Section of Fisheries

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THE EFFECTS OF WATER LEVELS AND OTHER FACTORS ON WALLEYE AND NORTHERN PIKE REPRODUCTION AND ABUNDANCE IN RAINY AND NAMAKAN RESERVOIRS

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Division of Fish and Wildlife

The Effects of Water Levels and Other Factors on Walleye and Northern Pike Reproduction and Abundance in Rainy and Namakan Reservoirs[1/]

by

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ABSTRACT

The walleye population in Minnesota waters of Rainy Lake has increased from depressed levels of abundance observed in the mid-1960's. Growth rates have decreased and the mean age of walleyes caught in test nets has increased. The effect of changes in the regulation of spring water levels, instituted in 1969, was examined to see if the increased abundance of walleye was the result of higher water levels at time of spawning. No significant correlation between spring water levels and walleye abundance 5 years later could be detected for the years after the regulation change. There is some evidence that reduction in exploitation may have been associated with the increased abundance of walleye. The abundance of brood stock and of progeny 5 years later was significantly correlated.

In the lakes of the Namakan Reservoir no positive relationship between mean spring water levels and subsequent abundance of walleye and northern pike could be detected. There was some evidence in these lakes that rising water levels in the first half of May benefited northern pike reproduction.

1/ Completion Report-Study 122, D.J. Project F-26-R Minnesota

INTRODUCTION

Rainy Lake and lakes of the Namakan Reservoir (Crane, Kabetogama, Namakan, Sand Point) on the Minnesota-Ontario border undergo wide annual fluctuations in water levels. Each of these reservoirs contains valuable fish populations, especially northern pike and walleye, which support important sport and commercial fisheries.

Previous investigations established that a lakewide decline had occurred in the Rainy Lake walleye population and two factors which may have caused that decline, spring water levels at time of spawning and brood stock abundance, were identified (Johnson, et al. 1966; Johnson, 1967). Bonde et al (1965) and Chevalier (1977), also identified overexploitation as a probable factor contributing to the decline. Management strategies adopted by Minnesota to restore the walleye population included a resumption of fry stocking, a reduction of commercial exploitation by changing licensee's minimum mesh size from 4-to-5¼ inch as new licenses are issued, the closing of Black Bay to sport fishing until spawning fish had dispersed, the installation of artificial spawning reefs in Black Bay, and advocacy of higher spring water levels.

The regulation of water levels for the reservoirs are specified by the International Joint Commission[2/]. These regulations or "rule curves" specify the maximum and minimum permissible water levels for each day of the year for each reservoir. The regulations have been changed several times over the 71 year history of the reservoir, the two most recent in

2/ The International Joint Commission (I.J.C.) is a regulatory body composed of both Canadian and U.S. representatives which resolves matters of concern to both nations. A subsidiary board, the Rainy Lake Control Board, implements the policy decisions of the Commission and informs the Commission of matters which concern it.

1957 and 1969.

The Commission attempts to accommodate the often conflicting needs of the various "users" of the reservoirs. The Commission did consider the needs of spawning fish in its deliberations in 1969.

Recently, resort owners on Namakan Reservoir, immediately upstream of Rainy Lake, have advocated higher spring water levels on that reservoir. These interests have expressed concern that low spring water levels are having an adverse effect on walleye and northern pike populations. As higher spring levels on Namakan Reservoir may require lower spring levels on the downstream reservoirs, the need for higher spring water levels must be documented. A previous field investigation (Sharp, 1941) reported on the conditions encountered with low water levels, noting that northern pike spawning area was limited. However, the effect of possible adverse water levels during spawning has not been related to subsequent abundance of walleye or northern pike.

The purpose of this investigation was: 1) to evaluate the effect of the water level management regime established in 1969 by the International Joint Commission on the walleye population of Rainy Lake; and 2) to evaluate the effect of spring water levels on the walleye and northern pike populations of lakes in the Namakan Reservoir.

Description of Study Area

The reservoirs of the study area are parts of a drainage system which begins in northeastern Minnesota and ends at Hudson Bay. Namakan reservoir is upstream of Rainy Lake (reservoir) and includes the connected lakes of Crane (3,396 acres), Kabetogama (25,750 acres), Namakan (28,260 acres) and

Sand Point (8,890 acres) for a total of 66,296 acres (Fig. 1). Namakan and Sand Point Lakes lie on the U.S. - Canadian border as does Rainy Lake. A dam at Kettle Falls on Namakan Lake regulates the levels of these lakes. This dam provides a 10.5 foot head, below which lies Rainy Lake. Rainy Lake totals 220,800 acres of which 54,140 are in Minnesota. Rainy Lake water levels are controlled by a dam on the Rainy River between International Falls, Minnesota and Ft. Frances, Ontario. Operation of both dams, providing water levels are within the rule curves, is the responsibility of a private corporation[3/]. When water levels are outside of the rule curves, an emergency condition exists and the I.J.C. assumes control of the dams.

Although both of the dams regulate water levels the study areas are only technically reservoirs. Natural rock ledges (dams) did and would support the integrity of the lakes though at slightly lower levels. For a more detailed description of the study area, see Ernst and Osborn (1980), or the Final Report of the International Joint Commission on the Rainy Lake Reference, 1934.

METHODS

The initial study design for Rainy Lake was to update the data base of commercial gillnet walleye catch per unit of effort (CUE) assembled in the previous studies (Johnson, et al. 1966; Johnson, 1967; Chevalier, 1977) and relate this measure of abundance to mean water levels at the time of walleye spawning 4, 5 and 6 years earlier as these authors had done. This

3/ Boise Cascade Corporation and it's subsidiary, Minnesota and Ontario Paper Company.

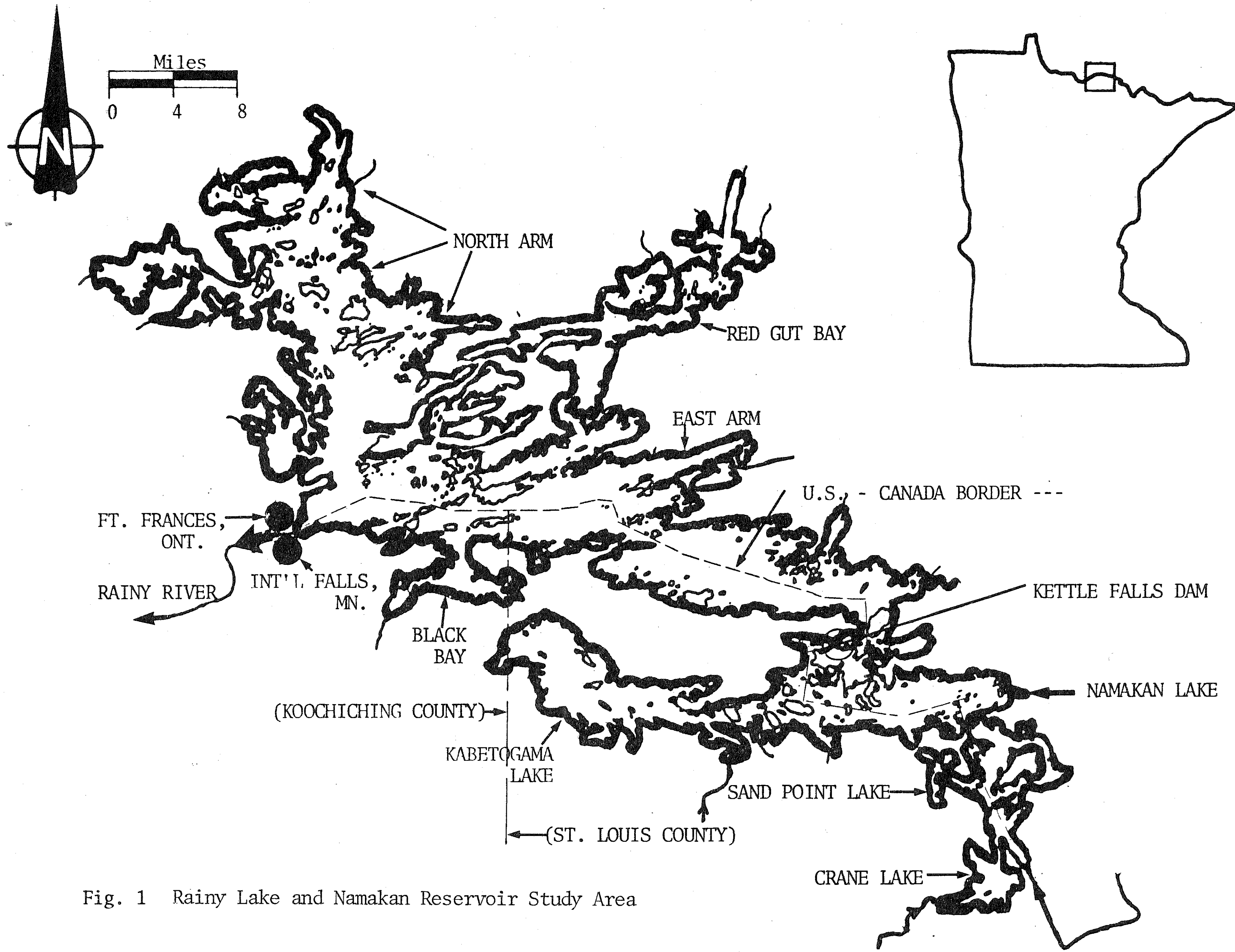

Fig. 1 Rainy Lake and Namakan Reservoir Study Area

approach was precluded by Ontario's conversion of commercial gillnet mesh size from 4-inch stretch mesh to 4¼-inch stretch mesh between 1969 and 1972. Closure of all Ontario waters, except the North Arm, to commercial walleye fishing in the early 1970's due to high mercury levels also disrupted the continuity of the data base.

The study design, therefore, had to be modified to include only Minnesota commercial gillnetting information, though it was recognized that the findings may not be valid for the entire lake. The CUE for commercial gillnets (4-inch stretch measure) fished in Minnesota waters and Minnesota experimental gillnets set in August (250 feet X 6 feet with 50-foot sections of 1½, 2, 3, and 4-inch stretch mesh) were used as indices of walleye abundance. Records of commercial fishing effort are available only since 1949 so CUE could not be calculated for earlier years. Experimental gillnet sets varied from 15 in 1963 to 65 in 1959. Since 1970 the same 25 stations have been netted each year.

Fish taken in nets were weighed and all walleye were measured to the nearest 0.1 inches total length and a scale sample was taken. Scales were read by three readers. If agreement could not be reached on ages they were removed from the sample. A direct proportion nomograph was used for back-calculating growth to the last annulus. Mean ages were calculated by summing the products of age times frequency for that age and dividing the total by sample size.

Mean water levels at time of spawning were derived by inspection of U.S. Army Corps of Engineers water level charts for the 15-day period following ice-out. Ice-out dates were those listed in the _International Falls Daily Journal_, International Falls, Minnesota.

Field examinations of the lakes of Namakan Reservoir were made in May of 1978 and 1979. The purpose of these reconnaissances was to determine the relative extent of walleye and northern pike spawning habitat and how these areas would be affected by different water levels. The 1978 examination included Kabetogama, Crane and Sand Point lakes and the results of this examination were reported in June of 1978[4/]. The western part of the American shoreline of Namakan Lake was checked in 1979[5/].

FINDINGS

Rainy Lake Water Levels

Mean spring water levels under the 1969 rule tended to be similar to, but less variable than they were under the previous regulation of 1957 (Table 1). Mean water levels at the time of most probable walleye spawning (ice-out date plus 2 weeks) averaged 1106.5 feet for the 12 years under the 1969 rule, compared to 1106.6 feet for the 12 years under the 1957 rule. The 1969 rule has resulted in more consistent year-to-year levels than was the case under the 1957 rule. The range of mean spring levels was 2.4 feet (1105.2 to 1107.6) since 1969 compared to 4.1 feet (1104.4 to 1108.5) under the previous rule.

Johnson, et al (1966) suggested that a mean spring water level in

4/ Minn. Dept. of Nat. Resources Staff Report, 'Walleye and Northern Pike Spawning Area Examination of Crane, Kabetogama and Sand Point Lakes, Spring 1978". by T.C. Osborn, D.H. Schupp and D. Ernst. 23+ pages, mimeo June 1978.

5/ Minn. Dept. of Nat. Resources Int. Prog. Report, 'Walleye and Northern Pike Spawning Area Examination on Portions of Namakan and Rainy Lakes, Spring 1979," by T.C. Osborn and D. Ernst, 1979. 24+ pages, mimeo.

Table 1. Mean water levels for the period from ice-out to 14 days later, Rainy Lake, 1942-1979.

Year	Ice out date[a/]	Mean water level	Year	Ice out date[a/]	Mean water level
1942	April 23	1107.2	1961	May 8	1107.2
1943	May 3	1107.3	1962	May 7	1107.1
1944	May 4	1107.2	1963	April 30	1105.6
1945	April 21	1108.3	1964	May 6	1106.6
1946	April 20	1108.3	1965	May 7	1106.7
1947	May 12	1107.5	1966	May 14	1108.5
1948	May 6	1107.8	1967	April 25	1107.2
1949	April 29	1107.2	1968	April 29	1107.2
1950	May 22	1111.2	1969	April 25	1106.1
1951	May 9	1107.7	1970	May 6	1107.0
1952	May 4	1105.7	1971	May 11	1106.8
1953	May 4	1105.2	1972	May 11	1106.4
1954	May 14	1108.1	1973	April 21	1105.7
1955	April 23	1106.2	1974	May 9	1107.4
1956	May 12	1107.3	1975	May 8	1107.0
1957	May 7	1107.3	1976	April 18	1106.4
1958	April 22	1104.4	1977	May 1	1105.2
1959	May 6	1105.3	1978	May 8	1106.6
1960	May 16	1105.8	1979	May 12	1107.6
			1980	May 2	1105.4

a/ From International Falls Daily Journal.

excess of 1106.8 feet is probably necessary to inundate sufficient rubble substrate to insure adequate walleye reproduction. Under the 1957 rule, the mean water levels exceeded 1106.8 feet in 6 of 12 years (50% of the years), but in only 4 of 12 years (33% of the years) since 1969.

Walleye Abundance in Rainy Lake

A 58% decline in abundance of walleye between 1948 and 1969 was reported by Chevalier (1977) for Rainy Lake as a whole. Since 1964, however, the walleye population in the Minnesota waters of Rainy Lake has been increasing (Fig. 2 and 3). Commercial CUE for 4-inch gillnets set in St. Louis County waters (eastern part of East Arm - see Fig. 1) as calculated from the regression equation (Fig 2, $P<0.01$) increased from 20.4 pounds per thousand feet per day in 1964 to 64.6 in 1980, a 216% increase. The nine highest CUE recorded in 32 years have occurred since 1971 (Appendix Table 3A).

The CUE for Minnesota test nets, set throughout the Minnesota waters of the East Arm (both commercially fished and noncommercially fished zones) also increased significantly. Catch per unit of effort, calculated from the regression equation (Fig. 3, $P<0.01$; Appendix Table 1A), changed from 1.0 pounds per lift in 1963 to 6.3 in 1980, a 530% increase.

Test net results suggest that this recovery has occurred in both the commercially fished and non-commercially fished areas, but the walleye population in the commercially fished area has increased at a more rapid rate (Fig. 4; Appendix Table 2A). The slopes of linear regressions of CUE on time for the years 1970-1980, differed significantly from zero indicating a real change in abundance for both the commercially and non-commercially fished areas ($P<0.01$ and $P<0.05$ respectively). Analysis of covariance

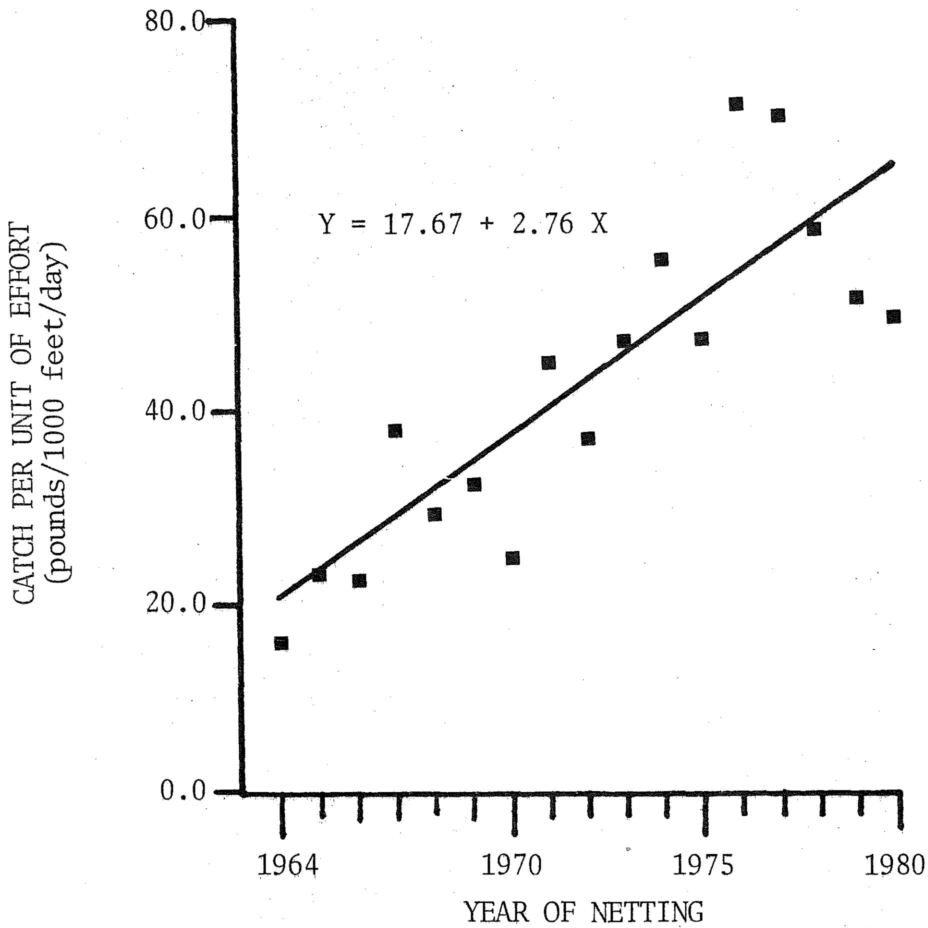

Fig. 2. Linear regression of walleye CUE (lbs/1000 feet/day) on time for commercial 4 inch gillnets on the Minnesota waters of the East Arm of Rainy Lake, 1964-1980. ($r = 0.84$, $P < 0.01$)

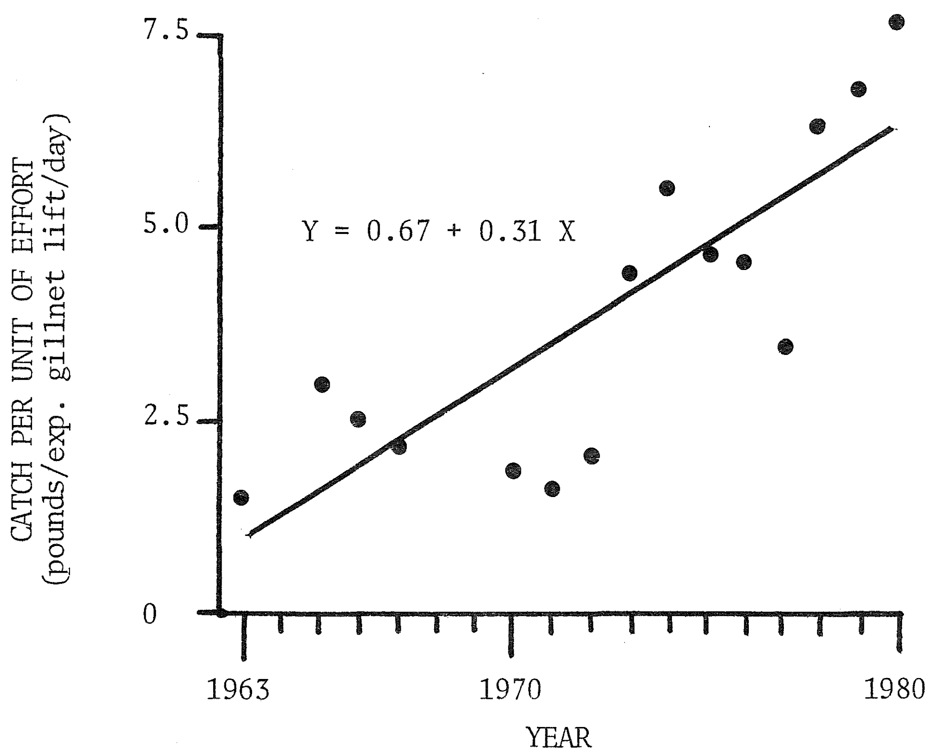

Fig. 3. Linear regression of walleye CUE (lbs/exp. gillnet/day) from Minnesota testnets on time, Rainy Lake, 1963-1980. ($r = 0.82$, $P < 0.01$)

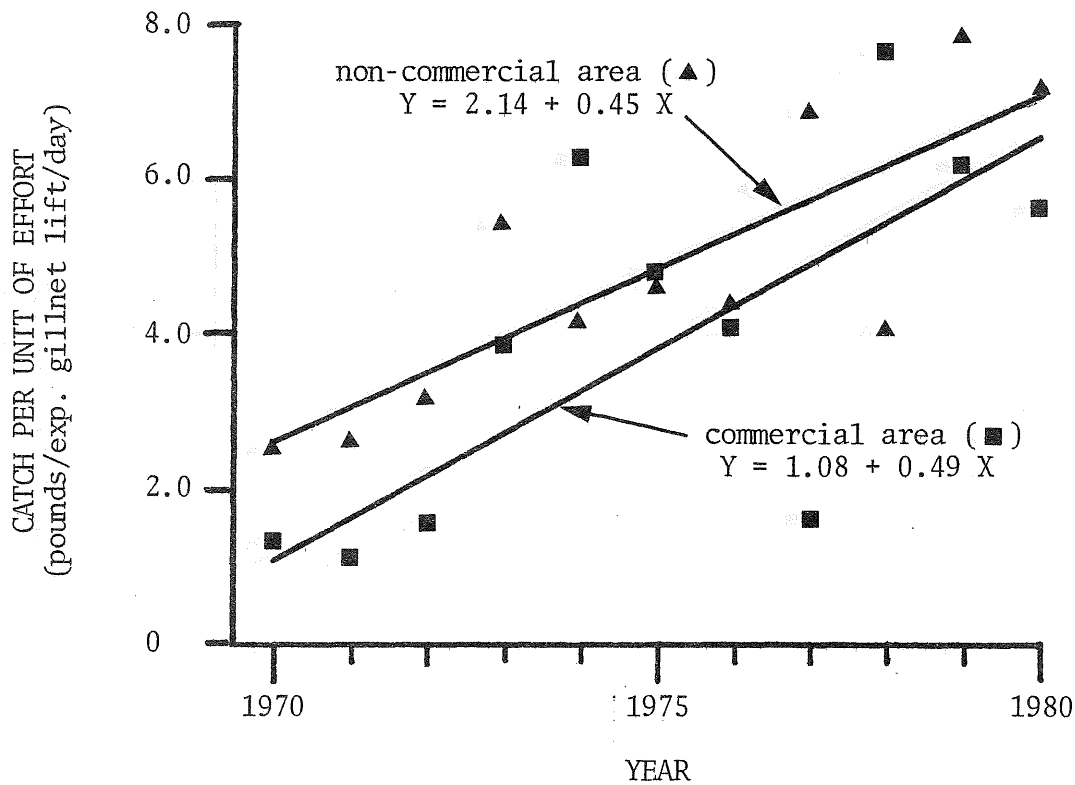

Fig. 4. Linear regressions of CUE (experimental gillnets or Minnesota test nets) on time for Minnesota waters of Rainy Lake from commercially fished area in St. Louis County waters (16 sets/year, $r = 0.70$, $P < 0.05$) and non-commercially fished waters of Koochiching County (9 sets/year, $r = 0.82$, $P < 0.01$), 1970-1980.

showed that the slopes for the two areas also differed significantly ($P<0.05$), indicating that the rate of recovery was faster in the commercially fished area.

Rainy Lake Walleye Growth Rates

The growth rate of walleye appeared to be density dependent. The most rapid growth for age II, III, and IV walleyes was observed in the mid-1960's when commercial CUE was lowest (Fig. 5). A significant ($P<0.05$) decrease in growth was observed for each of these ages between 1963 and 1980, the period when CUE increased significantly. These findings mark a reversal in the trend toward increasing growth rates observed for the East Arm subpopulation between 1959 and 1965 by Johnson, et al (1966), and by Chevalier (1977) for the North Arm subpopulation[6/] during the same years.

The increased abundance and slower growth of walleye noted since 1963 was accompanied by an increase in the mean age (Fig. 6). The mean age of fish caught in test nets increased from 2.6 in 1963 to 4.2 in 1980. Chevalier (1977) reported a decline in the mean age for the years 1955-67 in the East Arm.

Factors Influencing Rainy Lake Walleye Abundance

Inadequate water levels at time of walleye spawning were identified as a possible cause of the decline of walleye in Rainy Lake (Johnson, et al. 1966; Johnson 1967; Chevalier, 1977). Shoal areas on the East Arm with rubble - rock of a type preferred by walleye for lake spawning (Johnson,

6/ Bonde, Elsey and Caldwell (1965) identifed three subpopulations in Rainy Lake: North Arm, East Arm, and Red Gut Bay.

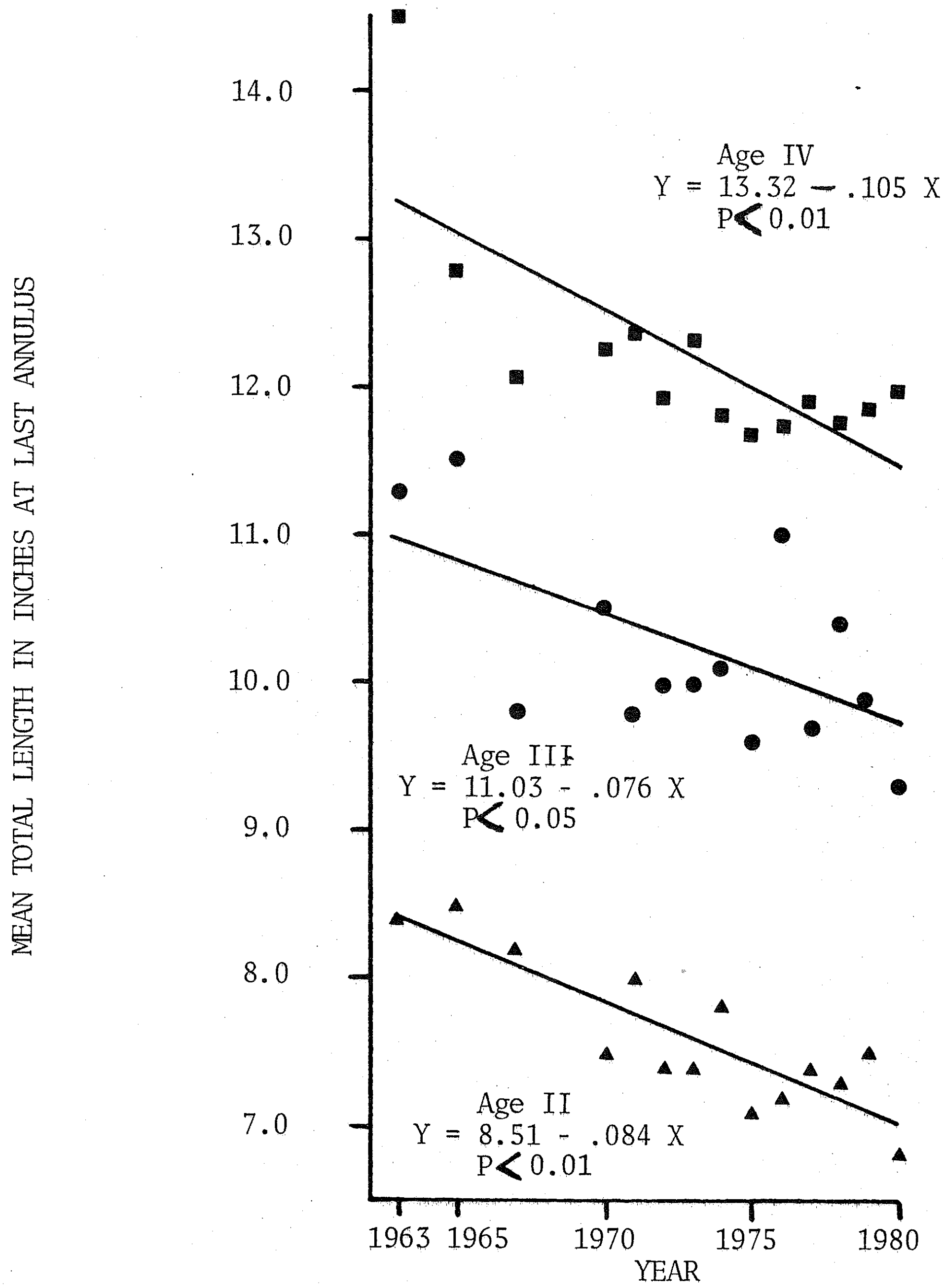

Fig. 5. Linear regressions of mean total length at annulus formation on time for Age II, III and IV walleye taken in Minnesota test nets, 1963-1980. Growth back-calculated to last annulus only. Sample size ranged from 5 to 81.

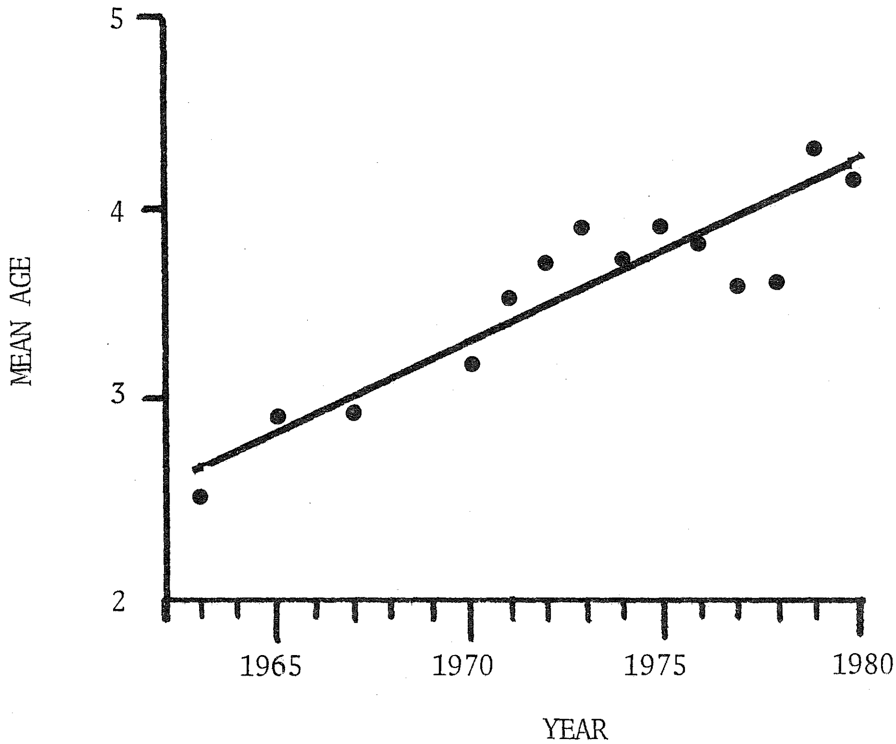

Fig. 6. Linear regression of mean age on time of walleye caught in test-nets from Minnesota waters Rainy Lake, 1963-1980. ($r = 0.907$, $P < 0.01$)

1961) are narrow and require a water level of approximately 1106.8 feet to flood these areas to a depth where walleye can use them (Johnson, et al. 1966; Johnson, 1967). If water levels prevented the use of preferred substrates and walleye spawned on mud or sand, lower reproductive success would likely result (Johnson, 1961).

Chevalier (1977) found that 50% ($r=0.71$, $P<0.01$) of the annual variation in CUE of commercial four-inch mesh gillnets between 1948 and 1969 **might** be attributed to spring water levels occurring five years prior to that catch. Chevalier's analysis could not be extended to include the years 1970-80 because of the changes in Ontario regulations and the closure of Ontario's commercial fishery in the early 1970's. The relationship between water level and CUE five years later, for the years 1949-69, using only Minnesota data, was also positive ($r=0.12$, $P>0.05$) but not significant. The addition of data for the years 1970-80 failed to increase the correlation ($r=0.11$, $P>0.05$).

The decline of brood stock abundance to inadequate numbers may have been a factor in the precipitous decline of the walleye population. Reproductive capacity and population resiliency are dependent upon the number of spawners and Johnson (1967) suggested that the Rainy Lake spawning stock had been reduced to such a level that progeny abundance could be affected. Chevalier (1977) regressed gillnet CUE (progeny abundance) on CUE five years earlier (brood stock abundance) and found a significant relationship ($P<0.01$) for the 1948-1969 period. Brood stock abundance alone explained 44% of the variation in catch. Our analysis (Minnesota CUE 1949-1980) also indicated a significant correlation

($r=0.61$, $P<0.01$) between brood stock abundance and progeny produced 5 years later. This analysis indicated that 38% of the variation in progeny catch was attributable to brood stock abundance five years earlier. This finding covers both the period of decline (1949-1963) and recovery (1964-1980).

The combined effect of spring water levels and brood stock abundance was measured by Chevalier (1977) using multiple regression analysis. The correlation coefficients between progeny abundance and both spring water levels and brood stock abundance differed significantly from zero and the addition of either improved the model; that is, the addition of either variable to the regression reduced the amount of unexplained variation in progeny abundance. The multiple regression explained 65% of the variation in progeny abundance. A similar analysis using only Minnesota CUE for the years 1949-80 indicated that brood stock abundance was the only factor that improved the model significantly.

Over exploitation was first mentioned as a cause of the walleye decline by Bonde, et al (1965) who noted that the abundance of fast growing, small fish, coupled with declining fishing success, was an indication of over-fishing. Total commercial production of walleye at that time had not declined but CUE was lower and effort had increased. In a later study, Chevalier (1977) documented a significant decrease in catch per unit of effort and noted that the commercial harvest of all species from Rainy Lake exceeded the yield predicted from the MEI (Ryder, 1965) by 45% between 1924 and 1975. Adams and Olver (1977) estimated that a sustainable percid yield may approximate one-third the allowable total yield estimated from the MEI in similar waters. Commercial production from Ontario waters had been about at that level before walleye abundance declined. Tagging studies in Rainy Lake in the late 1950's indicated that sport fishing harvests of walleye approximated commercial production (Bonde, et al. 1965). Thus for the lake as a whole total walleye harvest may have been nearly twice the level that could be sustained.

Since 1949, the walleye population of Minnesota waters of Rainy Lake has gone through a period of decline followed by a period of recovery. This indicates that the walleye population was able to sustain itself over time against the average amount of fishing effort directed against it between 1949 and 1980. Fishing effort affects CUE not only in the year in which it occurs but in subsequent years as well. The cumulative percentage departures from the 31-year means (1949-1980) for CUE and fishing effort were plotted against each other (Fig. 7) and show that between 1949 and 1962 the cumulative force of exploitation (fishing effort) on the population was increasing while CUE was decreasing gradually through 1970. The lowest CUE occurred eight years after the maximum force of fishing effort. CUE began to rise as fishing effort declined. The eight-year lag is very near the time it takes female walleye to mature at this latitude (Schupp, 1974).

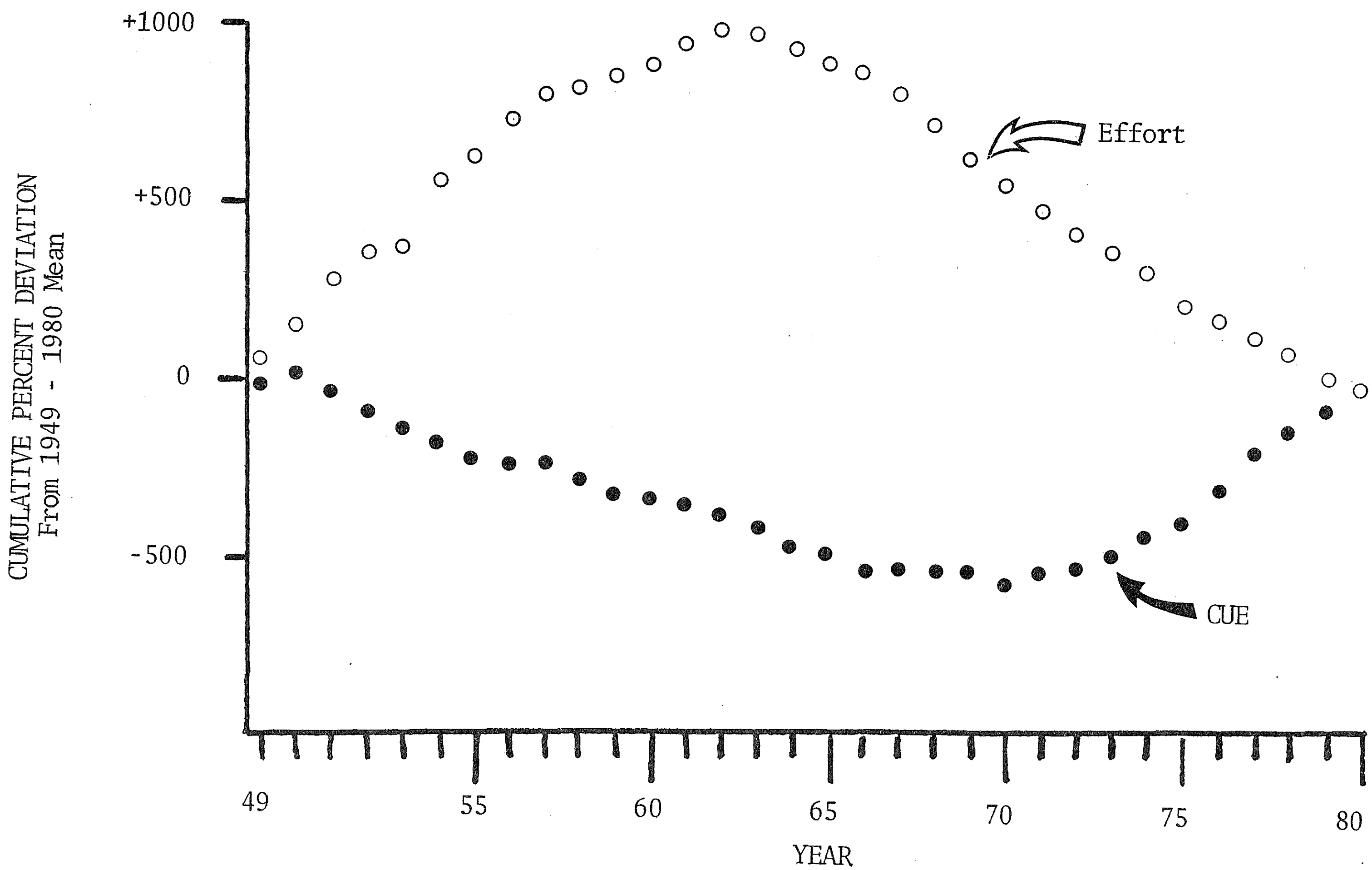

Fig. 7. Comparison of cumulative percentage deviation from 1949-1980 means for commercial fishing effort (footdays) and for catch in pounds per 1000 feet of 4" gillnet for Minnesota waters of Rainy Lake.

Spring Water Levels in Namakan Reservoir

Spring water levels for the Namakan Reservoir have tended to be lower and more consistent from year to year under the 1969 rule than the previous rule (1957). Spring water levels at time of spawning for the period 1969-1980 averaged 1114.5 feet, seven-tenths of a foot lower than during the period 1957-1968 (Table 3). Variances of the two sets of spring water levels differed significantly ($F=1.73$, $P<0.05$).

Year to year variations in spring water levels on Namakan Reservoir were significantly greater than those observed for Rainy Lake. For the 38 year period (1942-1979) the standard deviation for spring water levels for Namakan Reservoir was 2.12 feet compared to 1.18 feet for Rainy Lake ($F=1.70$, $P<0.01$). The greater variation noted on Namakan Reservoir can be attributed to its smaller capacity (1/3 that of Rainy Lake) and the use of the reservoir as storage for Rainy Lake.

Walleye and Northern Pike Abundance in Namakan Reservoir

The relative abundance of walleye and northern pike varied considerably from lake to lake (Table 4). In each lake gillnet catches of walleye were higher than those of northern pike. An average of 7.8 walleyes were caught for each northern pike from Kabetogama Lake (70 lifts in 6 nettings). The ratio for Crane Lake was 4.1 walleye per northern pike (41 lifts in 6 nettings) and for Namakan Lake, 3.9 (89 lifts in 6 nettings). The lowest ratio of walleye to northern pike was for Sand Point Lake, where walleye outnumbered northern pike by a ratio of 3.3 to 1 (19 lifts in 3 nettings) (Table 4). Average abundance of walleye for all netting periods was highest

Table 3. Mean Spring Water Levels on Namakan Reservoir 1915-1980

Year	Mean Level (May 1 - May 15)	Mean Level (Ice Out Date + 14 Days)	Year	Mean Level (May 1 - May 15)	Mean Level (Ice Out Date + 14 Days
1915	1110.3		1948	1117.0	
1916	1116.9		1949	1113.3	
1917	1110.0		1950	1115.0	
1918	1108.7		1951	1116.4	
1919	1110.6		1952		1113.7
1920	1111.9		1953		1111.4
1921	1111.6		1954		1118.0
1922	1113.1		1955		1111.2
1923	1109.9		1956		1113.8
1924	1107.5		1957		1115.1
1925	1112.6		1958		1110.5
1926	1109.8		1959		1112.4
1927	1119.4		1960		1116.8
1928	1109.8		1961		1115.6
1929	1115.4		1962		1113.5
1930	1108.3		1963		1115.2
1931	1110.5		1964		1116.4
1932	1114.0		1965		1115.0
1933	1114.2		1966		1119.0
1934	1114.6		1967		1115.5
1935	1112.8		1968		1117.8
1936	1112.0		1969		1115.3
1937	1113.1		1970		1115.6
1938	1118.7		1971		1116.1
1939	1111.9		1972		1114.7
1940	1110.1		1973		1112.7
1941	1113.0		1974		1115.4
1942	1114.4		1975		1115.6
1943	1112.5		1976		1113.7
1944	1114.7		1977		1110.7
1945	1118.5		1978		1114.5
1946	1117.4		1979		1117.0
1947	1116.5		1980		1112.8

Table 4. Walleye and Northern Pike abundance in the Lakes of Namakan Reservoir as measured by Minnesota Experimental Gillnets, 1936-1980

			Walleye		Northern Pike	
Year	Lake	No. Lifts	CUE Number	CUE Weight	CUE Number	CUE Weight
1953	Crane	16	6.1	5.0	1.1	2.4
1967	"	3	24.0	---	4.3	---
1970	"	6	12.7	9.5	1.0	2.6
1973	"	4	15.3	16.5	3.5	12.1
1976	"	6	12.8	8.6	4.0	16.3
1980	"	6	9.8	6.8	5.3	14.3
1946	Kabetogama	32	12.3	---	1.2	---
1966	"	8	9.4	13.9	1.6	5.3
1970	"	12	14.1	12.4	1.5	3.2
1973	"	6	20.8	28.9	5.3	13.6
1977	"	6	12.2	15.5	1.7	4.1
1980	"	6	15.0	14.5	1.0	6.6
1962	Namakan	24	7.3	4.5	4.0	7.1
1966	"	8	5.0	6.4	1.2	---
1970	"	15	9.1	6.2	0.9	1.9
1973	"	15	4.9	4.1	1.2	3.2
1975	"	15	9.9	7.6	2.0	6.4
1978	"	12	12.3	9.5	1.9	5.6
1970	Sand Point	7	4.8	2.2	1.8	4.7
1973	"	5	11.2	9.6	2.8	9.2
1979	"	7	7.1	5.5	2.1	6.0

in Crane Lake (13.5/lift), followed closely by Kabetogama (12.9/lift) and then Namakan (8.1/lift), and Sand Point (7.7/lift) lakes. Northern pike were most abundant in Crane Lake (3.2/lift) followed in order by Sand Point (2.2/lift), Namakan (2.1/lift) and Kabetogama (1.7/lift) lakes.

Namakan Reservoir Spring Water Levels and Their Effect Upon Subsequent Walleye and Northern Pike Abundance

Field examinations of Namakan Reservoir walleye spawning areas indicated that all lakes likely have sufficient high quality walleye spawning substrate at water levels within those specified by the rule curve and probably at water levels above and below the allowable range[3/4/].

There are few potential northern pike spawning areas and their availability to spawning fish is affected by water levels. Only Kabetogama Lake has ample shallow, vegetated flowages conducive to northern pike spawning. Areas on the other lakes are typically small and restricted to the heads of bays and inlets.

A positive relationship between spring water levels and subsequent abundance of either northern pike or walleye in any of the four reservoir lakes is not indicated by the evidence available. Northern pike abundances as determined by periodic test netting CUE appeared to vary over time independent of spring water levels two to four years[7/] prior to the respective nettings (Table 5). Walleye indices of abundance were not correlated with mean spring water levels two, three and four years prior to netting.

If the distribution of aquatic vegetation necessary for successful

7/ Two, three, and four year old fish comprise the majority of walleye and northern pike caught in experimental gillnets with the modal age generally three.

Table 5. Coefficients of correlation (r) between mean spring water levels and gillnet indices (no./lift) of walleye and northern pike two, three, and four years later for lakes of the Namakan Reservoir

	Years Netted	Spring water level 2,3, and 4 yrs. prior to testnetting 2 Years	3 Years	4 Years
Crane Lake				
Walleye	6	-0.247	+0.498	+.278
Northern Pike	6	-0.915 a/	-0.535	-0.441
Kabetogama Lake				
Walleye	6	-0.011	+0.057	+0.303
Northern Pike	6	+0.168	+0.487	+0.117
Namakan Lake				
Walleye	6	-0.563	+0.111	+0.363
Northern Pike	6	-0.183	-0.939 a/	-0.783 b/
Sand Point Lake				
Walleye	3	-0.070	+0.206	-0.819
Northern Pike	3	-0.004	+0.270	-0.779

a/ $P < 0.01$
b/ $P < 0.05$

northern pike spawning was dependent upon summer and fall water levels, then the amount of water rise in spring would determine whether or not these areas were flooded. Northern pike abundance indices, when compared to the average water level rise during the probable spawning period two, three, and four years earlier, show no consistent relationships (Table 6) although in two of the lakes, Kabetogama and Sand Point, a significant correlation was found for four-year-old fish.

There was no apparent correlation between walleye abundance and feet of rise during the spawning period. During field investigations in 1978-79 it was found that there was good spawning substrate available to walleye at all water levels within normal operational limits.[4/] [5/]

Table 6. Coefficients of correlation (r) between water rise in spring and gillnet indices (no./lift) of walleye and northern pike two, three, and four years later for lakes of the Namakan Reservoir

	Years Netted	2 Years	3 Years	4 Years
Crane Lake				
Walleye	5	+0.245	+0.728	-0.017
Northern Pike	5	+0.706	-0.622	-0.097
Kabetogama Lake				
Walleye	5	-0.481	-0.096	+0.650
Northern Pike	5	-0.507	+0.190	+0.938[a]
Namakan Lake				
Walleye	6	-0.457	-0.073	-0.007
Northern Pike	6	+0.573	+0.036	-0.557
Sand Point Lake				
Walleye	3	+0.094	-0.411	+0.870
Northern Pike	3	+0.137	-0.350	+0.901[b]

a/ $P < 0.01$
b/ $P < 0.05$

DISCUSSION

Walleye abundance in Minnesota waters of Rainy Lake has increased significantly from the low levels of the mid-1960's. The CUE for commercial gillnets and for testnets has increased steadily since 1963, growth rates have declined, and the mean age of walleye caught has increased. The recovery followed implementation of a Minnesota management policy which sought to: (1) optimize spring water levels for walleye spawning; (2) reduce exploitation through conversion of commercial gillnets from 4-inch stretch mesh to 5¼-inch mesh and the closure of Black Bay to sport fishing during the early part of the season; (3) increase walleye stock through a resumption of walleye fry stocking in 1967; and (4) provide low-water spawning substrate by installing artificial spawning reefs in Black Bay. The increase in abundance cannot be specifically associated with any single measure.

Water levels at spawning time were implicated as a possible cause of the lakewide decline in walleye abundance (Johnson, et al. 1967; Chevalier, 1977) through correlation analyses. These analyses could not be performed for the years following the earlier investigations because commercial gillnet CUE from Minnesota waters provide the only continuous data series available that covers both the periods of declining and increasing walleye abundance. During the years walleye abundance was declining, only 20% of the commercial walleye production from Rainy Lake came from Minnesota waters. Correlation analyses using only Minnesota data, through 1969, would not have implicated water levels as a possible cause of the decline.

The recovery of the walleye population cannot be attributed to higher spring water levels caused by the 1969 rule curve adjustment since it did not establish minimum lake levels sufficient for improving spawning conditions (Chevalier, 1977). Mean levels at time of spawning have been slightly lower since 1969 than they were in the preceding two decades. Johnson, et al. (1967) and Chevalier (1977) pointed out that only the upper levels of the rule curve range (1106.8) were considered satisfactory for properly inundating spawning areas. Thus, the lack of a correlation between abundance and spring water levels is not surprising and does not preclude a beneficial influence of high water levels on walleye spawning. The population may have recovered more rapidly if higher water levels had been attained consistently.

The combination of more efficient commercial gear and increased harvests by sport fishing could have been important factors in the decline. The use of nylon gillnets in Rainy Lake began in the late 1940's (Bonde, et al, 1961). Regier, et al, (1969) suggested that the introduction of more efficient nylon gillnets may have been a major factor in the collapse of the Lake Erie walleye fishery in the late 1950's. Sport fishing has also increased at a high rate after World War II in Minnesota lakes. A five-fold increase in sport fishing effort was observed at Lake Winnibigoshish, Minnesota between 1939 and 1958 and the walleye harvest doubled (Johnson and Johnson, 1971).

The evidence for over-exploitation by the combined commercial and sport fisheries as a cause of the decline in walleye abundance is circumstantial. Chevalier (1977) pointed out that commercial yields had exceeded yields predicted from the MEI for many years. An inverse relationship between fishing effort and CUE is considered a classic sign of overfishing and is evident in the commercial fishing statistics for Minnesota waters of Rainy Lake (Fig. 7). The faster rate of recovery of walleye abundance from parts of the lake open to commercial fishing (Fig. 4) could be expected if abundance had been more depressed in areas subjected to both sport and commercial fishing. The decline probably began before the study by Bonde, et al. (1961) since complaints about the small size of walleye being caught led to that study. Increased recruitment of young fish is a common compensatory mechanism in exploited fish populations.

At minimum population levels in the 1960's, commercial fishing became uneconomical and several fishermen retired. Regulation changes in 1964 permitted the issuance of new licenses only for mesh sizes larger than 5¼-inches. These actions coupled with the conversion of Canadian gillnet mesh sizes from 4-to 4¼-inches between 1969 and 1971 and a ban on commercial fishing in Ontario waters of the East Arm from 1972 to 1974 reduced pressures on the East Arm subpopulation, and may have allowed it to recover. The arguments for over-exploitation as a cause of the decline appear to be at least as strong as those for spring water levels.

Spring water levels alone cannot explain the variations which have occurred in walleye and northern pike populations in the Namakan Reservoir. The variations observed in abundance indices could not be correlated with mean spring water levels two, three, and four years earlier. There is some evidence that the amount of rise in water level during the first half of May is beneficial to the reproduction of northern pike. Data for water levels are not conclusive and water levels are not the only factor which could influence these populations.

The inability to identify a relationship between walleye abundance and spring water levels is not surprising given the extent of suitable spawning shoals of various depths in all lakes. The lack of an apparent correlation for northern pike populations with spring water levels was surprising. Considering the apparent scarcity of suitable spawning areas except at very high levels, a better correlation would have been expected.

A partial explanation of this observation was found in the May 1978 examination of Kabetogama Lake. Although walleye had apparently completed spawning, we saw northern pike exhibiting spawning behavior on newly flooded vegetation and found eggs to confirm that spawning had occurred. The relative timing of spawning for the two species is the opposite of that which is usually observed in other Minnesota lakes. Kallemeyn (personal communication) examined 93 female pike after May 16, 1981 and 47% were still carrying ovaries full of eggs. It would be of interest to determine whether the northern pike in this reservoir system tend to consistently spawn later than is observed in other lakes.

Water levels observed in recent years have been quite low although this is probably not due to the 1969 regulations so much as it is to low precipitation especially in 1976-77 and 1978-79. The regulations anticipate both a substantial spring runoff to fill the reservoirs and ample spring precipitation, a situation which is normal. The control structure of Namakan Reservoir cannot be regulated to change water levels quickly, thus precise control of water levels for optimum spawning is probably not possible.

Northern pike populations have remained relatively stable under a variety of spring water levels regimes. Attempting to increase northern pike abundance through higher spring water levels should be carefully considered as a management goal since any gain in northern pike biomass may be at the expense of walleye biomass, and these lakes are regarded by fishermen as primarily walleye fisheries.

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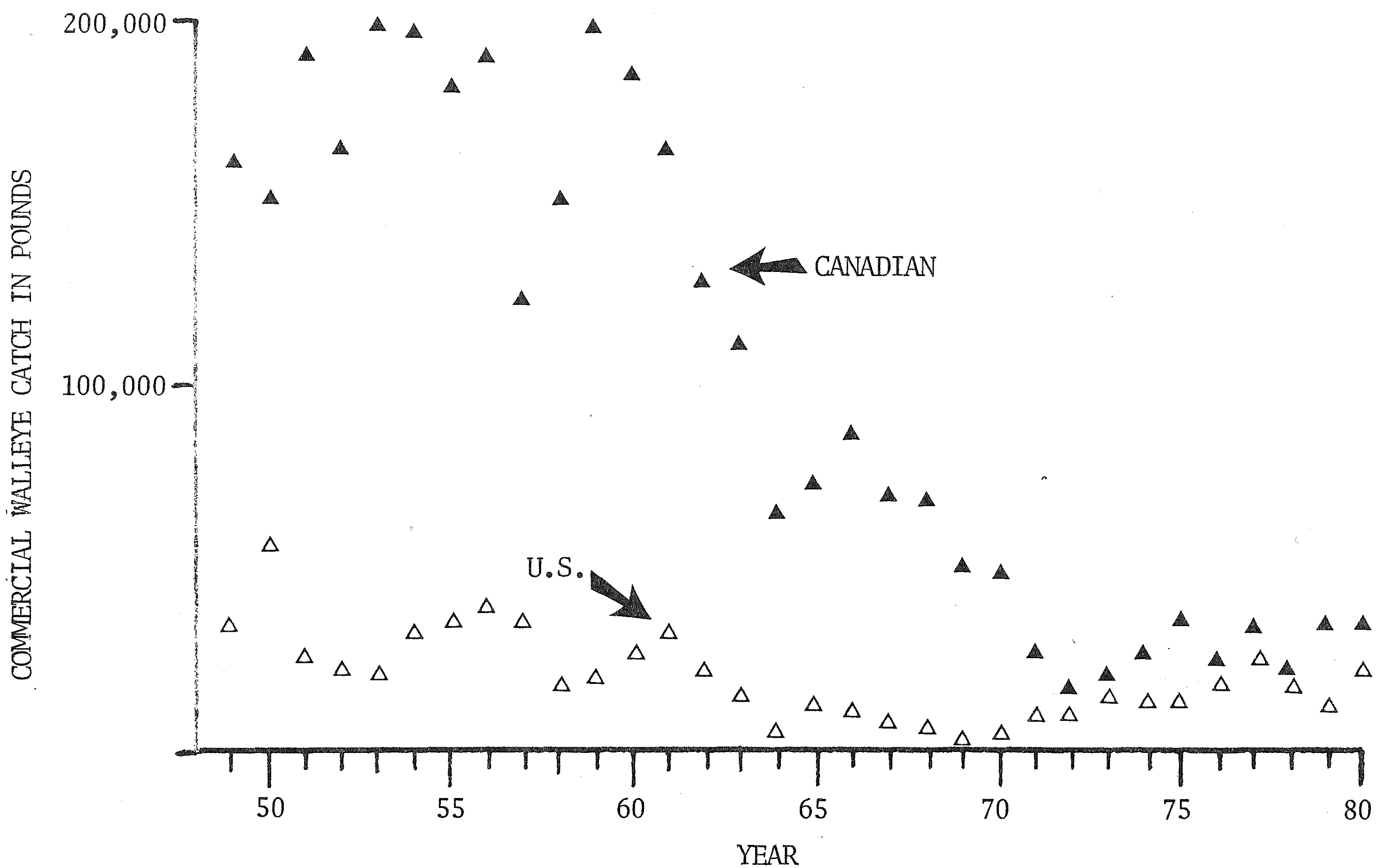

Appendix Figure 1A. U.S. and Canadian commercial walleye catches in Rainy Lake by year, 1949-1980.

Appendix Table 1A. Minnesota experimental gillnet catches, East Arm, Rainy Lake, August, 1959-1980,

Species	1959 (65 Lifts) No. per lift	Lbs. per lift	1963 (15 Lifts) No. per lift	Lbs. per lift	1965 (44 Lifts) No. per lift	Lbs. per lift	1966 (41 Lifts) No. per lift	Lbs. per lift	1967 (15 Lifts) No. per lift	Lbs. per lift	1970 (25 Lifts) No. per lift	Lbs. per lift
Sturgeon	-	-	-	-	0.02	0.01	-	-	-	-	-	-
Lake Herring	7.9	4.9	8.2	4.1	2.5	1.1	4.9	2.4	5.1	2.0	1.4	1.0
Lake Whitefish	0.2	0.2	-	-	0.2	0.2	-	-	-	-	-	-
Northern Pike	2.6	4.8	5.5	9.0	3.1	5.0	2.1	3.5	3.5	6.8	2.9	4.9
White Sucker	2.9	4.8	2.7	3.6	2.1	3.2	1.7	2.3	2.2	3.9	1.4	2.4
Sturgeon Sucker	0.2	0.8	-	-	0.02	0.03	0.1	0.2	-	-	-	-
N. Redhorse	-	-	-	-	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	-	-	-	-	-	-	-	-	-	-
Burbot	0.8	1.4	0.3	0.4	0.1	0.1	0.2	0.3	0.1	0.1	0.04	0.07
Black Crappie	-	-	-	-	-	-	-	-	-	-	0.04	0.004
Rock Bass	0.3	0.1	0.7	0.1	0.9	0.3	0.5	0.1	0.7	0.2	0.3	0.1
Smallmouth Bass	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.02	0.07	0.03	0.04	0.05
Yellow Perch	9.8	3.5	8.8	2.0	4.1	0.9	4.0	0.8	2.3	0.7	3.0	1.0
Sauger	4.1	1.2	4.9	1.4	6.2	1.9	9.7	2.6	10.1	2.7	4.4	1.2
Walleye	10.3	6.5	2.8	1.5	5.1	3.0	4.2	2.5	4.2	2.2	2.6	1.8

Appendix Table 1A. Minnesota experimental gillnet catches, East Arm, Rainy Lake, August, 1959-1980 (continued)

	1971 (65 Lifts)		1972 (15 Lifts)		1973 (44 Lifts)		1974 (41 Lifts)		1975 (15 Lifts)		1976 (25 Lifts)	
	No. per lift	Lbs. per lift	No. per lift	Lbs. per lift	No. per lift	Lbs. per lift	No. per lift	Lbs. per lift	No. per lift	Lbs. per lift	No. per lift	Lbs. per lift
Sturgeon	-	-	-	-	-	-	-	-	-	-	-	-
Lake Herring	1.5	0.9	3.8	1.5	0.4	0.2	2.9	0.9	1.6	0.8	0.5	0.2
Lake Whitefish	-	-	-	-	-	-	-	-	-	-	-	-
Northern Pike	2.0	3.7	2.7	5.0	3.1	7.2	3.5	7.2	2.8	5.4	3.4	5.6
White Sucker	0.9	1.2	1.3	2.0	2.8	4.2	2.4	3.8	1.9	2.2	3.0	3.8
Sturgeon Sucker	-	-	-	-	-	-	-	-	-	-	-	-
N. Redhorse	-	-	-	-	-	-	-	-	-	-	-	-
Brown Bullhead	-	-	-	-	-	-	-	-	-	-	-	-
Burbot	0.04	0.2	0.4	0.6	0.1	0.2	0.04	0.08	0.2	0.2	-	-
Black Crappie	0.04	0.004	-	-	-	-	-	-	-	-	-	-
Rock Bass	-	-	0.3	0.1	0.4	0.1	0.2	0.1	0.4	0.2	0.6	0.09
Smallmouth Bass	-	-	0.04	0.05	0.04	0.004	0.2	0.2	0.8	0.8	0.3	0.2
Yellow Perch	2.7	0.8	4.8	0.7	7.1	1.3	6.7	1.1	7.0	1.0	7.0	1.1
Sauger	2.6	0.9	5.2	1.6	4.6	1.3	5.0	1.2	6.1	1.7	4.3	1.4
Walleye	1.8	1.7	2.3	2.1	4.5	4.4	6.1	5.5	4.9	4.7	4.3	4.2

Appendix Table 1A. Minnesota experimental gillnet catches, East Arm, Rainy Lake, August, 1959-1980 (continued)

Species	1977 (25 Lifts) No. per lift	1977 (25 Lifts) Lbs. per lift	1978 (25 Lifts) No. per lift	1978 (25 Lifts) Lbs. per lift	1979 (25 Lifts) No. per lift	1979 (25 Lifts) Lbs. per lift	1980 (25 Lifts) No. per lift	1980 (25 Lifts) Lbs. per lift
Sturgeon	-	-	-	-	-	-	-	-
Lake Herring	0.1	0.04	1.4	0.3	0.2	0.1	0.2	0.2
Lake Whitefish	-	-	-	-	-	-	-	-
Northern Pike	4.3	8.4	3.4	7.8	3.6	8.7	4.8	8.5
White Sucker	2.2	3.8	2.7	3.7	2.8	5.0	2.7	4.1
Sturgeon Sucker	-	-	0.1	0.3	-	-	-	-
N. Redhorse	-	-	-	-	-	-	0.04	0.01
Brown Bullhead	0.5	0.1	0.1	0.02	0.7	0.1	0.6	0.2
Burbot	0.08	0.08	0.04	0.05	-	-	0.04	0.004
Black Crappie	0.1	0.01	0.2	0.04	0.2	0.08	0.2	0.1
Rock Bass	0.2	0.4	0.5	0.3	1.0	0.4	1.3	0.4
Smallmouth Bass	0.4	0.2	0.4	0.2	0.6	0.5	0.4	0.2
Yellow Perch	7.0	1.5	10.2	1.6	8.0	1.2	7.3	1.1
Sauger	3.2	1.1	5.0	1.7	5.9	1.7	3.6	1.1
Walleye	3.7	3.5	7.1	6.4	6.5	6.8	6.3	6.2

Appendix Table 2A. Minnesota experimental gillnet catches of walleye in commercially netted areas and areas closed to commercial netting Rainy Lake, 1970 - 1980.

	West End			East End		
	Non-commercial Netting Area			Commercial Netting Area		
Date	Sets	No/Set	Lbs/Set	Sets	No/Set	Lbs/Set
8/4-14/70	9	3.2	2.5	17	2.2	1.3
8/9-25/71	9	2.6	2.7	16	1.4	1.1
8/7-18/72	9	3.6	3.2	16	1.8	1.5
8/6-16/73	9	4.1	5.5	16	4.1	3.9
8/5-20/74	9	4.0	4.2	16	7.3	6.3
8/4-14/75	9	5.4	4.7	16	4.6	4.8
8/2-13/76	9	4.0	4.3	16	4.4	4.1
8/8-19/77	9	5.0	6.9	16	2.9	1.7
8/7-17/78	9	3.8	4.0	16	8.9	7.7
8/6-14/79	9	6.1	7.8	16	6.8	6.2
8/4-14/80	9	8.6	7.2	16	5.1	5.6

Appendix Table 3A. Catch of walleye in 4-inch mesh commercial gillnets, Minnesota waters of Rainy Lake, 1949-79.

Year	Tallied[a/] Footdays	Tallied[a/] Catch (lbs)	CUE (lbs/1000 ft)	Reported[b/] Catch	Adjusted[c/] Footdays
1949	791,700	22,891	28.9	34,534	1,181,803
1950	930,600	40,669	43.0	57,698	1,327,942
1951	1,131,500	21,080	16.0	26,086	1,613,520
1952	996,500	17,457	17.5	22,783	1,288,427
1953	898,300	20,519	22.8	22,180	962,750
1954	1,043,000	18,164	17.4	33,457	1,902,937
1955	857,500	23,969	28.0	35,693	1,261,572
1956	1,264,300	33,216	26.3	28,090	1,433,316
1957	939,700	30,736	32.0	36,703	1,135,111
1958	855,000	17,897	20.9	18,661	883,640
1959	851,500	18,776	22.1	20,540	919,803
1960	966,100	27,245	28.2	27,662	966,100
1961	1,109,300	33,463	30.1	33,817	1,109,300
1962	997,100	22,224	22.3	23,470	1,041,585
1963	667,350	16,770	25.1	16,827	667,350
1964	360,600	5,782	16.0	5,433	360,600
1965	463,500	10,873	23.5	7,734	463,500
1966	502,500	11,484	22.8	11,852	502,500
1967	195,400	7,383	37.8	7,625	195,400
1968	227,400	6,783	29.8	7,171	227,400
1969	49,600	1,592	32.1	1,628	49,600
1970	156,400	3,827	24.5	3,913	156,400
1971	212,100	9,667	45.6	9,670	212,100
1972	267,500	9,941	37.2	10,104	267,500
1973	324,500	15,318	47.2	15,641	324,500
1974	266,100	14,878	55.9	14,923	266,100
1975	312,800	14,737	47.1	14,930	312,800
1976	266,000	19,025	71.5	19,178	266,000
1977	235,700	17,009	72.2	26,503	235,700
	4¼[d/] 132,900	9,227	69.4		

a/ Taken from fishermen's monthly records, complete data only.
b/ Total reported, may include 4", 4¼, 5 and 5¼ inch mesh data.
c/ Reported catch x .989 (to compensate for 5¼" mesh catch) ÷ C.P.E.
d/ 4¼" mesh gillnet. Switch was voluntary.

Appendix Table 3A (con't). Catch of walleye in 4-inch mesh commercial gillnets, Minnesota waters of Rainy Lake, 1949-79.

Year	Tallied[a/] Footdays	Tallied[a/] Catch (lbs)	CUE (lbs/1000 ft)	Reported[b/] Catch	Adjusted[c/] Footdays
1978	227,800	13,557	59.5	19,914	227,800
4¼[d/]	110,700	6,284	56.8		
1979[e/]	171,900	8,911	51.8	13,412	171,900
4¼[d/]	105,000	4,414	42.0	22,994	308,400
1980	308,400	15,294	58.0		
4¼[d/]	132,000	7,659	49.6		

a/ Taken from fishermen's monthly records, complete data only.

b/ Total reported, may include 4", 4¼, 5 and 5¼ inch mesh data.

c/ Reported catch x .989 (to compenstate for 5¼" mesh catch) ÷ C.P.E.

d/ 4¼" mesh gillnet. Switch was voluntary

e/ Decrease in effort due to illness of one fisherman.

Appendix Table 4A. Total commercial fish production by species, in pounds, Rainy Lake, 1963-77.

Year of Catch

Species	1963	1964	1965	1966	1967
Walleye[a/]					
Ontario	113,531	65,195	73,956	87,207	70,367
Minnesota	16,831	5,433	13,149	11,859	7,632
Both	130,362	70,628	87,105	99,066	77,999
Northern Pike					
Ontario	129,259	136,669	153,895	124,891	134,947
Minnesota	10,336	5,923	9,610	8,588	4,365
Both	139,595	142,592	163,505	133,479	139,312
Tullibee[b/]					
Ontario	80,014	77,964	54,538	59,338	82,373
Minnesota	23,872	12,178	14,522	13,014	10,280
Both	103,886	90,142	69,060	72,352	92,653
Whitefish					
Ontario	25,769	36,838	27,109	24,174	44,800
Minnesota	12,069	25,108	17,263	15,028	17,242
Both	37,838	61,946	44,372	39,202	62,042
Perch					
Ontario	1,646	1,767	889	1,165	2,365
Minnesota	215	27	86	79	51
Both	1,861	1,794	975	1,244	2,416
Burbot					
Ontario	81,950	95,188	55,504	32,995	41,974
Minnesota	38,908	20,412	14,202	10,357	6,972
Both	120,858	115,600	69,706	43,352	48,946
Sucker[c/]					
Ontario	188,810	159,587	149,394	154,915	184,043
Minnesota	22,780	22,091	19,883	26,268	20,564
Both	211,590	181,678	169,277	181,183	204,607
Sturgeon[d/]					
Ontario	4,453	3,142	1,275	1,461	355
Minnesota	--	--	--	--	--
Both	4,453	3,142	1,275	1,461	355

a/ Includes sauger
b/ Includes goldeye
c/ White sucker and redhorse sucker
d/ Includes caviar

Appendix Table 4A. (con't)

Year of Catch

Species	1963	1964	1965	1966	1967
Crappie					
Ontario	---	---	---	3,039	5,183
Minnesota	---	---	---	---	---
Both	---	---	---	3,039	5,183
Total					
Ontario	625,432	576,350	516,560	489,185	566,417
Minnesota	125,011	91,172	88,715	85,193	67,106
Both	750,443	667,522	605,275	574,378	633,513

Appendix Table 4A. (con't)

Year of Catch

Species	1968	1969	1970	1971	1972
Walleye[a/]					
Ontario	69,872	51,497	49,954	27,284	18,931
Minnesota	7,173	1,628	3,923	9,670	10,104
Both	77,045	53,125	53,877	36,954	29,035
Northern Pike					
Ontario	149,649	134,599	128,063	83,380	60,394
Minnesota	4,435	1.960	3,131	4,040	6,273
Both	154,084	136,559	131,194	87,420	66,667
Tullibee[b/]					
Ontario	99,232	80,125	38,895	35,370	23,428
Minnesota	8,053	3,409	5,644	2,301	4,383
Both	107,285	83,534	44,539	37,671	27,811
Whitefish					
Ontario	60,627	50,244	41,290	45,744	60,765
Minnesota	47,188	28,276	17,546	5,742	15,548
Both	107,815	78,520	58,836	51,486	76,313
Perch					
Ontario	1,605	1,554	1,197	502	132
Minnesota	76	---	40	3	87
Both	1,681	1,554	1,237	505	219
Burbot					
Ontario	54,154	73,697	79,117	54,577	64,023
Minnesota	6,508	3,170	4,718	3,076	6,255
Both	60,662	76,867	83,835	57,653	70,278
Sucker[c/]					
Ontario	186,586	194,385	216,910	128,842	115,665
Minnesota	15,048	6,904	8,560	6,454	10,530
Both	210,634	210,289	225,470	135,296	126,195
Sturgeon[d/]					
Ontario	1,629	1,286	469	536	234
Minnesota	---	---	---	---	---
Both	1,629	1,286	469	536	234

a/ Includes sauger
b/ Includes goldeye
c/ White sucker and redhorse sucker
d/ Includes caviar

Appendix Table 4A. (con't)

Year of Catch

Species	1968	1969	1970	1971	1972
Crappie					
Ontario	7,652	12,308	53,186	81,972	28,815
Minnesota	---	---	---	---	---
Both	7,652	12,308	53,186	81,972	28,815
Total					
Ontario	631,006	599,695	609,081	458,207	372,407
Minnesota	88,481	45,347	43,562	31,286	53,180
Both	719,487	645,042	652,643	489,493	425,587

Appendix Table 4A. (con't)

Year of Catch

Species	1973	1974	1975	1976	1977
Walleye[a/]					
Ontario	21,433	28,641	36,417	25,075	34,531
Minnesota	15,641	14,924	14,934	19,182	26,515
Both	37,074	43,565	51,351	44,257	61,046
Northern Pike					
Ontario	67,496	72,918	66,166	67,680	72,567
Minnesota	8,556	6,659	6,070	5,433	10,821
Both	76,052	79,577	72,236	73,113	83,388
Tullibee[b/]					
Ontario	33,628	16,100	17,775	22,747	29,602
Minnesota	4,900	3,178	2,794	3,721	4,151
Both	38,528	19,278	20,569	26,268	33,753
Whitefish					
Ontario	68,416	46,915	37,350	48,829	77,422
Minnesota	30,244	28,384	24,385	27,801	23,682
Both	98,660	75,299	61,735	76,630	101,104
Perch					
Ontario	14	17	2	35	2
Minnesota	6	21	2	---	2
Both	20	38	4	35	4
Burbot					
Ontario	44,811	68,167	45,680	43,585	42,511
Minnesota	5,340	4,820	5,545	5,255	11,061
Both	50,151	72,987	51,225	48,840	53,572
Sucker[c/]					
Ontario	157,227	178,686	129,966	123,104	213,814
Minnesota	10,682	7,172	8,066	8,949	15,158
Both	167,909	185,858	138,032	132,053	228,972
Sturgeon[d/]					
Ontario	23	---	---	61	---
Minnesota	---	---	---	---	---
Both	23	---	---	61	---

a/ Includes sauger
b/ Includes goldeye
c/ White sucker and redhorse sucker
d/ Includes caviar

Appendix Table 4A. (con't)

Year of Catch

Species	1973	1974	1975	1976	1977
Crappie					
Ontario	16,397	5,204	1,871	949	1,670
Minnesota	---	---	---	---	---
Both	16,397	5,204	1,871	949	1,670
Total					
Ontario	409,484	416,648	335,768	332,142	472,261
Minnesota	75,369	65,197	61,796	70,341	91,384
Both	484,853	481,845	397,564	402,483	563,645

Appendix Table 4A. (con't)

Year of Catch

Species	1978	1979	1980
Walleye[a/]			
Ontario	24,979	35,850	na
Minnesota	19,929	13,424	23,008
Both	44,908	52,274	na
Northern Pike			
Ontario	91,347	84,499	na
Minnesota	9,191	7,481	10,256
Both	100,538	91,980	na
Tullibee[b/]			
Ontario	18,068	12,407	na
Minnesota	3,737	3,228	4,776
Both	21,805	15,635	na
Whitefish			
Ontario	80,546	45,442	na
Minnesota	45,854	44,382	40,214
Both	126,400	89,824	na
Perch			
Ontario	12	3	na
Minnesota	10	---	---
Both	22	3	na
Burbot			
Ontario	27,318	13,752	na
Minnesota	8,426	8,694	9,645
Both	35,744	22,446	na
Sucker[c/]			
Ontario	132,639	136,954	na
Minnesota	15,869	18,928	24,493
Both	148,508	155,882	na
Sturgeon			
Ontario	---	---	na
Minnesota	---	---	---
Both	---	---	na

a/ Includes sauger
b/ Includes goldeye
c/ White Sucker and Redhorse Sucker
d/ Includes Caviar