Population estimates and standing crops of fish in Nebish Lake. Report 96 1978

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POPULATION ESTIMATES AND STANDING CROPS OF FISH IN NEBISH LAKE

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ABSTRACT

Nebish Lake was treated with a fish toxicant 3 October 1966 to remove all fish and prepare the lake for a subsequent study of a re-introduced two-species fish population (smallmouth bass and yellow perch). Populations of each species were estimated and standing crop was calculated by the mark-and-recapture method.

The standing crop of fish was 210 lb/acre. Minnows alone made up 135 lb/acre and accounted for 64 percent of the total weight of all fish. The walleye was the major game fish species present, comprising 10.8 lb/acre and 5.1 percent of the total weight. The yellow perch was the primary panfish species, accounting for 29 lb/acre and 13.8 percent of the total weight.

The study is unique in that: (1) Nebish Lake was not a "problem lake", a type from which most of Wisconsin's standing crop data have originated, (2) the estimates are more detailed, by species and age or size interval, compared to available data on other waters, and (3) the estimate of the minnow population, found to be very high, is a "first" in Wisconsin.

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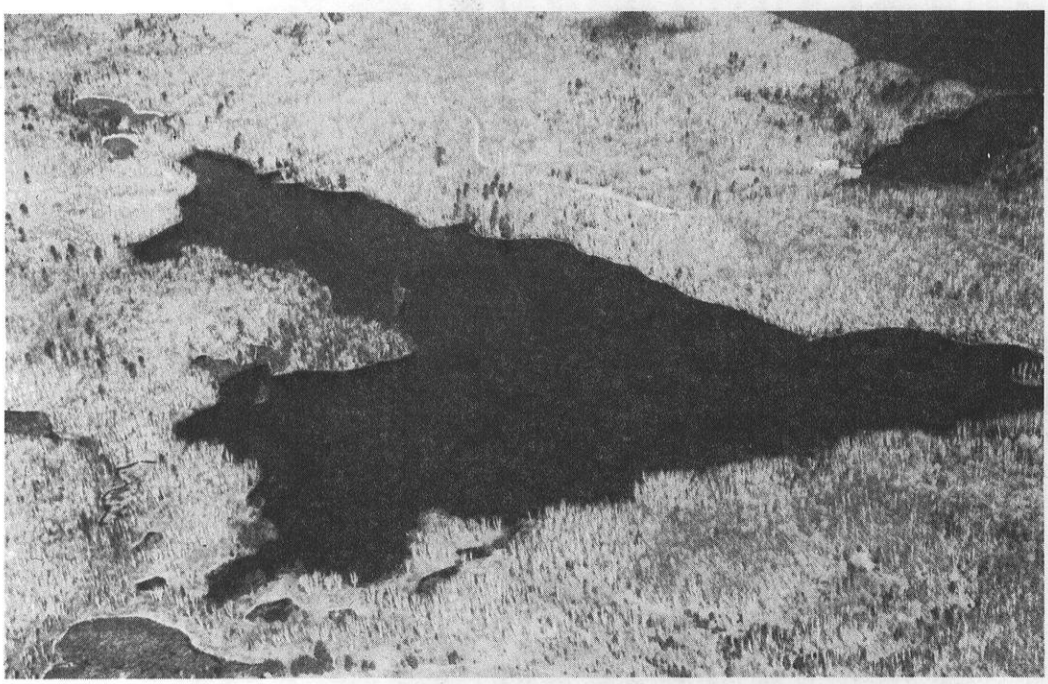


Nebish Lake.

INTRODUCTION

Although chemical reclamation of lakes is an established fish management practice in Wisconsin, quantitative documentation of the benefits has not been pursued. The obvious successes have supported program expansion and have observed the need for further study.

In an analysis of a fishery, the determination of the capability of a water to produce fish is of primary importance (Christenson and Smith 1965). Further, as Cooper (1952) has pointed out, any major advances in sport fishery management must be based on a knowledge of total fish populations. We have been remiss in failing to take advantage of the opportunities to extend our knowledge in both areas as an adjunct of the chemical reclamation program.

In only 10 of 126 complete reclamation projects undertaken between 1941, the year of Wisconsin's first such project, and 1968 have estimations of standing crop and species composition been made. Seven of these were made in the 1940's when study effort was limited and toxicant application techniques were themselves in a developmental stage. This is not to be critical of early efforts but merely to underscore the fact that our present knowledge of fish productivity of Wisconsin lakes, as indicated by standing crops, and of species composition of total fish populations rests in large measure upon limited and incomplete data.

Nebish Lake was chemically treated on 3 October 1966 to prepare the lake for study of the development and yield of a re-introduced two-species fish population--smallmouth bass, Micropterus dolomieui Lacepede, and yellow perch, Perca flavescens (Mitchill). Advantage was taken of this opportunity to determine the standing crop and species and age composition of the fish population. Collectively these two objectives seek to lessen the gap in areas of knowledge referred to above--(1) fish productivity and total fish populations, and (2) quantitative documentation of the benefits of chemical reclamation and an associated re-stocking program. This paper is concerned only with the former.

Most of the reports in the literature on standing crops and species composition, as determined by chemical treatment, refer to problem waters and are not typical of normal conditions (Solman 1950). Certainly that applies to the treated lakes of Wisconsin on which reports have been published. It is to be noted, then, that Nebish Lake was not a problem lake from the management viewpoint, and that as a designated research facility, it was chemically treated to meet a research need.

DESCRIPTION AND HISTORY OF NEBISH LAKE

Nebish Lake, Vilas County is one of the five lakes in Northern Highland Fishery Research Area (Fig. 1). Access to the lake is provided by an unimproved boat landing with parking facilities for 10 cars and boat trailers. The lake has 2.6 miles of irregular state-owned shoreline, is 94 acres in size, contains 1,731 acre-ft of water and has a maximum depth of 50 ft. The bottom contour (Fig. 2) is irregular with a sharp descent from shore which creates a narrow littoral zone.

The water is of seepage origin and is infertile, having a total alkalinity of 15-19 ppm (surface). Physical-chemical features of the lake at various depths showing seasonal variation between summer stagnation and fall overturn are presented in Table 1. Detailed water chemistries are listed in Table 2.

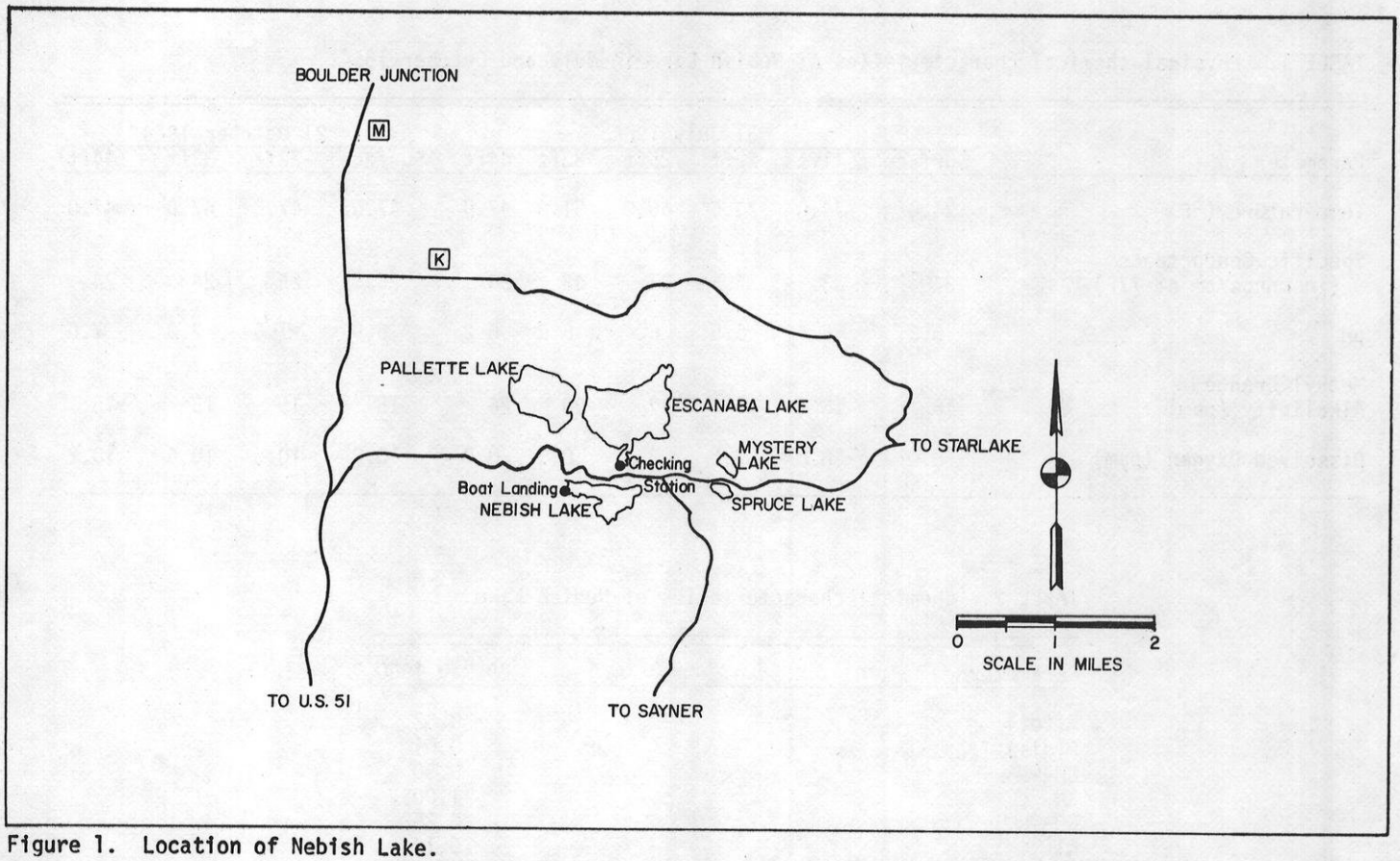


Figure 1. Location of Nebish Lake.

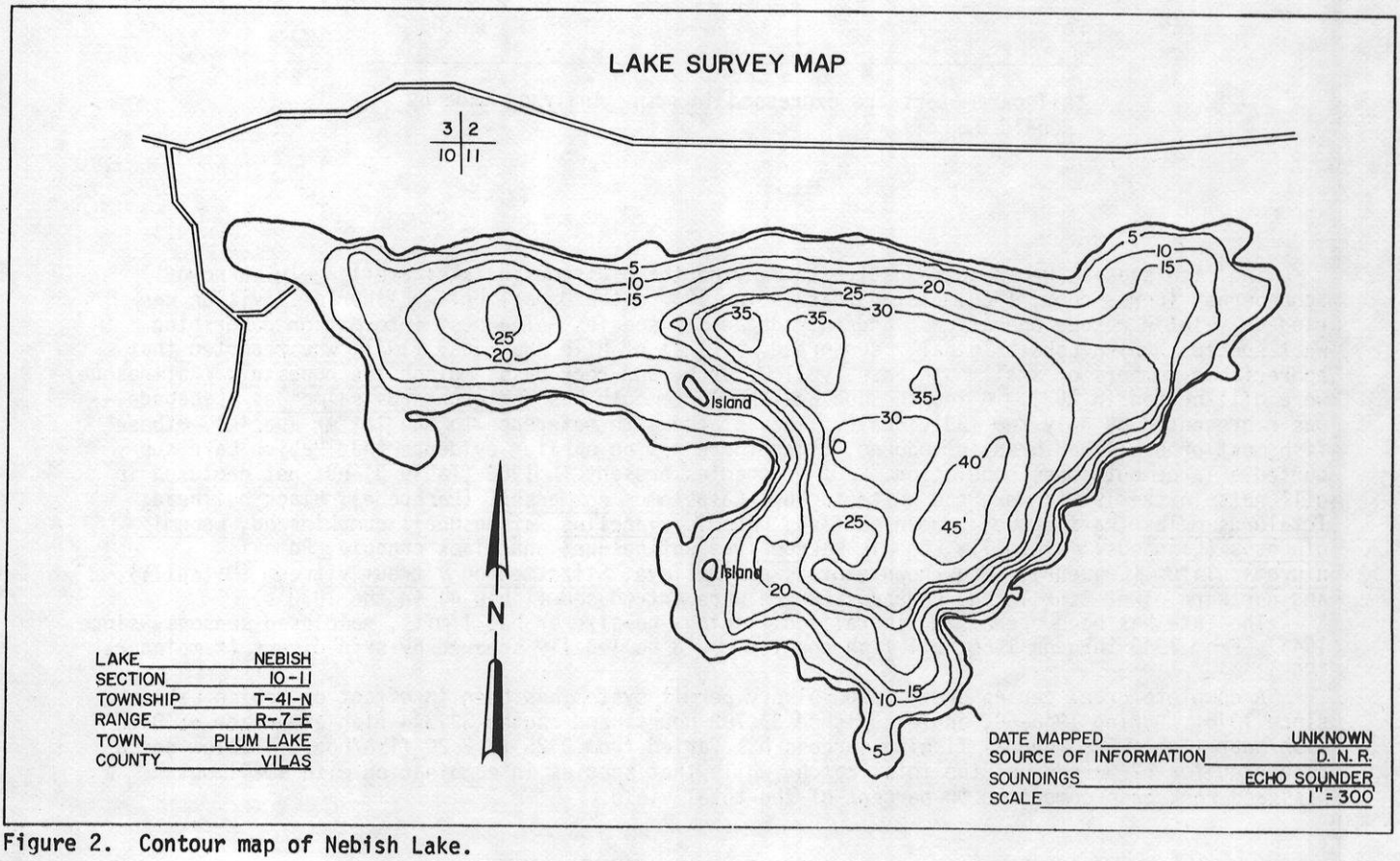


Figure 2. Contour map of Nebish Lake.

TABLE 1. Physical-chemical characteristics of Nebish Lake in July and October 1964.

Parameter	31 July 1964						21 October 1964			
	Surface	11ft	22ft	25ft	33ft	44ft	Surface	22ft	33ft	44ft
Temperature (^{O}F)	74.0	74.0	70.5	65.0	51.0	47.0	47.0	47.0	47.0	47.0
Specific Conductance (in mnhos/cm at 77F)	34	33	34	37	42	54	25	25	24	24
pH	6.2	6.4	6.5	6.4	6.2	6.2	6.9	7.0	7.0	7.0
Methyl Orange Alkalinity (ppm)	16	16	16	17	20	26	15	15	15	15
Dissolved Oxygen (ppm)	8.0	8.0	7.8	3.7	0.3	0.0	10.2	10.6	10.6	10.2

TABLE 2. Chemical characteristics of Nebish Lake.

Parameter*	20 May 1960
P(tot)	0.02
P(dis)	0.01
NH_3-N	0.50
KN	1.00
NO_3-N	0.25
Cl	0.10
SO_4	1.00
Ca	1.00
Mg	1.50
Na	0.90
K	0.20
Fe	0.06

*All parameters are expressed in ppm. Analyses made by Ronald J. Poff.

The fish species known to be native to many northern Wisconsin lakes are largely unknown. Schneberger (pers. comm. 1968) stated that in the 1930's the Department's Fisheries Division carried on "winter rescue operations" and introduced new species. The best information describing what species Nebish Lake originally supported was that of Hile and Juday (1941) who reported that appreciable numbers of smallmouth bass, yellow perch, and rock bass Amblophites rupestris (Rafinesque) were gill-netted in 1932. A fourth species--the largemouth bass, Micropterus salmoides (Lacepede)--was represented by only two individuals. They stated with reference to the latter species, "these fish most probably had been introduced, since there was no earlier evidence that Nebish Lake supported a largemouth bass population." Other species present in 1966 (Table 3) but not captured in gill nets in the 1930's were the white sucker, Catostomus commersoni (Lacepede); black bullhead, Ictalurus melas (Rafinesque); green sunfish, Lepomis cyanellus Rafinesque); pumpkinseed, Lepomis gibbosus (Linnaeus); bluegill, Lepomis macrochirus Rafinesque; and black crappie, Pomoxis nigromaculatus (Lesueur). The known exotics are walleye, Stizostedion vitreum vitreum (Mitchill), and northern pike, Esox lucius Linnaeus, which were introduced (Table 4) in the 1930's.

The lake has been opened to liberalized fishing--no size or bag limits, no closed seasons--since 1946. From 1946 through 1966, all fish species could be legally speared by skin divers (Kempinger 1968).

A complete creel census under a compulsory permit system has been in effect on Nebish Lake since 1946. During 1946-66, anglers fished 39,702 hours, and caught 32,374 fish at a rate of 0.82 fish/hour (Table 5). Annual fishing success has varied from 0.25 to 2.20 fish/hour. Yellow perch accounted for 57 percent of the total catch, while that species in combination with smallmouth bass and rock bass comprised 90 percent of the total yield.

TABLE 3. History of fish species present at the time of chemical treatment.

Species	Native	Unknown	Probably Introduced
ESOCIDAE - PIKE			
Northern pike, Esox lucius Linnaeus			X
CYPRINIDAE - MINNOWS AND CARP			
Bluntnose minnow, Pimephales notatus (Rafinesque)		X	
Mimic shiner, Notropis volucellus (Cope)		X	
CATOSTOMIDAE - SUCKER			
White sucker, Catostomus commersoni (Lacepede)			X
ICTALURIDAE - FRESHWATER CATFISH			
Black bullhead, Ictalurus melas (Rafinesque)			X
CENTRARCHIDAE - SUNFISH			
Smallmouth bass, Micropterus dolomieui Lacepede	X		
Largemouth bass, Micropterus salmoides (Lacepede)			X
Green sunfish, Lepomis cyanellus Rafinesque			X
Pumpkinseed, Lepomis gibbosus (Linnaeus)			X
Bluegill, Lepomis macrochirus Rafinesque			X
Rock bass, Ambloplites rupestris (Rafinesque)	X		
Black crappie, Pomoxis nigromaculatus (Lesueur)			X
PERCIDAE - PERCH			
Yellow perch, Perca flavescens (Mitchill)	X		
Walleye, Stizostedion vitreum vitreum (Mitchill)			X

TABLE 4. Records of fish stocked in Nebish Lake.

Species	Number	Age	Year
Walleye	95,000	Fry	1937
Northern pike	100,000	Fry	1939
Walleye	300,000	Fry	1941
Largemouth bass	1,000	Fingerling	1943
Largemouth bass	950	Fingerling	1944
Largemouth bass	300	Fingerling	1945
Walleye	9,534	Fingerling	1957
Northern pike	525	Fingerling	1962
Northern pike	502	Fingerling	1963

TABLE 5. Number of fish caught and percent of total harvest, 1946-66.

Species	For all Seasons, 1946-66		For 1966 Fishing Season	
	Number	Percent	Number	Percent
Yellow perch	18,526	57	47	14
Smallmouth bass	5,731	18	169	49
Rock bass	4,800	15	8	2
Largemouth bass	1,014	3	1	--
Walleye	889	3	107	31
Bluegill	737	2	4	1
Northern pike	418	1	12	3
Miscellaneous species*	259	1	1	--
TOTAL	32,374	100	349	100

*Includes black bullhead, green sunfish, pumpkinseed, and black crappie. The last black bullheads and black crappies were recorded in 1951; thus in all probability, these 2 species had disappeared prior to 1966.

METHODS AND MATERIALS

Pre-treatment Period

On 29 April 1966, the first day of open water, six 4-ft fyke nets (1-inch square mesh) were set to capture and mark adult walleyes. All walleyes captured were measured, scales were obtained for aging, and those fish 11.5 inches and over in total length were marked with Monel jaw tags. While these fish were originally marked for a different reason, they also served our purpose here in that all tagged walleyes that remained in the population after the 1966 fishing season, i.e., the number marked minus the recorded catch, were used to estimate the population of these fish on the date of chemical treatment. The validity of this approach will be discussed in a later section.

In September, fyke nets and a 230-volt, 3000-watt AC boom shocker were employed to capture Age 0 walleyes and smallmouth bass and Age I and older northern pike, smallmouth bass, largemouth bass, white sucker, and the several panfish species present. All fish were marked by fin-clipping.

Two weeks prior to treatment, yellow perch fingerlings were captured with a 75-ft small mesh seine. They were also marked by fin-clipping.

Seining and marking of minnows was discontinued when initial efforts resulted in a high mortality, precluding the possibility of subsequently estimating the minnow population by the mark-and-recapture method. However, the seine samples provided the ratio of minnows to fingerling perch which was later employed to estimate the minnow population.

Chemical Application

Nebish Lake was treated with 550 gallons or approximately 1 ppm of emulsifiable rotenone (Pro-noxfish) on 3 October 1966. (This chemical was manufactured by the S. B. Penick Co., New York.) Water temperature at the time of treatment was 56°F at the surface, 55°F at 38 ft, 50°F at 39 ft, and 48°F at 45 ft. The chemical was dispersed by means of outborad motor-activated boat balers. Test fish were placed in live cages in the lake one week after treatment to determine if the lake was still toxic.

Post-treatment Period

Fish were collected and processed immediately after treatment. All fish except minnows and those sizes of certain species which had not been marked were examined for tags (walleyes only) and for fin clips. All walleyes, largemouth bass, northern pike, and white suckers were measured and weighed. Total counts and bulk weights by species listed as follows were recorded and representative samples of each size group of smallmouth bass, age I and over yellow perch, pumpkinseed, bluegill, green sunfish, and rock bass were measured and weighed and scale samples were taken for aging. Minnows and yellow perch fingerlings were counted and weighed separately in bulk.

Population estimates for each species except the minnows were made by the mark-and-recapture method employing the following formula:

$$P = \frac{M\,(R+U)}{R}$$

Where: P = estimated population, M = number of fish marked prior to chemical treatment, R = number of marked fish recovered after treatment, and U = number of unmarked fish recovered after treatment.

Where no fish had been marked or where no marked fish were recovered, estimates were based on percentage recovery rates of other groups, as follows: (1) estimates of Age Group I and II walleyes were based on the recovery rate (55 percent) of Age Group III and older walleyes, (2) estimates of smallmouth bass 9.0 inches and over were based on the recovery rate (30 percent) of smallmouth bass in the 7.3- to 8.9-inch group, and (3) estimates of white suckers were based on the average recovery rate (21 percent) of all species of Age Group I and older.

The minnow population was estimated by applying the numerical ratio of minnows to yellow perch fingerlings (11:1), as determined from pre-treatment seine hauls, to the estimated perch fingerling population.

EFFECTIVENESS OF CHEMICAL TREATMENT

One week after treatment all fish which were placed in the lake in cages died within a 24-hour period. Netting and shocking during the spring of 1967 yielded no fish and subsequent sampling disclosed no species other than those re-introduced. These observations support the contention that a complete kill of all fish was achieved.

POPULATION ESTIMATES AND STANDING CROPS

Population estimates by species and by age group or size interval are shown in Table 6. These estimates do not include the numbers of smallmouth bass, yellow perch or minnows removed immediately prior to chemical treatment.

Standing crops are presented by species and by age group or size interval in Table 7, expressed as numbers and pounds per acre. Those figures do include the numbers and weights of fish removed immediately prior to chemical treatment.

TABLE 6. Population estimates based on marked fish recovered in Nebish Lake after chemical treatment (does not include fish removed immediately prior to treatment).

Species and Age Group or Size[1]	No. Fish Marked	No. Unmarked Fish Recovered	No. Marked Fish Recaptured	Recovery Rate (in Percent)[2]	Population Estimate
Walleye					
0	75	172	19	25.0	754
I	0	118		(55.0)	216
II	0	18		(55.0)	33
III> [3]	132	215	73	55.0	521
Sub-total	207	523	92		1,524
Smallmouth bass					
0	128	527	3	2.3	22,613
4.3-7.2 inches	149	197	33	22.0	1,038
7.3-8.9 inches	72	56	22	30.0	255
9.0-17.7 inches	0	28		(30.0)	100
Sub-total	349	808	58		24,006
Northern pike					
9.6-29.2 inches	48	100	8	17.0	648
Yellow perch					
0	2,250	2,002	16	0.8	283,781
I	508	1,332	85	17.0	8,469
II>	47	133	18	38.0	394
Sub-total	2,815	3,467	119		292,644
Rock bass					
I	108	150	4	4.0	4,158
II	258	178	62	24.0	999
III>	68	63	31	46.0	206
Sub-total	434	391	97		5,363
Bluegill					
I	78	172	5	6.0	2,761
II>	710	339	185	26.0	2,011
Sub-total	788	511	190		4,772
Pumpkinseed					
I	86	25	12	16.0	234
II>	107	39	30	28.0	246
Sub-total	183	64	42		480
Green sunfish	27	79	2	7.0	1,094
Largemouth bass	4	6	1	25.0	28
White sucker	7	98	0	(21.0)	466
Minnows	0	37,250			3,121,591[4]

[1]Where age or length (total length) is not indicated, refers to Age I and above.

[2]Assumed recovery rates employed in population estimations are shown in parentheses (see text for explanation).

[3]Population estimate based on number of fish tagged in the spring of 1966 minus the number of tagged fish recorded through the creel census (see text for explanation).

[4]Based on minnow:perch fingerling ratio of 11:1 (see text for explanation).

TABLE 7. Standing crop of fish in Nebish Lake, 3 October 1966.

Species and Age Group or Size[1]	Number per Acre	Pounds per Acre	Percentage of Total Weight
Walleyes			
0	7.9	0.9	
I	2.3	0.9	
II	0.3	0.3	
III >	5.5	8.7	
	16.0	10.8	5.1
Smallmouth bass			
0	238.0	3.1	
4.3-7.2 inches	10.9	0.9	
7.3-8.9 inches	2.7	0.7	
9.0-17.9 inches	1.1	0.9	
I>[2]	1.6	0.5	
	254.3	6.1	2.9
Yellow perch			
0[2]	3,034.5	24.0	
I >	93.2	5.0	
	3,127.7	29.0	13.8
Northern pike			
9.6-29.2 inches	6.8	6.5	3.1
Rock bass	56.5	5.9	2.8
Bluegill	50.2	2.5	1.2
Pumpkinseed	5.1	0.3	0.1
Green sunfish	11.5	0.6	0.3
Largemouth bass	0.3	0.4	0.2
White sucker	0.9	13.1	6.2
Sub-total	3,533.3	75.2	35.7
Minnows[2]	33,801	135.2	64.3
Grand Total	37,334.3	210.4	100.0

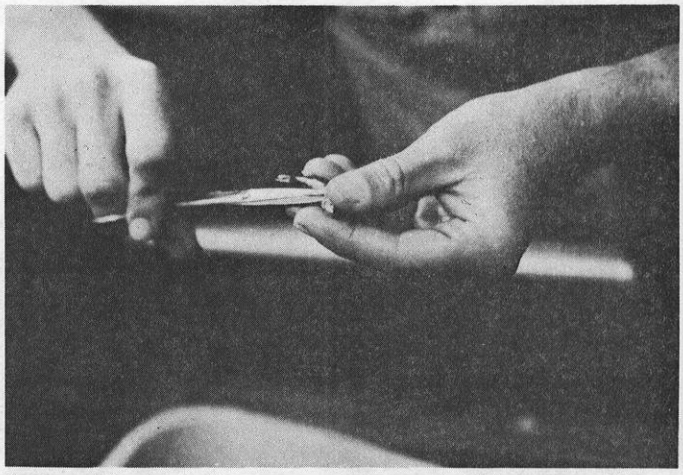
[1]Where age group or length is not indicated, refers to Age I and above. Length ranges (total length) are shown for species not aged.

[2]Includes minnows (89,500; 358 lb), yellow perch (4,500; 36 lb) and smallmouth bass (150; 47 lb) which were removed from the lake immediately prior to chemical treatment.

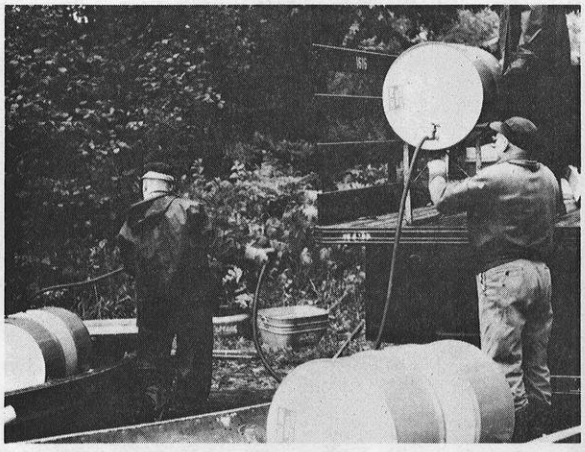
The standing crop of fish in Nebish Lake on 3 October 1966 was estimated to be 210.4 lb/acre. Two species of minnows, the bluntnose minnow and the mimic shiner, collectively dominated the population in terms of both number and weight, comprising 135.2 lb/acre and 64.3 percent of the total weight of all fish. (Total weight as used here refers to the total weight of all species, including that of smallmouth bass, yellow perch, and minnows removed immediately prior to chemical treatment.) The walleye, at 10.8 lb/acre, was the major game fish species and comprised 5.1 percent of the total weight. The yellow perch was the primary panfish species, accounting for 29.0 lb/acre and 13.8 percent of the total weight.

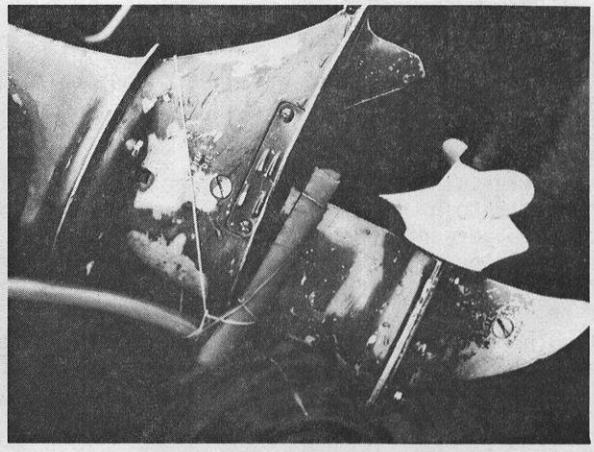
Limitations of the data preclude a detailed analysis but some discussion of the major species present is warranted.

Fyke nets (left) and boom shocking equipment (right) were used to capture fish which were later marked and released.



Here a fin is being removed to mark this fingerling.





The 550 gallons of rotenone used to treat the lake were siphoned from barrels in a truck (left) into containers in boats, from which the chemical was dispersed by means of boat balers (right).

Walleye

The walleye population was estimated to be 1,524, or 16 fish/acre, over one-third of which were Age III or older. With 95 percent confidence limits, the population (521) of Age III and older walleyes ranged from 435-650. With a standing crop of 10.8 lb/acre, 80 percent of which was contributed by Age III and older fish, the walleye accounted for 5.1 percent of the total weight.

As stated previously the estimate of Age III and older walleyes is based upon a known number of fish marked in the spring of 1966 minus the recorded catch of marked fish. Under the compulsory creel census system, full creditability is ascribed to the angling mortality records; however, the extent of natural mortality of this segment of the population must be based upon assumption. Acceptance of the assumed zero natural mortality of tagged walleyes between spring and fall employed in the estimate is predicated on two facts: (1) research findings from many years of study of the walleye in nearby Escanaba Lake that natural mortality of Age III fish and older is low (unpubl.), and (2) the recovery rate (55 percent) of the assumed number of tagged walleyes present was much higher than the average (21 percent) of all species and considerably higher than that of even just the large size groups of all other species.

Smallmouth Bass

The smallmouth bass population was estimated to be 24,006. However, this estimated total is open to question since it is so strongly influenced by the Age Group 0 estimate (94 percent) which was based upon a very low return of marked fish. More reliably, the estimates by size ranges 4.3-7.2, 7.3-8.9 inches, and 9.0 inches and over, approximating Age Groups I, II, and III and over, respectively, were 1,038, 255, and 250, or 10.9, 2.7, and 2.6 fish/acre, respectively. The standing crop was 6.1 lb/acre, or 2.9 percent of the total weight.

Northern Pike

The estimate for all sizes combined was 648, or 6.8 fish/acre. With 95 percent confidence limits, the population (156) of northern pike 17 inches and larger ranged from 100-328. At 6.5 lb/acre, the northern pike comprised 3.1 percent of the total weight.

Yellow Perch

The yellow perch population estimate was 292,644, but as in the case of smallmouth bass, the strong influence of Age Group 0 (97 percent), based on a low return of marked fish, affects the accuracy of that figure. The population included 8,469 and 394 fish of Age Groups I and II and over, respectively, which collectively represented 93.4 fish/acre. Exceeded only by the minnow component, the standing crop of yellow perch was 29.0 lb/acre and accounted for 13.8 percent of the total weight.

Rock Bass

The rock bass population of Age Group I and older was estimated to be 5,363, or 56.5 fish/acre. The high returns of marked fish lend credence to the values of 10.5 and 2.2 fish of Age Groups II and III and older per acre, respectively. Although numerically less, the standing crop of Age Group I and older, at 5.9 lb/acre, exceeded that of the yellow perch (5.0) for comparable age groups. Age Group I and older accounted for 2.8 percent of the total weight.

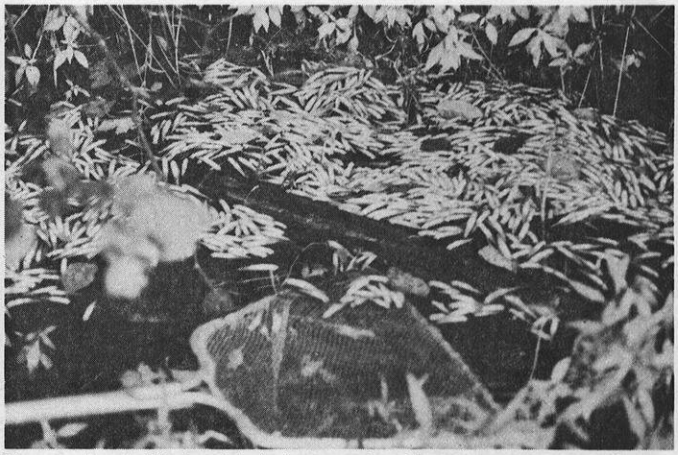
Minnows

Minnows were by far the most abundant component of the fish population in terms of both number and weight. The estimate approximated 34,000 fish and 135 lb/acre and accounted for 64.3 percent of the total weight.

The numerical estimate was based upon the ratio of minnows to Age Group 0 yellow perch (11:1) observed in seine hauls made prior to chemical treatment, i.e., the minnow population was calculated to be 11 times greater than the fingerling yellow perch population. This assumes that dispersal of both species throughout the lake was the same as in the areas seined and that both were equally vulnerable to capture; both assumptions are open to question. Compounding the problem is the estimate of Age Group 0 yellow perch which is based on a return of only 16 fish of 2,250 marked (0.8 percent) prior to chemical treatment.

Lending credence to the estimate is the 18:1 minnow to Age Group 0 yellow perch ratio observed in the collection following treatment. The assumption of uniform dispersal referred to above would be less of a factor here, but the assumption of equal flotation and visibility--in effect equal vulnerability to capture--would be a major consideration. Since the latter assumption appeared to be less tenable than its counterpart above, the 18:1 ratio was rejected as a basis for estimation.

Here dead fish recovered after chemical treatment are being sorted as to species and examined for marks.



These dead fish which began to float to the surface immediately after treatment are minnows-- the major component of the standing crop in Nebish Lake.

This attempt to estimate a minnow population is clearly a pioneering effort in Wisconsin waters. Lacking other reference points, an estimate as high as 34,000 minnows and 135 lb/acre might well be viewed with suspicion. However, data on minnow harvest from stocked rearing ponds, although not directly comparable, support the estimates at least as "ball park" figures. Cooper (1935) reported a harvest of 100,000 (50 lb) bluntnose and fathead minnows/acre from a Michigan gravel pit pond of very low fertility. The bluntnose minnow has been propagated in another Michigan pond in excess of 100,000/acre (Cooper 1936). Yield of 200,000 fathead minnows (328 lb) per acre in Michigan rearing ponds has also been reported by Cooper (1936). Yield of 21-40,000 bluntnose minnows and 65,000 fathead minnows per acre from Wisconsin rearing ponds was cited by Dobie, Meehean, and Washburn (1948); they also reported yields of 25-32,000 fathead minnows and 180,000 bluntnose minnows per acre from Minnesota rearing ponds.

While the accuracy of the minnow estimate is open to question, establishment of the fact that a very high minnow population was present is not. Assessment of the minnow population in other chemically treated Wisconsin waters was virtually ignored. Accordingly, this minnow estimate is significant not only in relation to its magnitude but as an essentially initial contribution to our knowledge of the minnow component in a mixed warm water fish population.

MANAGEMENT IMPLICATIONS

As previously noted, data on fish population estimates and standing crops in Wisconsin are essentially limited to those from "problem waters" and, for the most part, only to species of concern to the angler. Nebish Lake was not a "problem" water. Analysis included all species present and delved into age and size class composition to an extent not recorded for other Wisconsin waters. Accordingly, the findings represent a significant addition to our knowledge of total fish population composition and structure, and a baseline for comparison to data subsequently gathered from other waters. The need for such information was underscored during early efforts to obtain fish population data input to the supply and demand phase of the Comprehensive Fish Management Plan. While such data do not emanate solely from chemical treatment projects, such treatments do offer excellent opportunities for obtaining data on entire fish populations--the type of information most needed for planning purposes.

Of special note is the very high minnow population found in Nebish Lake. This finding is significant not only in its magnitude but as an essentially initial contribution to our knowledge of the minnow component of mixed warm water fish populations.

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