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IMPROVED ANGLING QUALITY FOLLOWING CHEMICAL TREATMENT OF NEBISH LAKE AND RE-INTRODUCTION OF SMALLMOUTH BASS AND YELLOW PERCH

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ABSTRACT

Angling quality, in terms of catch (number/acre), yield (lb/acre) and catch rate (number/100 angling hours), greatly improved following chemical treatment and restocking of Nebish Lake, Vilas County, in 1966. A 12-species fish population was eradicated and adults of only 2 species -- smallmouth bass (Micropterus dolomieui) and yellow perch (Perca flavescens) -- were re-introduced. Harvest statistics for a 12-year pretreatment period were compared to those of the 1st 4 years after treatment (transition period) and to those of the following 5 years (posttreatment period).

During the posttreatment period, the catch, yield, and catch/100 hours increased 209%, 105%, and 59%, respectively, as compared to the pretreatment period. While the game fish yield increased only 38%, the catch of game fish increased 256%.

From a species management perspective, improvement of angling quality for the smallmouth bass and yellow perch was phenomenal. The catch, yield, and catch rate of smallmouth bass rose from 2.6 to 15.3 fish/acre (488%), from 0.8 to 4.7 lb/acre (488%), and from 12.4 to 35.0 fish/100 hours (182%), respectively. Comparable percentage increases for the yellow perch were 263%, 244%, and 95%.

Although chemical treatment and restocking has long been an important fish management practice in Wisconsin, this study is the 1st to document fishing quality, as defined above, before and after the reclamation process.

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Department of Natural Resources • Madison, Wisconsin

INTRODUCTION

Chemical treatment and restocking of lakes has been a major facet of Wisconsin's fish management program since the 1st lakes were treated in 1941. However, evaluation of the practice in Wisconsin and elsewhere has been essentially limited to subjective observations. The literature pertaining to chemical reclamation is voluminous but, as stated by Lennon et al. (1970), "objective evaluations of subsequent management are conspicuously absent in much of the reclamation literature."

In failing to document the benefits accruing to the fisheries from chemical reclamation projects,, opportunities to advance our knowledge on what species combinations provide the best fishing were also foregone. Bennett (1944) concluded: "There is obviously a need for many careful experimental studies before a great deal will be known about the value of species combinations in fish management." That need has been echoed by others (Brasch 1957, Hooper et al. 1964, Klingbiel 1975) specifically with respect to introductions following chemical reclamation -- but the call has not been heeded.

A limited-species fish community was characteristic of many northern Wisconsin lakes prior to initiation of a major fish introduction program in the 1930's (Hile and Juday 1941). Nebish Lake, Vilas County, was one of those lakes. It originally supported a fish community of smallmouth bass, Micropterus dolomieui; rock bass, Ambloplites rupestris; and yellow perch, Perca flavescens. Schneberger (1935) reported that Nebish Lake also contained "a few minnows", but did not identify the species. Stocking of hatchery-reared fish and unrecorded or inadvertant transplantings from other waters, beginning in the late 1930's, converted the simple fish community to one containing numerous species. Walleye, Stizostedion vitreum vitreum, were 1st introduced in 1937; northern pike, Esox lucius, in 1939, and largemouth bass, Micropterus salmoides, in 1943. The early releases of walleye fry failed to establish a population, but a 1957 stocking of fingerlings was successful (Christenson and Kempinger, Wis. Dep. Nat. Resour., unpubl. data). Green sunfish, Lepomis cyanellus; pumpkinseed, Lepomis gibbosus; bluegill, Lepomis macrochirus; white sucker, Catostomus commersoni; black crappie, Pomoxis nigromaculatus, and black bullhead, Ictalurus melas, were probably introduced, but there are no stocking records for these species. The black crappie and black bullhead were last observed in Nebish Lake in 1951.

Nebish Lake was chemically treated in October 1966, to remove that warm water fish population composed of 12 species (Kempinger and Christenson 1978); complete eradication was achieved. In the spring of 1967, adults of 2 warm water species -- smallmouth bass and yellow perch -- were re-introduced. Both species were stocked prior to the spawning period and were protected by prohibition of angling throughout that year. The smallmouth bass and yellow perch were selected for re-introduction because they had been important members of the native fish community, and were popular in the regional sport fisheries. In addition, it was theorized that the smallmouth bass and yellow perch would occupy the littoral and pelagic zones, respectively, thus effectively partitioning the available fish habitat.

Rainbow trout, Salmo gairdneri, and brown trout, Salmo trutta, fingerlings were also stocked in 1967 (Brynildson and Kempinger 1973) to support an interim fishery while the warm water fish population was developing. They were also stocked in 1973 after the warm water fish community was established, but that release failed to survive (Avery 1975). Reference to trout in this report is made only where their presence had an effect on the angling data pertaining to the warm water population.

The success of a reclamation program should be measured in terms of quality of fishing produced (Lilliox and Pfeiffer 1960). The primary objective of this study was to test the hypothesis that angling quality -- in terms of weight and number of fish harvested and catch per unit effort -- can be enhanced by channeling productivity into 2, rather than several, fish species. Since complete angling records were available back to 1955, Nebish Lake was an excellent facility for testing that hypothesis. Another objective was to describe the development of that 2-species population following restocking, but that is the subject of another report (Kempinger et al. 1982).

STUDY AREA

Nebish Lake, 1 of the 5 lakes in the Northern Highland Fishery Research Area, is located on undeveloped, state-owned land in the Northern Highland State Forest in central Vilas County (Fig. 1). Access to the lake is provided at an unimproved boat landing with parking facilities for approximately 10 cars and boat trailers. The lake has a surface area of 94 acres, a shoreline of 3.2 miles, and a maximum depth of 50 ft. The bottom contour is irregular, with a sharp "dropoff" (Fig. 2) along most of the perimeter which limits the abundance of rooted aquatic plants.

The water is of seepage origin and is infertile, with a total alkalinity of 8-16 ppm. Other water quality characteristics are shown in Table 1. Fish species composition at the time of the chemical treatment consisted of 12 warm water species representing 5 families (Table 2). At that time, the standing crop was estimated to be 210.4 lb/acre (Table 2) (Kempinger and Christenson 1978).

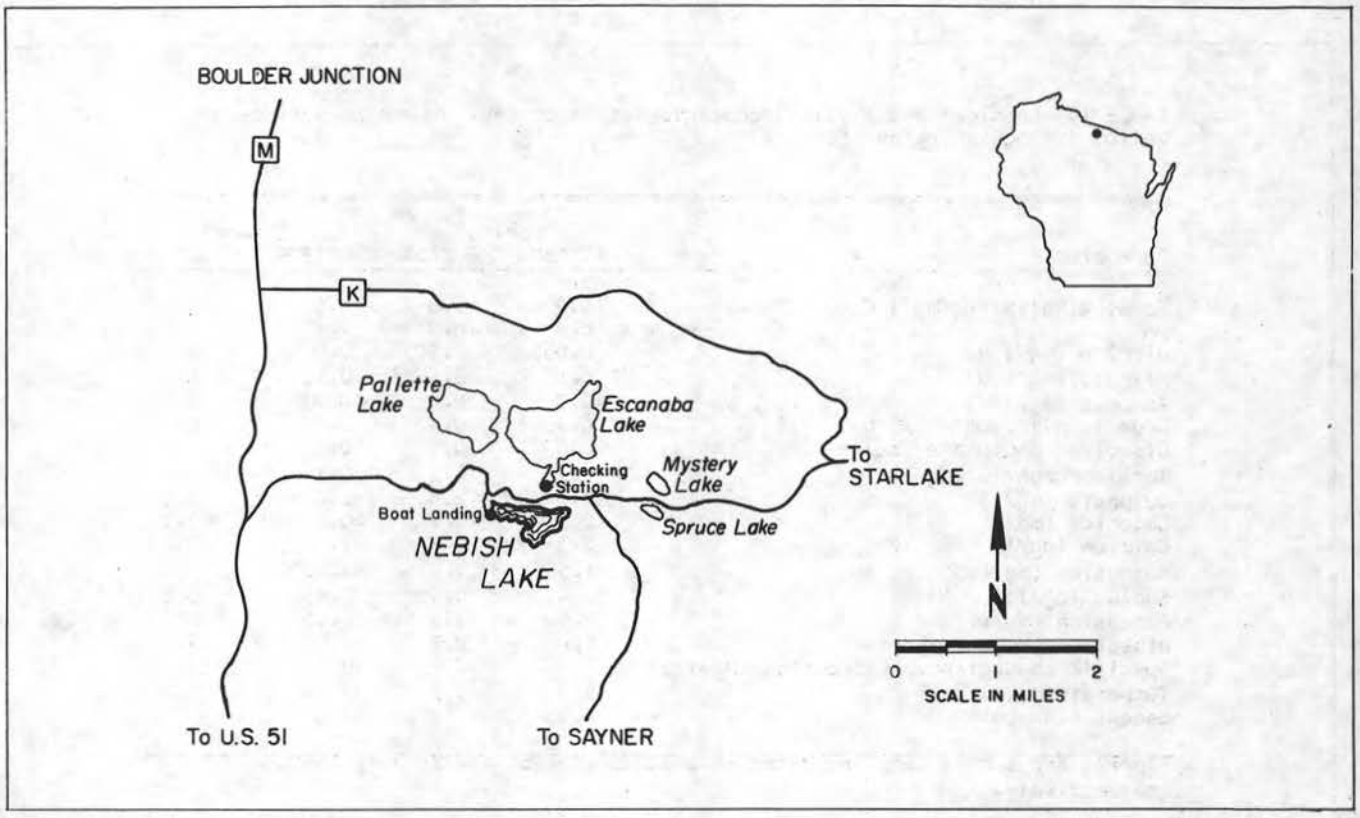

FIGURE 1. Location of Nebish Lake.

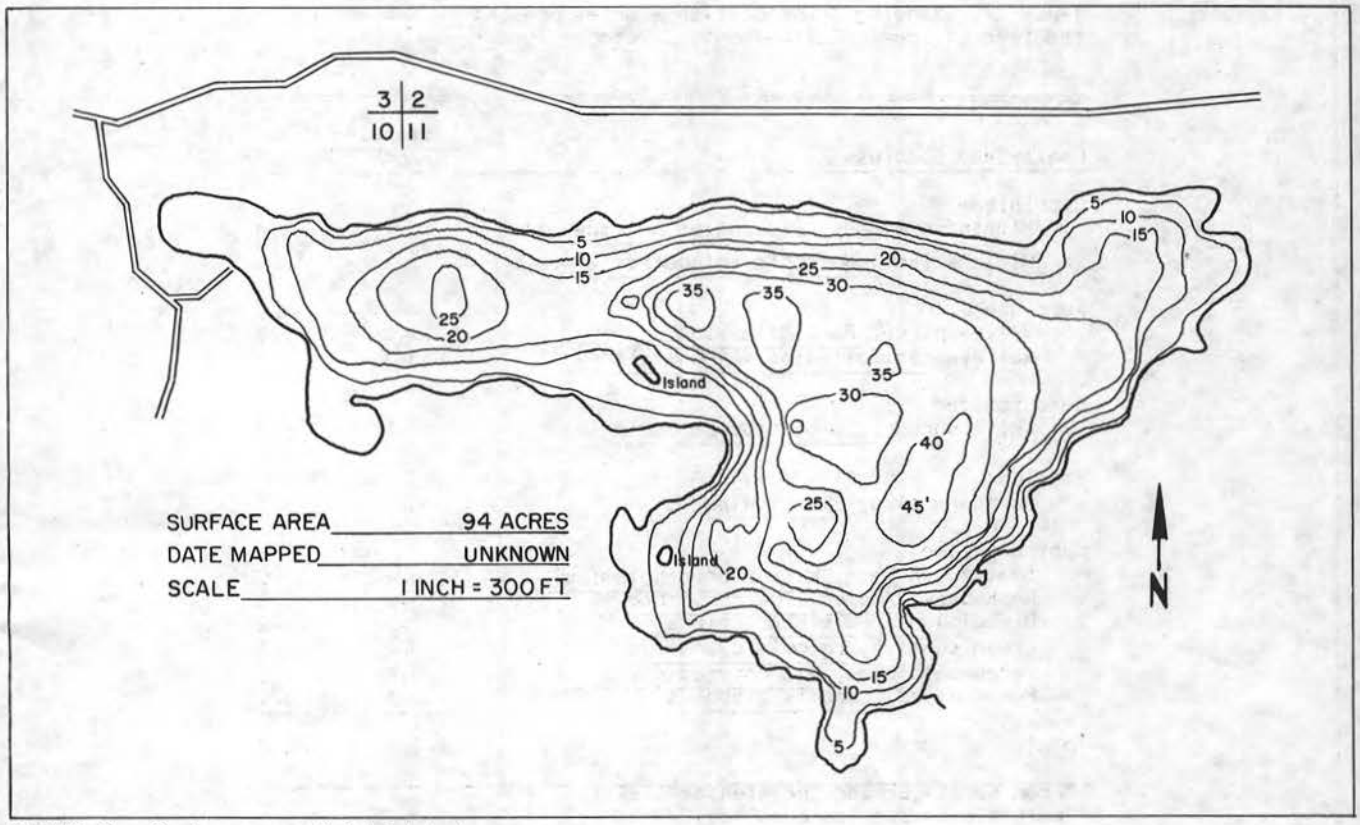

FIGURE 2. Contour map of Nebish Lake.

TABLE 1. Chemical and physical characteristics of Nebish Lake at surface and bottom during spring and summer.

Parameter	Spring*		Summer*	
	Surface	Bottom	Surface	Bottom
Total alkalinity (mg/l $CaCO_3$)	10.0	11.0	8.0	16
pH	6.9	6.8	7.1	6.1
Nitrite (mg/l N)	0.005	0.003	0.0	0.002
Nitrate (mg/l N)	0.1	0.1	<0.1	0.1
Ammonia (mg/l N)	0.0	0.0	<0.03	0.46
Organic nitrogen (mg/l N)	0.43	0.43	0.67	0.97
Dissolved phosphate (mg/l)	<0.03	0.0	0.0	0.07
Total phosphate (mg/l)	0.2	0.2	0.1	0.4
Sulphate (mg/l)	<2.0	<2.0	8.0	9.0
Chloride (mg/l)	<0.5	<0.5	<0.5	<0.5
Calcium (mg/l)	2.3	2.2	1.9	2.6
Magnesium (mg/l)	1.55	1.6	1.12	1.25
Sodium (mg/l)	0.42	0.45	0.45	0.55
Potassium (mg/l)	0.52	0.55	0.45	0.63
Dissolved oxygen (mg/l)	9.6	8.7	7.9	0.0
Specific conductance (micro mhos/cm at 25 C)	-	-	30	45
Temperature (C)	5.5	5.5	22.2	7.2
Secchi disk (m)	4.25		4.0	

*Spring and summer sampling dates were 28 April 1969 and 28 July 1969, respectively.

TABLE 2. Standing crops of fish species present in Nebish Lake at the time of chemical treatment, 3 October 1966.*

Family and Species	Standing Crop	
	Lb/Acre	Percent
Cyprinidae		
Bluntnose minnow, Pimephales notatus Mimic shiner, Notropis volucellus	135.2**	64.3**
Percidae		
Yellow perch, Perca flavescens	29.0	13.8
Walleye, Stizostedion vitreum vitreum	10.8	5.1
Catostomidae		
White sucker, Catostomus commersoni	13.1	6.2
Esocidae		
Northern pike, Esox lucius	6.5	3.1
Centrarchidae		
Smallmouth bass, Micropterus dolomieui	6.1	2.9
Rock bass, Ambloplites rupestris	5.9	2.8
Bluegill, Lepomis macrochirus	2.5	1.2
Green sunfish, Lepomis cyanellus	0.6	0.3
Largemouth bass, Micropterus salmoides	0.4	0.2
Pumpkinseed, Lepomis gibbosus	0.3	0.1
Total	210.4	100.0

*From Kempinger and Christenson (1978).
**Both minnow species combined.

METHODS

Angling records were obtained through a compulsory creel census. Permits were issued free of charge at a checking station located within 1 mile at Escanaba Lake. All fish caught* were inspected by Department personnel at the end of each angler's fishing trip. Various types of data were recorded, but we note here only those utilized in this report: (1) number of each species caught, (2) weight (to the nearest 0.01 lb) of all game fish and a representative sample of panfish, (3) number of anglers, and (4) number of hours fished. There was no closed fishing season, and neither a bag nor a size limit on warm water fish was in effect on Nebish Lake. The checking station was in operation every day of the year. There were 2 restrictions on fishing: (1) no permits were issued after 9:00 p.m. in summer and 6:00 p.m. in winter, and (2) use of fish as bait was prohibited after chemical treatment. Anglers arriving before the station opened in the morning (7:00 a.m.) filled out their own permits and returned permits after the station opened.

Each fishing year, except 1966, began and ended with the disappearance of ice cover, essentially from mid-April to mid-April; i.e., it included an open water season and the winter season immediately following. Nebish Lake was chemically treated on 3 October 1966; therefore, angling records for that year refer only to the open water season through 2 October.

Creel census data were tabulated for catch rate (number/100 hours of fishing), yield (lb/acre), and catch (number/acre). Checking station operations began in 1946, but data on weights of fish caught were incomplete for the 1946-54 period; we therefore chose 1955 as the initial year of the pretreatment study period (i.e., prior to chemical treatment) to facilitate comparison in this report. Means for each parameter were calculated for 3 time periods; (1) 1955-66 (pretreatment period), (2) 1968-71 (transition period when trout were present and the warm water fishery was being re-established), and (3) 1972-76 (posttreatment period representing the re-established warm water fishery).

To permit comparison of angling statistics beyond those made in this report, data on annual fishing pressure, total number of fish caught, and total number of fish caught/100 hours for the 1946-76 period are presented in Appendix Tables 1, 2, and 3, respectively; those for total pounds and pounds/acre harvested annually during the 1955-76 period are shown in Appendix Tables 4 and 5, respectively.

RESULTS

Changes in the quality of the fishery in terms of catch rate (number caught/100 hours of fishing effort), yield (pounds caught/acre), and catch (number caught/acre) are described below. All comparisons made under the Posttreatment Period subheading relate to pretreatment period data.

CATCH RATE (Number/100 hours)

Pretreatment Period

The average annual number of anglers fishing on Nebish Lake during the pretreatment period was 534 (Table 3). They fished an average of 2,022 hours/year -- an angling pressure of 22 hours/acre. They caught 82.4 fish/100 hours, of which game fish and panfish comprised 25% and 75%, respectively. Smallmouth bass and perch were caught at the rate of 12.4 and 49.4 fish/100 hours, respectively.

Transition Period

The number of anglers rose sharply during the transition period to an average of 1,477/year and fishing pressure increased from 22 to 58 hours/acre (Table 3). The combined catch rate of warm water game fish and panfish, now represented solely by smallmouth bass and perch, respectively, was 59.0 fish/100 hours. Both the increase in angling pressure and the decline in the combined warm water species catch rate are attributed to the presence of, and angler interest in, trout during the transition period. Nevertheless, the catch rates for smallmouth bass and perch alone approximated those of the pretreatment period.

Posttreatment Period

The number of anglers annually fishing Nebish Lake was twice that of the pretreatment period (1,097 vs. 534) and hours of fishing/acre also doubled (45 vs. 22) (Table 3). The catch rate of game fish and panfish combined rose 59%, from 82.4 to 131.3 fish/100 hours. The game fish catch/effort increased 70%, but for the smallmouth bass alone it rose 182%. The panfish catch rate increased 56% while that of yellow perch alone rose 95%.

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*All references to fish harvest in this report, whether to weight or number, pertain only to those fish caught and retained by anglers; fish caught and returned to the water were not recorded. The words "harvested" and "caught" are used interchangeably.

TABLE 3. Average annual fishing pressure and number of game fish and panfish caught/100 hours from Nebish Lake prior to and after chemical treatment.*

Species	Pretreatment Period (1955-66)	Transition Period (1968-71)	Posttreatment Period (1972-76)
Number of anglers/year	534	1,477	1,097
Number of hours fished/year	2,022	5,434	4,234
Number of hours/acre/year	22	58	45
Game fish caught/100 hours			
Smallmouth bass	12.4	12.5	35.0
Largemouth bass	2.5	0.0	0.0
Northern pike	1.3	0.0	0.0
Walleye	4.4	0.0	0.0
Total game fish	20.6	12.5	35.0
Panfish caught/100 hours			
Yellow perch	49.4	46.5	96.3
Rock bass	9.7	0.0	0.0
Bluegill	2.1	0.0	0.0
Miscellaneous**	0.6	0.0	0.0
Total panfish	61.8	46.5	96.3
Grand total fish caught/100 hours	82.4	59.0	131.3

*Excludes 353 brown and 869 rainbow trout caught during the 1968-71 transition period.
**Includes green sunfish and pumpkinseed.

TABLE 4. Average annual yield (in pounds/acre) of game fish and panfish from Nebish Lake prior to and after chemical treatment.*

Species	Pretreatment Period (1955-66)	Transition Period (1968-71)	Posttreatment Period (1972-76)
Game fish			
Smallmouth bass	0.8	2.3	4.7
Largemouth bass	0.4	0.0	0.0
Northern pike	1.1	0.0	0.0
Walleye	1.1	0.0	0.0
Total game fish	3.4	2.3	4.7
Panfish			
Yellow perch	2.5	4.6	8.6
Rock bass	0.5	0.0	0.0
Bluegill	0.1	0.0	0.0
Miscellaneous**	0.0	0.0	0.0
Total panfish	3.1	4.6	8.6
Grand Total	6.5	6.9	13.3

*Excludes the average annual yield of 4.6 lbs/acre of trout caught during the 1968-71 transition period.
**Includes green sunfish and pumpkinseed; less than 0.1 lb/acre was caught during the pretreatment period.

TABLE 5. Average annual catch (in numbers/acre) of game fish and panfish from Nebish Lake prior to and after chemical treatment.*

Species	Pretreatment Period (1955-66)	Transition Period (1968-71)	Posttreatment Period (1972-76)
Game fish			
Smallmouth bass	2.6	7.2	15.3
Largemouth bass	0.6	0.0	0.0
Northern pike	0.3	0.0	0.0
Walleye	0.8	0.0	0.0
Total game fish	4.3	7.2	15.3
Panfish			
Yellow perch	12.2	24.7	44.3
Rock bass	2.3	0.0	0.0
Bluegill	0.5	0.0	0.0
Miscellaneous**	0.1	0.0	0.0
Total panfish	15.1	24.7	44.3
Grand Total	19.3***	31.9	59.6

*Excludes the average annual catch of 3.1 trout/acre caught during the 1968-71 transition period.
**Includes green sunfish and pumpkinseed.
***Difference of 0.1 from sum of figures above due to rounding.

YIELD (Pounds/acre)

Pretreatment Period

The average annual yield to the angler was 6.5 lb/acre (Table 4), of which game fish and panfish comprised 52% and 48%, respectively. Northern pike and walleye contributed over half of the game fish weight in equal amounts, followed by the smallmouth bass and largemouth bass in that order.

Among the panfish, yellow perch accounted for 81% of the weight. The only other panfish species appreciably represented was the rock bass.

Transition Period

The combined average annual yield of game fish (now smallmouth bass only) and panfish (now yellow perch only) during the 4-year period following re-introduction rose only slightly, from 6.5 to 6.9 lb/acre (Table 4). Although the yield of smallmouth bass (2.3 lb/acre) was less than the combined pretreatment yield of game fish, it, nevertheless, approximated a 3-fold (188%) increase for that species alone. The yield of panfish rose 48% while that of perch alone increased 84%.

While the average total yields during the pretreatment and transition periods were approximately equal, it was the increase in perch during the latter period that off-set the reduction in game fish to bring the total transition period yield up to 6.9 lb/acre.

Posttreatment Period

The combined yield of game fish and panfish, now as in the transition period, represented only by smallmouth bass and yellow perch, rose from 6.5 lb/acre (pretreatment) to 13.3 lb/acre (Table 4), a gain of 105%. Substitution of the smallmouth bass as the sole game fish species for the pre-existing combination of walleyes, northern pike, and smallmouth and largemouth bass resulted in an increase in yield of game fish of only 38%, from 3.4 to 4.7 lb/acre.

While the yield of the game fish component exhibited only this modest increase from that of the pretreatment level, yield of smallmouth bass alone rose a phenomenal 488% (0.8 vs. 4.7 lb/acre).

The panfish yield was almost 3 times as great as that during the pretreatment period (3.1 vs. 8.6 lb/acre). The increase in yellow perch alone was 244%.

CATCH (Number/acre)

Pretreatment Period

The average annual catch of 19.3 fish/acre (Table 5) was dominated by panfish (78%), primarily perch. Among the game fish, the smallmouth bass was the most abundant species in the catch (60%), contrasting sharply with its representation in the game fish yield (24%).

Transition Period

The combined numerical harvest rose from 19.3 to 31.9 fish/acre during the transition period (Table 5). Appreciable gains were made in both the game fish and panfish categories -- 67% and 64%, respectively. The catch of smallmouth bass increased 177% while that of perch rose 102%, paralleling the increases in yield (lb/acre) of those species -- 188% and 84%, respectively.

Posttreatment Period

The harvest of game fish and panfish combined rose from the pretreatment level of 19.3 to 59.6 fish/acre, an increase of 209% (Table 5). The catch of game fish increased from 4.3 to 15.3 fish/acre (256%). Harvest of the smallmouth bass alone displayed, as it did in yield, a dramatic 6-fold increase (2.6 vs. 15.3 fish/acre).

The panfish catch exhibited a virtual 3-fold increase, paralleling the increase in yield, from 15.1 to 44.3 fish/acre, with that of the yellow perch alone rising 263%.

DISCUSSION AND MANAGEMENT IMPLICATIONS

The hypothesis that a re-introduced smallmouth bass - yellow perch population would provide a higher quality fishery in Nebish Lake -- in terms of yield to the angler (pounds/acre), catch (number/acre), and catch rate (number/100 hours) -- than the pre-existing multi-species fish population was substantiated. We recognize, but cannot evaluate within the limits of available data, the opportunity to catch different species of fish as a factor in angling quality.

TRANSITION PERIOD

The yield of warm water game fish declined and that of panfish rose with a net result of essentially no change, compared to pretreatment data, in the total yield (Table 6). However, the catches of warm water game fish, panfish, and species combined all increased more than 60%.

The abundance of walleyes and the atypical chronology of their appearance in the harvest during the 1955-66 period (Christenson and Kempinger, unpubl. data) accounted in large measure for the lower game fish yield during the transition period. Walleyes had been stocked as fingerlings in 1957, but did not enter the catch in appreciable numbers until 1963. By that time, they were all large fish, strongly influencing, along with their progeny, the pretreatment yield. They had been stocked to evaluate the effects of finclipping, not as an overt attempt to establish a walleye population in Nebish Lake where prospects for success were dim. They did, in fact, exhibit slow growth in later years and the population was dwindling by the time of chemical treatment. Had the walleye not been stocked, as would normally have been the case in a small soft water lake such as Nebish, it is unlikely that any compensatory increase of the other game fish species present would have occurred. The net result then would have been a lower pretreatment yield of game fish and a comparatively greater increase in the transition period yield.

The yield and the catch of both smallmouth bass and yellow perch increased sharply during the transition period. However, due to the marked increase in fishing pressure during that period, attributable to the presence of trout, the catch rate of the combined warm water species declined, from 82.4 to 59.0 fish/100 hours and those of smallmouth bass and perch remained essentially the same. Since we cannot separate angling pressure directed solely or primarily at trout, the catch rates cannot be included in an assessment of changes in the warm water fishery during the transition period. However, even though there was essentially no change in total yield, there was an appreciable increase in the catch of game fish and panfish, and a sharp increase in the catch of both smallmouth bass and yellow perch.

A 1-time stocking of trout after chemical treatment to provide an interim fishery while the warm water fish population is developing is a common practice in Wisconsin. Although the trout harvest did not bear directly on the objective of this study, its contribution to the fishery during the transition period was appreciable. The average annual yield of trout was 4.6 lb/acre, 35% greater than that of the pretreatment game fish yield. While the total pretreatment and transition period yields of warm water species were approximately the same, addition of trout resulted in a 77% increase during the transition period. Only in terms of catch/effort of all species combined did the trout fail to raise the transition period level above that of the pretreatment period.

The warm water fishery was favorably, but not dramatically, enhanced during the 4-year transition period. However, when viewed solely in terms of smallmouth bass and perch, a marked improvement in the quality of the fishery was evident.

TABLE 6. Comparative changes in catch rate, yield, and catch, in Nebish Lake, expressed as percent, between pretreatment levels and those of the transition and posttreatment periods.

Species	Pretreatment Period (1955-66)	Percent Change From Pretreatment Level: Transition Period (1968-71)	Percent Change From Pretreatment Level: Posttreatment Period (1972-76)
Number of anglers/year	534	+177	+105
Number of hours fished/year	2,022	+169	+109
Number of hours/acre/year	22	+164	+105
Catch Rate (Number/100 hours)			
Smallmouth bass	12.4	+1	+182
Total game fish*	20.6	-39	+70
Yellow perch	49.4	-6	+95
Total panfish	61.8	-25	+56
Grand total	82.4	-28	+59
Yield (Pounds/acre)			
Smallmouth bass	0.8	+188	+488
Total game fish*	3.4	-32	+38
Yellow perch	2.5	+84	+244
Total panfish	3.1	+48	+177
Grand total	6.5	+6	+105
Catch (Number/acre)			
Smallmouth bass	2.6	+177	+488
Total game fish*	4.3	+67	+256
Yellow perch	12.2	+102	+263
Total panfish	15.1	+64	+193
Grand total	19.3**	+65	+209

*Excludes rainbow and brown trout present only during 1968-71 transition period.
**Difference of 0.1 from sum of total game fish and panfish due to rounding.

POSTTREATMENT PERIOD

The changes in all 3 parameters listed, between the pretreatment and posttreatment periods, were positive, whether viewed in terms of species combined, separate game fish and panfish categories, or the target species alone -- smallmouth bass and yellow perch.

Yield, catch, and catch rate for species combined increased 105%, 209%, and 59%, respectively (Table 6). The lowest response in the above parameters for a single category of fish was the game fish yield -- only 38% -- due primarily to the strong influence of the transient walleye population present during part of the pretreatment period; but countering that was the 256% increase in the game fish catch where the numerical impact of the walleyes was less. From a species management perspective, enhancement of the fishing for smallmouth bass and yellow perch was much greater -- even phenomenal -- than that depicted above for the fish population as a whole. The yield, catch, and catch rate for smallmouth bass rose 488%, 488%, and 182%, respectively; comparable increases for yellow perch were 244%, 263%, and 95%.

We cannot explain the reasons for the major improvement in fishing quality reflected in the figures above, but some conjecture is in order. Only 2 species were stocked; Carlander (1955) reported that standing crops of given species were usually highest when only 1 or 2 species were present. The smallmouth bass and yellow perch were primary species in the pristine Nebish Lake fish population and thus were historically adapted to the environment and to each other. The absence of a large minnow population may have influenced fishing quality in that the reduced forage base increased the likelihood of fish biting. One of the characteristics of Illinois lakes that produced high angling yields was the absence of large populations of forage fish (Bennett 1944). Elimination of white suckers may have permitted an increase in the standing crop of perch (Johnson 1977) and an increase in smallmouth bass spawning success (Forbes 1981).

TABLE 7. Comparative catch, yield, and catch rate of all fish and smallmouth bass only from lakes* in northern Wisconsin with a maximum total alkalinity of 38 ppm.

Lake and County	Period	Acres	Angler Hours Per Acre	Alkalinity (ppm)	All Fish			Smallmouth Bass			Source
					No./Acre	Lb/Acre	No./100 Hours	No./Acre	Lb/Acre	No./100 Hours	
Nebish (Vilas Co.)	1972-76	94	45	8-16							Present Study
Game Fish					15	4.7	35				
Panfish					44	8.6	96				
Total					59	13.3	131	15.3	4.7	35	
Nebish	1946-49		15								Wis. DNR files
Game Fish					5	-	27				
Panfish					9	-	55				
Total					14	-	82	4.3	-	24	
Escanaba (Vilas Co.)	1946-69	293	65	20							Kempinger et al. 1975
Game Fish					11	9.4	16				
Panfish					44	10.3	67				
Total					55	19.7	84	0.6	0.3	1	
Escanaba	1946-47**		27								Kempinger et al. 1975
Game Fish					2	1.9	9				
Panfish					27	8.3	100				
Total					29	10.2	109	1.8	1.0	7	
Clear (Oneida Co.)	1974-75	846	17	10							Marinac 1976; Marinac-Sanders and Coble 1981
Game Fish					2	-	12				
Panfish					12	-	63				
Total					14	-	73	0.9	0.3	6	
Black Oak (Vilas Co.)	1970 (Jun-Aug)	522	19	38							Serns and McKnight 1974
Game Fish					3	-	16				
Panfish					11	-	59	0.6	-	3	
Total					14	-	74				
Laura (Vilas Co.)	1970 (Jun-Aug)	599	20	25							Serns and McKnight 1974
Game Fish					2	-	12				
Panfish					10	-	47				
Total					12	-	58	0.2	-	1	
Pallette (Vilas Co.)	1946-74	169	7	8-10							Wis. DNR files
Game Fish					-	-	-				
Panfish					-	-	-				
Total					-	1.4	-	—	0.5	28	

*Refers only to lakes in which smallmouth bass were recorded in the harvest.
**Before walleyes became dominant.

As noted earlier, objective evalutions of subsequent management are conspicuously absent in much of the reclamation literature. We were unable to locate a single reference containing pre- and post-reclamation data on any of the parameters employed in this study to assess changes in fishing quality.

In the absence of such data, we compared the posttreatment Nebish Lake angling statistics with those from 5 other waters in northern Wisconsin which contained smallmouth bass and had a maximum total alkalinity of 38 ppm (Table 7). Only the catch rate is discussed here because it is the most comparable of the 3 parameters, being the least influenced by angling pressure. The posttreatment Nebish Lake catch rate of game fish (smallmouth bass only) exceeded that of game fish species combined in 4 other lakes by a 2-5 fold. The catch rate of panfish (perch only) in Nebish Lake was also higher than that of panfish species combined in the same 4 lakes, as was the catch rate for game fish and panfish combined. It is to be noted, however, that the angling data for 3 of those 4 lakes are from summer creel censuses only, while those for Nebish Lake (and Escanaba Lake) are year-round. Since smallmouth bass are rarely caught in the winter, that limitation would not influence a comparison of catch rates for that species. The posttreatment catch rate of Nebish Lake smallmouth bass was 35/100 hours, only the catch rate for Pallette Lake, at 28/100 hours, approached that value. Prior to the establishment of the walleye population, Escanaba Lake was highly regarded for its smallmouth bass fishing (Kempinger et al. 1975). Yet for the period 1946-47, before walleyes became dominant and when only 51 were recorded in the catch, the catch rate of smallmouth bass was only 7/100 hours, 1/5 of that for Nebish Lake during the posttreatment period. Clear Lake, Oneida County, produced only 6 smallmouth bass/100 hours during 1974-75 (Marinac-Sanders and Coble 1981).

The smallmouth bass has seldom been introduced into Wisconsin lakes following chemical treatment. Of the 377 lakes treated (and including some that were re-treated) reported by Hacker (1976), smallmouth bass were stocked in only 12. The limited attention to smallmouth bass is also reflected in the paucity of data available on smallmouth bass populations and harvest (Wis. Dep. Nat. Resour. 1979). It is ironic that the report of the 1st chemical treatment in Wisconsin (O'Donnell 1943) recommended stocking of smallmouth bass in 2 of the 3 Bayfield County lakes involved. O'Donnell further recommended that only 2 species be stocked in 2 of the lakes and only 3 species in the other. The Nebish Lake case history suggests that chemical treatment and introduction of smallmouth bass and yellow perch, accompanied by a prohibition of the use of fish as bait, may greatly increase angling quality in small infertile lakes. This may apply in particular to lakes which historically contained a limited-species fish community and were subsequently stocked, purposely or inadvertently, with other species. The findings also suggest that trials with other 2-species combinations, with provision for objective evaluation, be made.

APPENDIX TABLE 1. Annual fishing pressure on Nebish Lake during the period, 1946-76.

Year	No. Anglers	No. Hours	Angler Hours/ Acre
1946	--	936	10
1947	--	1,370	14
1948	--	1,001	11
1949	--	2,496	26
1950	--	2,678	28
1951	--	2,922	31
1952	--	2,171	23
1953	--	1,516	16
1954	--	1,367	14
1955	411	1,734	18
1956	548	2,317	25
1957	568	2,466	26
1958	620	2,716	29
1959	673	2,650	28
1960	703	2,471	26
1961	524	1,754	19
1962	517	1,426	15
1963	429	1,563	17
1964	594	2,088	22
1965	458	1,576	17
1966	369	1,504	16
1967*			
1968	1,716	6,486	69
1969	1,976	7,332	78
1970	1,338	4,793	51
1971	879	3,123	33
1972	907	3,320	35
1973	1,034	4,087	43
1974	981	3,962	42
1975	1,222	4,616	49
1976	1,339	5,085	54

*Lake was chemically treated in the fall of 1966 and closed to fishing in 1967.

APPENDIX TABLE 2. Number of fish caught annually by angling in Nebish Lake during the period, 1946-76.

Year	Smallmouth Bass	Largemouth Bass	Northern Pike	Walleye*	Brown Trout**	Rainbow Trout**	Yellow Perch	Rock Bass	Bluegill	Misc.***
1946	110	14	1	--	--	--	368	52	9	21
1947	249	0	4	--	--	--	672	118	2	11
1948	273	33	2	--	--	--	342	176	3	3
1949	994	136	3	--	--	--	1,219	273	9	20
1950	358	71	22	--	--	--	576	289	34	6
1951	365	2	4	--	--	--	1,078	416	44	5
1952	164	6	28	--	--	--	346	163	30	7
1953	266	19	32	--	--	--	187	324	61	6
1954	87	17	26	--	--	--	144	468	38	6
1955	320	72	58	--	--	--	462	153	55	10
1956	270	131	36	--	--	--	1,337	445	109	18
1957	381	140	24	0	--	--	1,449	542	56	42
1958	216	164	27	0	--	--	1,994	293	46	18
1959	571	154	31	37	--	--	2,023	356	90	45
1960	169	31	10	10	--	--	4,633	176	28	7
1961	268	12	6	24	--	--	1,074	108	52	6
1962	350	2	28	15	--	--	518	252	52	9
1963	81	5	25	332	--	--	88	0	0	0
1964	202	3	17	224	--	--	90	164	17	2
1965	129	6	22	141	--	--	31	49	17	2
1966	173	1	12	107	--	--	47	8	4	1
1967[a]										
1968	272	--	--	--	192	750	1,123	--	--	--
1969	1,364	--	--	--	122	113	3,030	--	--	--
1970	620	--	--	--	31	6	3,327	--	--	--
1971	450	--	--	--	8	0	1,813	--	--	--
1972	1,617	--	--	--	1	0	1,918	--	--	--
1973	2,106	--	--	--	0	0	1,724	--	--	--
1974	808	--	--	--	0	1	4,708	--	--	--
1975	1,228	--	--	--	0	0	8,505	--	--	--
1976	1,420	--	--	--	0	0	3,981	--	--	--

*Fingerlings stocked in 1957.
**Fingerlings stocked in 1967; not present before that year.
***Includes pumpkinseed, green sunfish, black crappie, and black bullhead; the black crappie and black bullhead were last caught in 1951.
[a]Lake was chemically treated in the fall of 1966 and closed to fishing in 1967.

APPENDIX TABLE 3. Number of fish caught/100 hours annually by angling in Nebish Lake during the period, 1946-76.

Year	Smallmouth Bass	Largemouth Bass	Northern Pike	Walleye*	Brown Trout**	Rainbow Trout**	Yellow Perch	Rock Bass	Bluegill	Misc.***
1946	11.8	1.5	0.1	--	--	--	39.3	5.6	1.0	2.2
1947	18.2	0.0	0.3	--	--	--	49.0	8.6	0.1	0.8
1948	27.3	3.3	0.2	--	--	--	34.2	17.6	0.3	0.3
1949	39.8	5.4	0.1	--	--	--	48.8	10.9	0.4	0.8
1950	13.4	2.6	0.8	--	--	--	21.5	10.8	1.3	0.2
1951	12.5	0.1	0.1	--	--	--	36.9	14.2	1.5	0.2
1952	7.6	0.3	1.3	--	--	--	15.9	7.5	1.4	0.3
1953	17.5	1.2	2.1	--	--	--	12.3	21.4	4.0	0.4
1954	6.4	1.2	1.9	--	--	--	10.5	34.2	2.8	0.4
1955	18.4	4.2	3.3	--	--	--	26.6	8.8	3.2	0.6
1956	11.6	5.6	1.6	--	--	--	57.7	19.2	4.7	0.8
1957	15.4	5.7	1.0	0.0	--	--	58.8	22.0	2.3	1.7
1958	8.0	6.0	1.0	0.0	--	--	73.4	10.8	1.7	0.7
1959	14.0	5.8	1.2	1.4	--	--	76.3	13.4	3.4	1.7
1960	6.8	1.2	0.4	0.4	--	--	187.5	7.1	1.1	0.3
1961	15.3	0.7	0.3	1.4	--	--	61.2	6.2	3.0	0.3
1962	24.5	0.1	2.0	1.0	--	--	36.3	0.0	3.6	0.6
1963	5.2	0.3	1.6	21.2	--	--	5.6	0.0	0.0	0.0
1964	9.7	0.1	0.8	10.7	--	--	4.3	7.8	0.8	0.1
1965	8.2	0.4	1.4	8.9	--	--	2.0	3.1	1.1	0.1
1966	11.5	0.1	0.8	7.1	--	--	3.1	0.5	0.3	0.1
1967[a]										
1968	4.2	--	--	--	3.0	11.6	17.3	--	--	--
1969	18.6	--	--	--	1.7	1.5	41.3	--	--	--
1970	12.9	--	--	--	0.6	0.1	69.4	--	--	--
1971	14.4	--	--	--	0.2	0.0	58.0	--	--	--
1972	48.7	--	--	--	0.03	0.0	57.8	--	--	--
1973	51.5	--	--	--	0.0	0.0	42.2	--	--	--
1974	20.4	--	--	--	0.0	0.02	118.8	--	--	--
1975	26.6	--	--	--	0.0	0.0	184.2	--	--	--
1976	27.9	--	--	--	0.0	0.0	78.3	--	--	--

*Fingerlings stocked in 1957.
**Fingerlings stocked in 1967, not present before that year.
***Includes pumpkinseed, green sunfish, black crappie, and black bullhead; the black crappie and black bullhead were last caught in 1951.
[a]Lake was chemically treated in the fall of 1966 and closed to fishing in 1967.

APPENDIX TABLE 4. Pounds of fish caught annually by angling in Nebish Lake during the period, 1955-76.*

Year	Smallmouth Bass	Largemouth Bass	Northern Pike	Walleye**	Brown Trout***	Rainbow Trout***	Yellow Perch	Rock Bass	Bluegill	Misc.[a]
1955	106	43	260	--	--	--	55	28	13	2
1956	92	94	145	--	--	--	185	99	27	5
1957	86	75	102	0	--	--	196	123	13	9
1958	82	130	119	0	--	--	326	67	12	3
1959	83	64	158	24	--	--	370	77	18	8
1960	66	27	59	5	--	--	1,171	44	8	1
1961	67	7	31	22	--	--	301	29	12	1
1962	102	1	77	20	--	--	144	56	12	1
1963	34	7	92	473	--	--	27	4	0	0
1964	90	3	53	308	--	--	34	16	4	1
1965	51	7	71	212	--	--	10	15	4	1
1966	63	4	13	159	--	--	8	2	1	1
1967[b]										
1968	59	--	--	--	182	983	163	--	--	--
1969	365	--	--	--	200	257	667	--	--	--
1970	278	--	--	--	70	17	590	--	--	--
1971	158	--	--	--	24	0	300	--	--	--
1972	459	--	--	--	6	0	266	--	--	--
1973	568	--	--	--	0	0	227	--	--	--
1974	268	--	--	--	0	2	893	--	--	--
1975	371	--	--	--	0	0	1,716	--	--	--
1976	549	--	--	--	0	0	947	--	--	--

*Data on weights of fish harvested prior to 1955 are incomplete.
**Fingerlings stocked in 1957.
***Fingerlings stocked in 1967; not present before that year.
[a]Includes pumpkinseed, green sunfish, black crappie, and black bullhead; the black crappie and black bullhead were last caught in 1951.
[b]Lake was chemically treated in the fall of 1966 and closed to fishing in 1967.

APPENDIX TABLE 5. Pounds of fish/acre caught annually by angling in Nebish Lake during the period, 1955-76.*

Year	Smallmouth Bass	Largemouth Bass	Northern Pike	Walleye**	Brown Trout***	Rainbow Trout***	Yellow Perch	Rock Bass	Bluegill	Misc.[a]
1955	1.13	0.46	2.76	--	--	--	0.58	0.30	0.14	0.02
1956	0.98	1.00	1.54	--	--	--	1.97	1.05	0.29	0.05
1957	0.91	0.80	1.08	0.0	--	--	2.08	1.31	0.14	0.10
1958	0.87	1.38	1.26	0.0	--	--	3.47	0.71	0.13	0.03
1959	0.88	0.68	1.68	0.26	--	--	3.94	0.82	0.19	0.08
1960	0.70	0.29	0.63	0.05	--	--	12.46	0.47	0.08	0.01
1961	0.71	0.07	0.33	0.23	--	--	3.20	0.31	0.13	0.01
1962	1.08	0.01	0.82	0.21	--	--	1.53	0.60	0.13	0.01
1963	0.36	0.07	0.98	5.03	--	--	0.29	0.04	0.0	0.0
1964	0.96	0.03	0.56	3.28	--	--	0.36	0.17	0.04	0.01
1965	0.54	0.07	0.76	2.26	--	--	0.11	0.16	0.04	0.01
1966	0.67	0.04	0.14	1.69	--	--	0.08	0.02	0.01	0.01
1967[b]										
1968	0.63	--	--	--	1.94	10.46	1.73	--	--	--
1969	3.88	--	--	--	2.13	2.73	7.10	--	--	--
1970	2.96	--	--	--	0.74	0.18	6.28	--	--	--
1971	1.68	--	--	--	0.26	0.0	3.19	--	--	--
1972	4.67	--	--	--	0.06	0.0	2.83	--	--	--
1973	6.04	--	--	--	0.0	0.0	2.41	--	--	--
1974	2.85	--	--	--	0.0	0.02	9.50	--	--	--
1975	3.95	--	--	--	0.0	0.0	18.26	--	--	--
1976	5.84	--	--	--	0.0	0.0	10.07	--	--	--

*Data on weights of fish harvested prior to 1955 are incomplete.
**Fingerlings stocked in 1957.
***Fingerlings stocked in 1967; not present before that year.
[a]Includes pumpkinseed, green sunfish, black crappie, and black bullhead; the black crappie and black bullhead were last caught in 1951.
[b]Lake was chemically treated in the fall of 1966 and closed to fishing in 1967.

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