1967. No northern pike were caught by anglers in 1966 or 1967.

Naturally reproduced bass were captured in fyke nets in 1965-67 and were the basis for a population estimate. Estimates of bass Age II and older ranged from 208 in 1967 to 1,878 in 1965 (Table 11).

TABLE 11

Population Estimates of Largemouth Bass, 1965-67

Year	No. Marked	Captures	Recaptures	Population Estimate	Exploitation Rate (Percent)
1965	95	416	46	859	48
1966	17	442	4	1,878	24
1967	46	122	27	208	59

Through the creel census exploitation rates were also determined and estimated at 48, 24 and 59 percent of the populations during the years 1965-67, respectively.

Food studies. Bass stomachs were collected during the summer seasons of 1964-67. Seven of 8 stomachs collected in 1964 contained food and 5 of these contained fish, primarily largemouth bass fingerlings. During the 1965 season no fish were found in any of the 92 stomachs examined. During the three-year period 1965-67, 17 percent of the 237 stomachs examined contained no food. The food most frequently found in bass stomachs was dragonfly nymphs. An average of 41 percent contained dragonfly numphs and 29 percent dragonfly adults. The next most frequently selected foods were adult predaceous diving beetles; adult back swimmers; and unidentified fish (Table 12).

TABLE 12

Food of Largemouth Bass, 1964-67

Year	No. Stomachs Examined	Percent Empty	Percent of Stomachs Containing: Dragonfly Nymphs	Dragonfly Adults	Predaceous Diving Beetle Adults	Back Swimmer Adults	Fish
1965	92	25	40	27	6	2	0
1966	29	10	55	27	27	10	7
1967	116	16	28	33	16	15.5	11
Average		17	41	29	16	9.2	6

Identified fish species found in the stomachs other, than minnows with hook marks, were largemouth bass fingerlings and mudminnows. Since 1965 there has been increased utilization of fish and back swimmers. In 1967 there was a decrease of dragonfly nymphs. Other food organisms found in lesser amounts in stomachs were frogs; adult and larvae caddis fly; adult wasps; larvae of predaceous diving beetles; adult water scorpion; and leeches.

Parasites were found for the first time in the summer of 1967. Twelve (10%) of the intestinal walls examined had infestations of Proteocephalus ambloplitis, tapeworm.

DISCUSSION

During 1961-67, after chemical treatment, anglers caught 0.81 fish per hour compared to 0.39 for the 1954-59 period which followed a 3-year closure to fishing and preceded chemical treatment. The comparable figure for 1946-50 was 0.32 fish per hour. Neither the liberalized regulations nor the 3-year closure improved the fishing quality. In contrast, chemical treatment and restocking produced a greatly improved fishery, with double the rate of angling success compared to that of the preceding periods.

The average annual catches, in terms of pounds per acre, during the 1946-50 and 1954-59 periods were 1.3 and 4.7, respectively, compared to 3.3 for 1961-67. During the first two periods the catch was made up of northern pike, largemouth bass, perch, and pumpkinseed, while during the last period the catch was composed of game fish only - largemouth bass (89%) and northern pike.

Averages for 1961-67 are influenced by data for the first few years when the re-introduced fish population was developing. Figures for 1965-67, more apropos for comparison with those for 1946-50 and 1954-59 when established fish populations were present, were: (1) catch per hour - 0.92 and (2) annual average catch - 5.9 pounds per acre. The latter figures serve to further underscore the greatly improved fishery created by chemical treatment and re-stocking.

Maintenance stocking of two year classes each of largemouth bass fingerlings and northern pike fry did not greatly augment their respective populations. Survival of bass from natural reproduction before chemical treatment was also poor, implying predation on young rather than poor hatching success. Elimination of perch which comprised 99 percent of the total population permitted excellent largemouth bass reproduction from re-introduced stock, thus creating an improved fishery.

The average size of bass caught after treatment was smaller than those caught during pre-treatment periods, but the growth rate was comparable to bass in other Wisconsin lakes.

MANAGEMENT IMPLICATIONS

1. Liberalized fishing regulations -- no size and bag limits, no closed season -- were unsuccessful in reducing an overcrowded panfish population.

2. The most restrictive fishing regulation -- closing the lake to all fishing for 3 years -- did not result in providing better fishing.

3. Maintenance stocking of largemouth bass fingerlings and northern pike fry in a lake with an overcrowded panfish population was unsuccessful in augmenting the predator population.

4. Improvement of the lake habitat through chemical treatment and stocking of adult largemouth bass subsequently created a desirable fishery.

5. Stocking of adult and fry northern pike following reclamation provided a negligible fishery and poor reproduction and growth.

6. Re-introduction of largemouth bass fingerlings 31 days after chemical treatment was a failure.

7. Rotenone applied at 1 ppm successfully killed all northern pike, largemouth bass, pumpkinseed and perch. Species that survived treatment were mudminnow and black bullheads.

8. Standing crop of Spruce Lake, an infertile bog lake in northeastern Wisconsin was estimated at 125 pounds of fish per acre.

9. Fyke netting was the most successful method of capturing fish for marking; electrofishing with presently available equipment was unsuccessful in this soft water lake.

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