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Fishery Resources for Lake of the Woods, Minnesota

Agricultural Experiment Station
University of Minnesota

Fishery Resources

of Lake of the Woods, Minnesota

Eugene G. Heyerdahl* and Lloyd L. Smith, Jr.
Department of Entomology, Fisheries, and Wildlife
University of Minnesota
St. Paul, Minnesota 55101

*Present address: National Marine Fisheries Service, Northeast Fisheries Center, U.S. Department of Commerce—NOAA, Woods Hole, Massachusetts 02543

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INTRODUCTION

Lake of the Woods is one of five Minnesota lakes with both sport fishing and a commercial fishery operating simultaneously. It offers fine sport fishing especially for walleye pike (*Stizostedion vitreum v.*), and since 1890 it has had a regulated commercial fishery using several kinds of nets authorized by the Minnesota State Legislature. These nets are: gill nets, pound nets, staked trap nets, submerged trap nets, fyke or hoop nets, and trawl nets. Sport fishermen annually harvest approximately 3/4 million pounds of fish and commercial fishermen harvest an average of 3-1/2 million pounds from the American and Canadian sides of the lake combined. Game fish constitute 30-35 percent of the total commercial catch and over 95 percent of the sport fishing catch.

Lake of the Woods, the 40th largest freshwater lake in the world, lies on the international boundary between Minnesota and the Canadian Provinces of Manitoba and Ontario. Carlander (1942) wrote a detailed description of the lake. The lake occupies 1,485 square miles in area, about 1/3 of which (470 square miles) lies within Minnesota (figure 1). The northern 2/3 of the lake (Ontario) has a very irregular shoreline and contains some 14,000 islands, but the Minnesota portion is a large open water expanse about 28 miles wide and 34 miles long containing only 25 islands (figure 2).

The Minnesota basin is very shallow with a maximum depth of 39 feet and an average depth of 24 feet. It has a soft mud bottom at depths greater than 15 feet, and the area of the basin less than 15 feet deep comprises 23 percent of Minnesota waters. The Rainy River is the principal tributary and provides 78 percent of the incoming water to the lake. The outlet from the lake, the Winnepeg River, is located at Kenora, Ontario, where several dams control the lake level and provide power to local industry. A detailed listing of the fauna and flora is found in Carlander (1942). The addition of the ninespine stickleback, *Pungitius pungitius* (Linneaus), was not recorded by Carlander but was collected during the present study.

Because the commercial fishery harvests game species as well as commercial species, the fishery has been criticized over the years and many persons have suggested that it cease operations completely. This controversy brought about a survey by the Minnesota Department of Conservation from 1939 to 1941, reported by Carlander in 1942. Based on the results of this report and realizing the rise in sport fishing pressure particularly during the last 10 years, the conservation department has carried out a management program to effect a gradual reduction of commercial fishing. This has been accomplished by not allowing the transfer of commercial licenses lost to the fishery through death or retirement.

This management approach has been complicated by the development of a large and important mink ranching industry in the local area which has relied on the fish resource of the lake as an inexpensive food source. Consequently, the problem facing the state conservation department has been to reduce the commercial catch of game fish without reducing the supply of commercial fish to the mink ranchers. The development and use of a submerged trap net and a trawl net were attempts along this management approach.

Although the submerged trap net never gained in popularity and subsequent use, the trawl net became an immediate success. Two experimental trawling permits were issued during 1961 and 1962. Each boat had a state employee aboard to record the catch and other data required to evaluate the use of trawls for future fishing and to verify that the operation was done

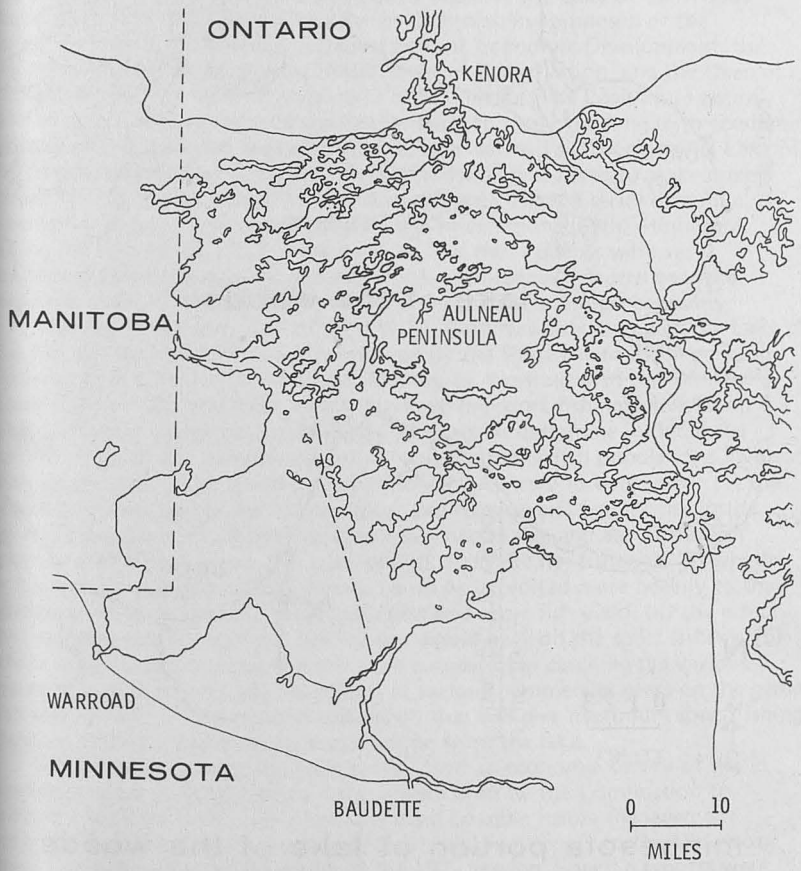
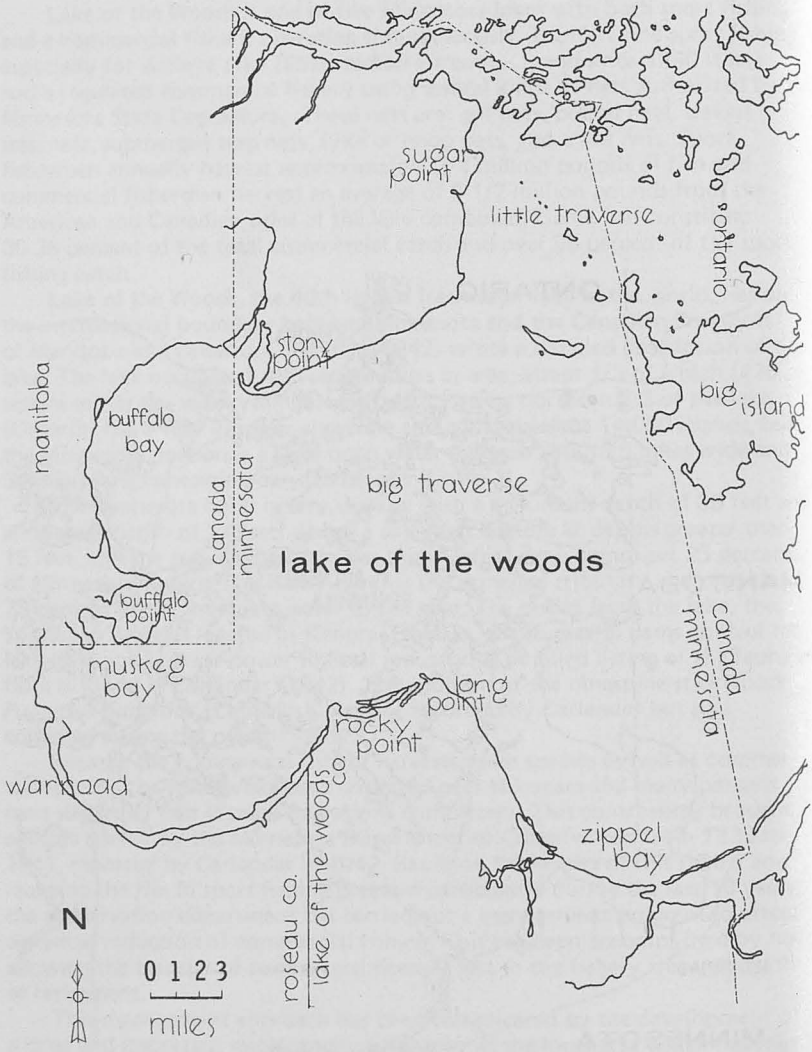


Figure 1. Map of Lake of the Woods, United States and Canada.



minnesota portion of lake of the woods

Figure 2. Map showing Minnesota portion of Lake of the Woods.

according to the permit conditions. After the two seasons of experimental operation, state legislation was passed authorizing two trawl net licenses to fish under commercial license during 1963 and 1964.

Many local people opposed the introduction of trawl fishing on Lake of the Woods. This appeared to stem from: (a) the existing commercial fishermen's fear of competition; and (b) some sportsmen's fear that the trawling operation would reduce the quality of sport fishing in the lake. This local opposition continued to grow through the 1963 and 1964 fishing seasons and by 1965 was able to convince the state legislature not to renew the licenses. Those persons involved in trawl fishing lost a large amount of potential earnings and their invested capital stagnated. Consequently, from 1965 to 1967, many Minnesotans wrote letters about trawling to their legislators.

When the Minnesota State Legislature met in 1967, the representatives from the Lake of the Woods area recognized the need for some definite answers to this problem. In response, a bill was passed creating the Lake of the Woods-Rainy Lake (LW-RL) Legislative Interim Commission composed of the Commissioner of the Minnesota Department of Economic Development, the Commissioner of the Minnesota Department of Conservation, and the Dean of the Institute of Agriculture, University of Minnesota. The Legislature appropriated money and authorized the Commission to study the long-term economic outlook of this northern area of the state, later defined as Koochiching, Lake of the Woods, and Roseau Counties. The Commission was asked to make recommendations to the Legislature in regard to this area. After a series of public hearings in Roseau, Warroad, Baudette, and International Falls, Minnesota, during the summer of 1967, it was evident that the residents were very concerned about the area's economic health with special concern over the economic status of the fisheries and related sectors of the local economy.

This report is a summary of the LW-RL Commission's survey of the Lake of the Woods Commercial Fishery conducted by the Department of Entomology, Fisheries, and Wildlife, University of Minnesota. Working with the Minnesota Department of Conservation, which surveyed the sport fishing activities on the lake, University personnel established a program to determine in detail the current status of the commercial fishery and the major fish populations involved with its operation. The specific program objectives were to determine: (1) the population structure of the various sport and commercial fish species in the lake; (2) the catch characteristics with reference to size and age of the fish species taken by the trawl, gill, trap, pound, and fyke net fisheries; (3) whether or not certain commercial fish species could be exploited more heavily to the advantage of both total protein production and sport fish yield; (4) the effect that stopping the commercial fish harvest would have on the sport fishery; (5) which types of commercial gear are most successful in catching the various commercial fish species; (6) the effects of various commercial gears on the game fish species; and (7) the type of utilization that will give maximum sport fishing together with maximum protein production from the lake.

Results of this study, the creel survey, and an economic survey of the combined sport and commercial fishery were used by the Commission to provide a basis for prediction of results from possible future management options. Their conclusions were spelled out in a final report to the Minnesota State Legislature during the spring of the 1971 session. Specific reports were prepared by Whitney, Leirfallom, and Berg (1971).

The authors wish to acknowledge the help of William A. Swenson, Kenneth M. Muth, Bruce W. Hawkinson, and a number of other laboratory assistants in collecting and compiling the data used in this study. Acknowledgement is given also to V. Macins, Kenora, Ontario, and R. Thompson,

Rainy River, Ontario, for providing insight and catch statistics on the fishery on the Canadian waters of the lake and to D. Schupp and W.J. Scidmore, Minnesota Department of Conservation, for their help in collecting and compiling data on the Minnesota fishery. The management of the Selvog Fish Company and the commercial fishermen have cooperated throughout the study. Financial aid has been given by the Minnesota Department of Natural Resources and the University of Minnesota Agricultural Experiment Station.

MATERIALS AND METHODS

Collection of the Samples

To collect information on the Lake of the Woods commercial fishery, a sampling schedule was established that began in early June and continued until late October from 1968 to 1970. Different weeks through the season were devoted to sampling the catch of the various standard gear types either on the lake or at the fishery plant located in Warroad, Minnesota. Measurements of the various fish species caught by a gear were recorded, and either scales or otoliths were collected for subsequent analyses.

In addition to sampling the standard commercial gear, a schedule was established to evaluate the performance of the commercial-sized trawl (65-88 foot head rope, 3-1/8 to 3-1/2 inch stretch mesh cod) with particular reference to its past performance during 1961-64. Eleven weeks, spaced through the season, or about 43 percent of the total commerical season, were included in the schedule. All fishing trips were monitored by University research personnel and a Minnesota State Conservation Officer. Complete records were kept of the species composition of each catch, the amount of time spent fishing, and the area of the lake where each catch was made. Two different sizes of mesh nets were used to help determine the appropriate mesh size for optimum utilization of the lake's fish populations.

To promote a better understanding by the general public of the Lake of the Woods commercial fishery and its methods of operation and catch, demonstration tours to accompany and observe a day's trawling were encouraged. Sportsmens clubs, resort associations, civic groups, government representatives, and other interested persons were invited to reserve a date for a tour through the University Extension Service. During the 3 study years, 64 reservations were made.

To test for the influence of the trawl operation on the bottom flora and fauna and for water quality of the lake, test areas were established and samples collected in areas where no trawling occurred, areas scheduled for trawling, and areas where trawling occurred. During 1968 and 1969, 217 bottom samples and 9 water samples were collected from these areas. In addition, seasonal monitoring of the lake temperature and light penetration into the lake was carried out.

To obtain samples not provided through observation of commercial catches, a program of experimental netting was begun with a gill net of varying meshes (250 feet long with five mesh sizes, 1-1/2 to 4-inches stretch measure). The conservation department uses this type of sampling gear extensively throughout the state, and the information obtained provides data for comparison with the Carlander survey, 1939-1941, and with other state waters.

Along with the program of experimental gill netting, a program of experimental trawling with a small sample trawl (25 foot head rope, 1/4-inch bar mesh with 1/8-inch bobbinet liner) was carried out to study the interrelationships of selected fish populations in the lake. In this regard, stomach samples

from young and older fish were collected for specified times during the summer and for specified 24-hour periods during 1968-1970. Sample trawling also provided comparative data on the abundance of various forage species of fish.

A tagging program provided information on the movement of walleyes in Lake of the Woods. During the early summers of 1969 and 1970, 997 and 939 walleyes, respectively, were tagged and released. Tag returns were monitored from both the commercial and sport fishing catches.

The measurements on all fish except burbot were fork length (from the tip of the snout to the point on the caudal fin where the greatest depth of the fork occurred) to the nearest 0.1 inch, and total weight, measured with a spring balance, was to the nearest 0.1 ounce. The measurements were total lengths for burbot. Scale samples were selected from the "key scale area" for each species. Otolith samples were collected from the burbot. Most commercial catch samples were made without knowledge of the sex of the individual, because most commercial fish are shipped to the market in the round.

Catch statistics were compiled from the summaries in Carlander (1942) and Burrows (1951) and from current fishery records. (See appendix tables.) As regulated by state statute, each licensed commercial fisherman must maintain a daily record of the area of the lake fished, the total amount of netting used, and the catch, in pounds, for each species. From these records, summaries of the total catch and fishing effort were tabulated and subsequent calculations of catch per unit of effort were made.

THE COMMERCIAL FISHERY

Organization, Framework, and Historical Development

The development of the Lake of the Woods commercial fishery has been traced from its beginnings in the late 1880's to 1941 (Carlander, 1942). Accordingly, the industry began with the fishing of commercial pound nets around 1885. By 1894, the fishery had grown so in importance that the Minnesota Board of Game and Fish Commissioners recommended to the State Legislature that regulatory actions be enacted to protect this important industry. As a result, regulations were established in 1895 specifying the season length, the number of nets permitted each license holder, the size of the nets and their mesh, and the areas in the lake that could be fished. Provisions were also made for recording the annual catches.

The fishery grew rapidly during the early years and by 1896 more than 300 pound nets were being fished by Minnesota and Canadian fishermen. Changes in fish populations preceded changes in regulations and in the amount of gear fished (table 1), generally tending toward greater restriction of the amount of licenses allowed and of the amount of netting each licensee could fish. Some of the more important changes included the establishment of size limits for certain species in 1905, the use of fyke nets in 1911 and gill nets in 1913, and the setting of a commercial fishing season in 1911.

Regulations had stabilized by 1941. Size limits were established for walleyes, saugers, northern pike, and whitefish; sturgeon, muskellunge, bass, and crappies were protected. Six pound nets, 10 fyke nets, or 4,000 feet of gill net were allowed per license holder. The season opening was set at June 1, and a helper's license was required to help a fisherman lift his nets. The precedent had been established for setting aside closed areas to avoid fishing conflicts between sports and commerical fishermen. These regulations have remained virtually unchanged to the present day.

Table 1. Commercial fishing regulations, 1895 to 1970

Year	General	Gear	Zones
1895	All species permitted. Season closed from April 1 to May 20.	50 pound nets per license.	Closed within 500 feet of the mouth of a stream.
1905	Size limits: lake trout & whitefish, 2 lbs.; walleye, 14 in.; sauger, 10 in.; muskellunge, 30 in.		
1911	Size limits: whitefish, 2-1/2 lbs.; walleye, 14 in. or 1 lb.; sturgeon, 15 lbs. (dressed).	Domestic gill nets permitted: 200 feet, 5 in. mesh, December 1 to March 1. 30 fyke nets per license. 25 pound nets per license: total for lake, 76; only 2 nets per string.	Closed within 1 mi. of the Warroad River mouth.
1913		10 pound nets per license; lake total, 100. Commercial gill net: 750 feet per license, 5 in. mesh. Domestic gill net: 100 feet per license plus 1 fyke net.	
1915	Season extended to include December through February.		
1917	Season extended through March.	5 fyke nets per license. 1,000 feet gill net per license: 4 in. mesh, 75,000 feet for lake total.	
1919		1 pound net station or 2 gill net boats per license. 10 fyke nets per license.	Closed within 3 mi. of the Rainy River mouth.
1923	Blackbass, rockbass, crappies, and sunfish protected. Must fish within 30 days from the beginning of new season or forfeit license. Eliminate pound net-gill net licenses. Season opening delayed to June 1.	7 pound nets per license; lake total of 60. 2,000 feet gill net per license.	Closed within 2 mi. of the mouths of the Warroad and Rainy Rivers.
1925	Size limits: N. pike, 14 in.; perch, bullhead, & crappie, 7 in.; whitefish, 16 in. Muskellunge protected. Fish buyers license required.	6 pound nets per license. Total gill net footage for lake, 90,000 feet.	All of 4-mile Bay closed.
1929	Must lift own nets if fishing.		
1931		4,000 feet gill net per license.	
1932	Season opening, May 15.		
1936	Season opening, June 1.	Gill nets of 30 meshes in depth permitted.	

Table 1. (continued)

Year	General	Gear	Zones
1940		Gill nets of 75 meshes in depth permitted.	
1941	Size limits: between 15 and 27 in.; sauger, 12 in.; N. pike, 18 in.; perch, 8 in.; bullhead, 10 in. Sturgeon protected. Helper's license required to help lift nets.		Closed within 80 rods of of the mouth of Morris gap.
1942		Gill nets of 50 meshes in depth permitted.	
1945	Season length from June 1 to December 31.		Closed around Oak & Flag Islands.
1946		Gill nets of 30 meshes in depth permitted.	
1947	Size limits on perch & bullhead removed. All licenses to operate only within designated areas.	3,000 feet gill net per license: lake total of 80,000 feet.	
1948	Nets for rough fish may operate in closed areas from Oct. 1 to March 1. No new gill net licenses issued.	Staked trap nets recognized.	
1950	Rough fish season from Oct. 1 to April 1. Operators may fish only 1 license.	Steel rule adopted to measure gill net mesh.	Closed within 1 mi. of the south shore from the Rainy River to Rocky Pt.
1952		Submerged trap nets authorized: may transfer gill net license to trap net license. Total gill net footage for lake: 70,000 feet.	
1953	State confication of illegal fish. Rough fish season from Sept. 1 to Apr. 1.		
1955		Trap & pound net mesh between 2-1/2 - 4 in. Total gill net footage for lake: 69,000 feet.	
1958			Closed within 1 mi. of the south and west shore from the Rainy River to the Manitoba border.
1959	Designated fishing areas abolished. No transfers of gill net licenses allowed.		
1962		Three nets per string allowed for rough fish sets.	
1963		Two commercial trawls permitted.	

Table 1. (continued)

Year	General	Gear	Zones
1965	Helpers may lift nets alone.	Commercial trawling recinded.	
1966		4,000 feet of gill net per allowed from June 20 to July 31 if no gill net fishing done before June 20.	Closed within 2 mi. of the mouth of the Rainy River between Pine and Curry's Islands, within Muskeg Bay to gill nets before June 20, & within the Angle Inlet.
1967	Season from June 1 to Oct. 31.		
1969	Season from June 1 to Nov. 7.	4,000 foot gill net option deleted.	

Major changes in regulations that have occurred since 1941 have been: a reduction from 4,000 to 3,000 feet of gill net allowed per license (1947), no new gill net licenses issued (1950), the size of the gill nets limited to 30 meshes in height (1946), an extension of the areas closed to commercial fishing (1945, 1950, 1958, and 1966), the commercial fishing season limited from June 1 to December 31 (1945) and later reduced to November 7 (1969), and the establishment of commercial trawling from 1961 to 1964.

The total size of the fishing operation has changed through the years, and today only 23 licensed fishermen are in the industry. Table 2 shows the number of nets that have been licensed since the 1880's.

Table 2. Commercial nets licensed for Minnesota waters of Lake of the Woods, 1888-1970 expressed as total number licensed and as a percentage of the 1958-1967 average

	Gill Nets		Pound & trap nets		Fyke nets	
Year	Ft. Lisc. (1,000)	Percent	No. Lisc.	Percent	No. Lisc.	Percent
1888	–		4	11.3	–	
1889	–		10	28.2	–	
1890	–		17	47.9	–	
1891	–		21	59.2	–	
1892	–		52	146.5	–	
1893	–		91	256.3	–	
1894	–		146	411.3	–	
1895	–		193	543.7	–	
1896	–		193	543.7	–	
1897	–		145	408.5	–	
1898	–		107	301.4	–	
1899	–		107	301.4	–	
1900	–		81	228.2	–	
1901	–		74	208.5	–	
1902	–		68	191.5	–	
1903	–		68	191.5	–	
1904	–		62	174.6	–	
1905	–		66	185.9	–	
1906	–		56	157.7	–	
1907	–		50	140.8	–	
1908	–		54	152.1	–	
1909	–		79	222.5	–	
1910	–		90	253.5	–	
1911-12	–		76	214.1	30	145.6
1913-16	–		100	281.7	30	145.6

Table 2. (continued)

Year	Gill Nets		Pound & trap nets		Fyke nets	
	Ft. Lisc. (1,000)	Percent	No. Lisc.	Percent	No. Lisc.	Percent
1917-23	75	116.7	100	281.7	30	145.6
1923-24	75	116.7	60	169.0	30	145.6
1925-31	90	140.0	60	169.0	100	485.4
1932	88	136.8	60	169.0	89	432.0
1933	90	139.9	60	169.0	95	461.2
1934	87	135.3	60	169.0	90	436.9
1935	89	138.4	60	169.0	89	432.0
1936	85.5	132.9	60	169.0	83	402.9
1937	88.5	137.6	60	169.0	96	466.0
1938	90	140.0	60	169.0	90	436.9
1939	85	132.2	60	169.0	89	432.0
1940	89	138.4	56	157.7	90	436.9
1941	88	136.9	59	166.1	89	432.0
1942	80.5	125.2	50	140.8	66	320.4
1943	90	140.0	40	112.6	70	339.8
1944	86.5	134.5	63	177.5	54	262.1
1945	86	133.7	50	140.8	20	97.1
1946	86	133.7	61	171.8	18	87.4
1947	80.5	125.2	63	177.5	24	116.5
1948	77.5	120.5	50	140.8	32	155.3
1949	80.5	125.2	52	146.5	45	218.4
1950	74.5	115.9	56	157.7	53	257.2
1951	65.5	101.9	44	123.9	60	291.3
1952	70	108.9	37	104.2	60	291.3
1953	70	108.9	38	107.0	59	286.4
1954	70	108.9	41	115.5	60	291.3
1955	67.5	105.0	38	107.0	60	291.3
1956	67.5	105.0	32	90.1	43	208.7
1957	67.5	105.0	26	73.2	23	111.7
1958	68.5	106.5	35	98.6	16	77.7
1959	66	102.6	35	98.6	15	72.8
1960	69	107.3	35	98.6	10	48.5
1961	69	107.3	44	123.9	18	87.4
1962	66	102.6	34	95.8	13	63.1
1963	60	93.3	23	64.8	25	121.4
1964	57	88.6	23	64.8	23	111.7
1965	63	98.0	41	115.5	30	145.6
1966	64	99.5	43	121.1	33	160.2
1967	60	93.3	42	118.3	23	111.7
1968	54	84.0	35	98.6	20	97.1
1969	51	79.3	20	56.3	10	48.5
1970	45	70.0	12	33.8	20	97.1

Operation of the Fishery

All commercial fishing operations are carried out by experienced individuals who in many instances have grown up in families where the father or even grandfather were commercial fishermen. These operators may fish together, usually in a family group, or may fish independently. The fishing grounds of the permanently attached pound and staked trap nets are reserved each year for the same fishermen. Gill net fishermen, although at one time also restricted to a certain fishing area, have been permitted since 1959 to fish anywhere within the Minnesota boundaries of the lake except for the specified closed areas.

The type and size of boat used for fishing vary. Gill and fyke net operators who fish near their docking facilities use outboard motor driven boats (about

17′ long), while the pound and trap net operators use larger vessels (20-25′ long) capable of being used as both a working boat and transport vessel to bring the catch to shore. Gill net operators who fish on the north side of the lake may also use a larger transport launch with their smaller working boats. The commercial trawlers, operating from 1961 to 1964, were larger vessels (43′ long) capable of hauling 7-8 tons of fish while being used for fishing at the same time.

Of the 38 species of fish in the lake, 7 are currently caught in commercial quantities:

walleye — *Stizostedion vitreum vitreum* (Mitchill)
sauger — *Stizostedion canadense* (Smith)
northern pike — *Esox lucius* (Linnaeus)
tullibee — *Coregonus artedii* LeSeuer (formerly *C. aretedii tullibee*) (Richardson)
yellow perch — *Perca flavescens* (Mitchill)
burbot — *Lota lota* (Linnaeus)
white sucker — *Catostomus commersoni* (Lacèpède)

Quillback, *Carpiodes cyprinus* (LeSueur); northern redhorse, *Moxostoma aureolum* (LeSueur); and black bullhead, *Ictalurus melas* (Rafinesque) together form a minor contribution. Lake sturgeon, *Acipenser fulvescnes* (Rafinesque); lake whitefish, *Coregonus clupeaformis* (Mitchill); and goldeye, *Hiodon alosoides* (Rafinesque), once important species, are rarely caught. (Sturgeon have been totally protected since 1941.)

The game fish that are caught are sold for human consumption either locally or to a fish buyer, and the commercial fish are sold to local mink ranches as animal food. Details on individual species will be presented in later sections.

Annual Catch

Records of the annual catches have been kept since 1888 for some species and since 1932 for all species. Carlander summarized the records for the years 1888 through 1941 in 1942. Records for catches from 1942 through 1969 have been obtained from Minnesota Department of Conservation files.

Figure 3 shows the average annual catch for all species over a 5-year interval and the average species composition over that interval. After going through an early growth period resulting in overfishing for the sturgeon, the industry readjusted and since 1910 has been quite stable, the catch fluctuating between 1-2 million pounds annually. The large increase in the 1960-64 average catch was due to the combined effect of very good tullibee and burbot fishing and the introduction of commercial trawling from 1961 to 1964. The species composition of the commercial catch has changed markedly since the early years of fishing from a catch which was virtually 100 percent game fish destined for human markets to a catch which is only 15 percent game fish and 85 percent commercial fish. The latter is marketed to local area mink ranchers as animal food.

Figure 4 shows a similar plot for the Ontario catch from the lake. Again the average catch has fluctuated between 1-2 million pounds annually since 1910, except for the 1960-64 period when the catch increased, this time without the influence of trawling. Changes in species composition of the Ontario catch have tended to shift in the same direction as Minnesota catches have but not to the same degree (50 percent game fish, 50 percent commercial fish). This is due in part to the fact that

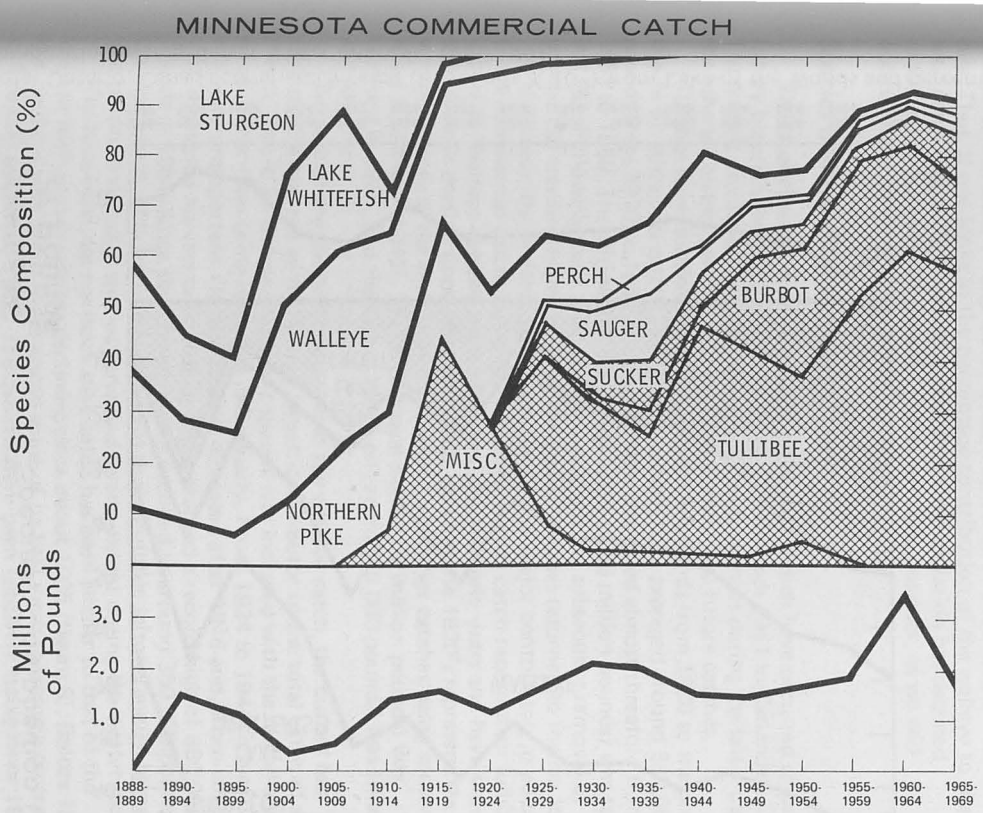


Figure 3. Total Minnesota commercial catch (in pounds X 10^6) from Lake of the Woods and percentage species composition averaged over 5-year intervals, 1888-1969.

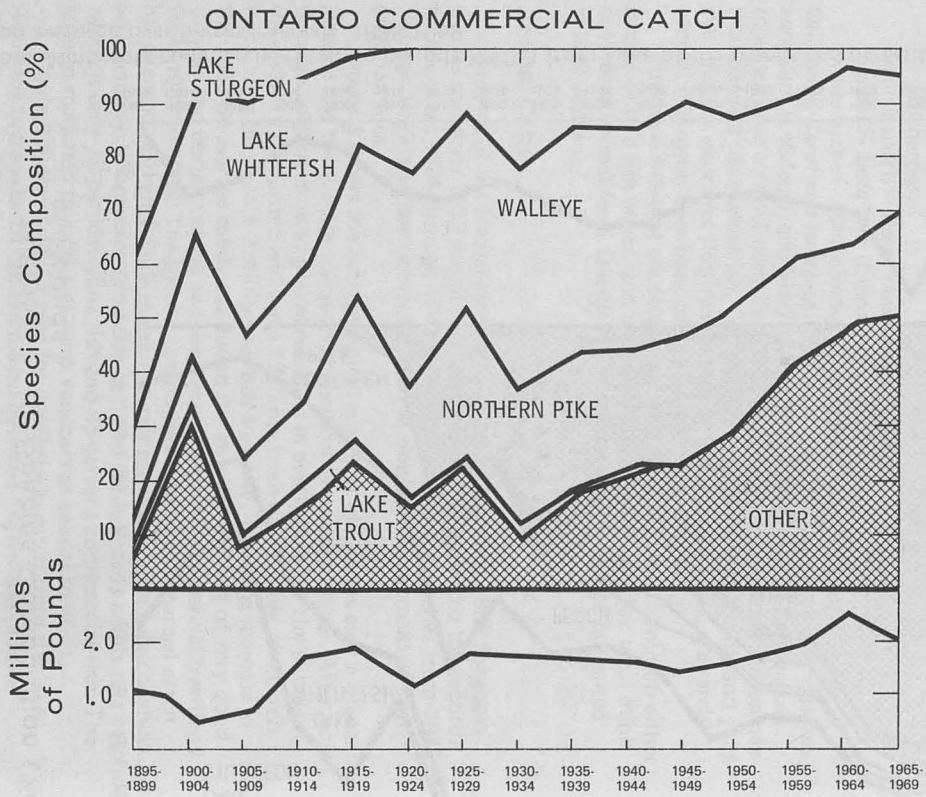


Figure 4. Total Ontario, Canada commercial catch (in pounds X 10^6) from Lake of the Woods and percentage species composition averaged over 5-year intervals, 1895-1967.

the Ontario portion of the lake is not as suitable in habitat for the commercial fish species, principally tullibee, as is the Minnesota portion of the lake. Also the local market for Ontario commercial fish has not been developed as it has been in Minnesota.

Although they accurately depict the structure of the existing commercial catches, percentage composition figures may not accurately describe changes in individual species catches and may be misleading when used to interpret the population status of the species. This is because if the catch of one species increases greatly, the percentage contribution of other species to the total catch may decrease even though their catches actually increased. The determining factor is the magnitude of the changes in each case. Thus, if one looks at the percentage contribution of the walleye to the total catch (figure 3), it would appear that the population has declined sixfold since the 1920-24 period. This is not true, however, as we will discuss later.

Species contribution to the total catch

The large changes in the species contribution which have occurred since the fishery began in the 1880's have been detailed through 1941 in Carlander, 1942. The present discussion will, therefore, deal with changes during the latter part of the fishery's history, with implications to present and future catches.

Tullibee have dominated the total catch in pounds from 1930 to the present (figure 5). Although catches fluctuated widely, they averaged around 580,000 pounds from 1930 to 1957 after which they increased almost threefold from 1958 to 1969. The alltime record annual catch (2.66 million pounds) was taken in 1962. Following these peak harvest years and the subsequent removal of commercial trawling from the lake, the annual catches returned to former levels.

Until recently, walleye have been the second major contributor, in pounds, to the commercial catch, but show a much different catch record than tullibee (figure 6). Walleye catches were highest during the early years and have shown a continuous decline since 1940. The peak years in the 1930's represent the best walleye catches in the history of the fishery, with prior catches being somewhat lower (Carlander, 1942). The best annual catch (1.2 million pounds) was recorded in 1935, and the lowest catch on record (79,000 pounds) was taken in 1969.

Because of the continued decline in the walleye catch, the burbot has replaced the walleye as the second largest contributor to the total catch of the fishery (figure 7). Before 1933, this species was included with the miscellaneous group rather than being recorded individually. From 1934 to 1944, it was relatively unimportant. Burbot catches increased after 1945 and, when combined with the winter harvest beginning in 1953, reached a record high of 880,000 pounds in 1961. Since then catches have declined to around 350,000 pounds per year which still ranks burbot second to the tullibee in total annual harvest. The burbot is the only species harvested to any extent during the winter months.

The history of the northern pike catch has been similar to that of the walleye with annual catches declining since about 1935 (figure 8). Before 1935, the northern pike catch experienced some of its best years reaching a record high of 525,000 pounds in 1915. The catches have been relatively stable since 1945 and now contribute only about 60,000 pounds annually to the total harvest.

The common white sucker after showing a stable harvest of approximately 140,000 pounds per year from 1930 to 1943 declined in catch to a low of 33,000 pounds in 1957 (figure 8). As with the tullibee, catches then increased, and a high of 282,000 pounds was recorded in 1965. After 1965, catches

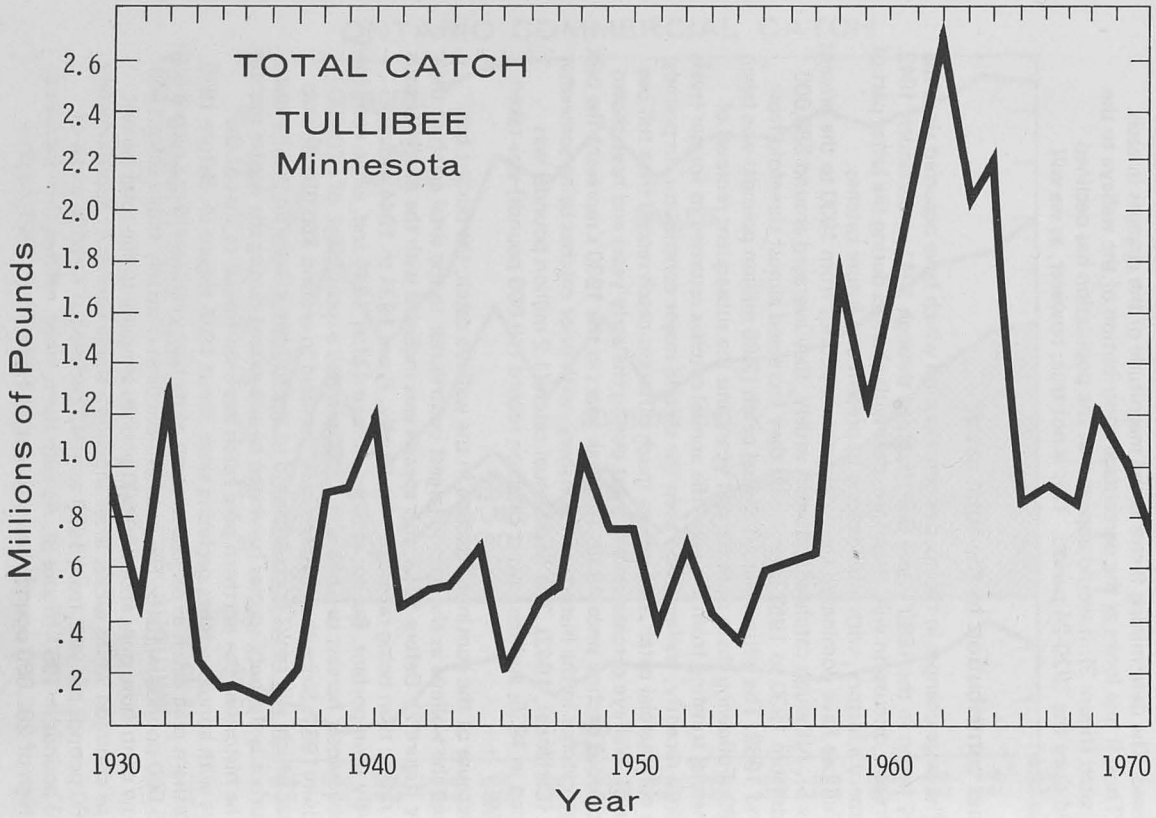


Figure 5. Annual commercial catch of tullibee, 1930-70.

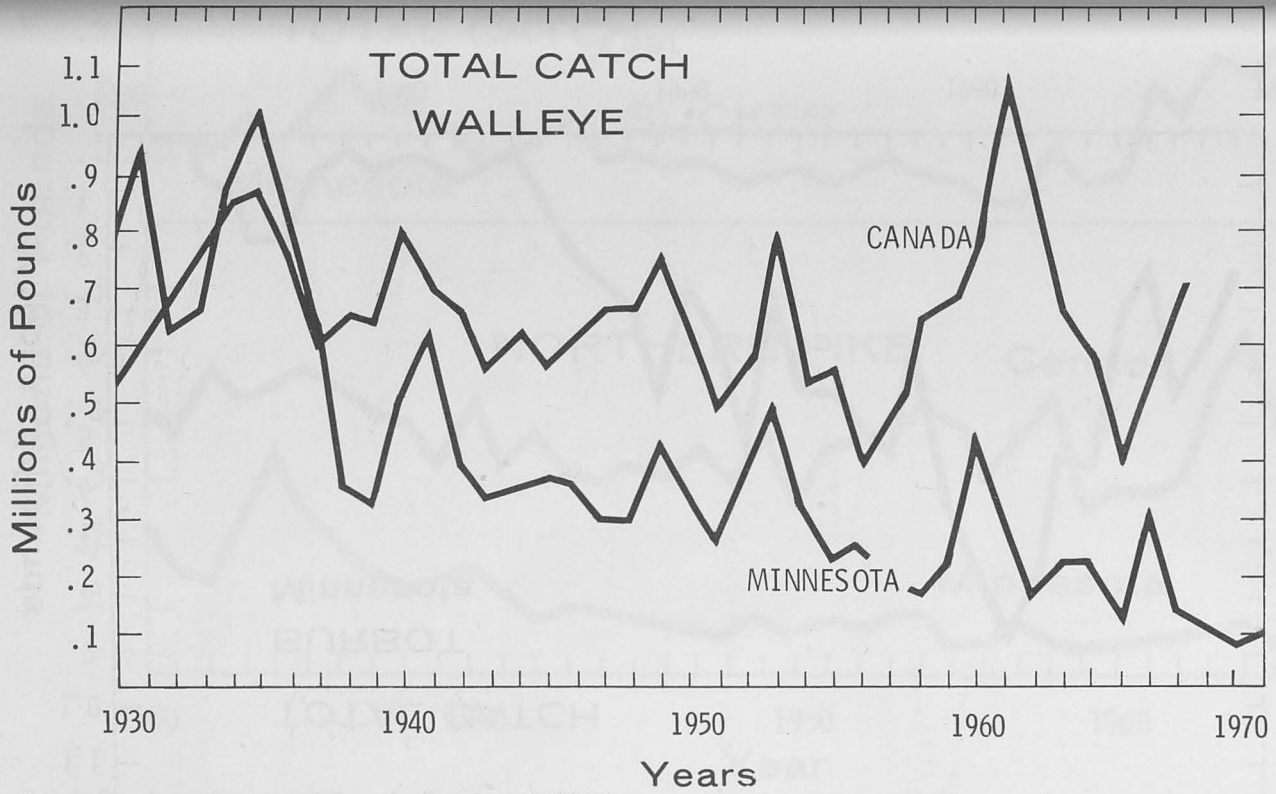


Figure 6. Annual commercial catch of walleye, 1930-70.

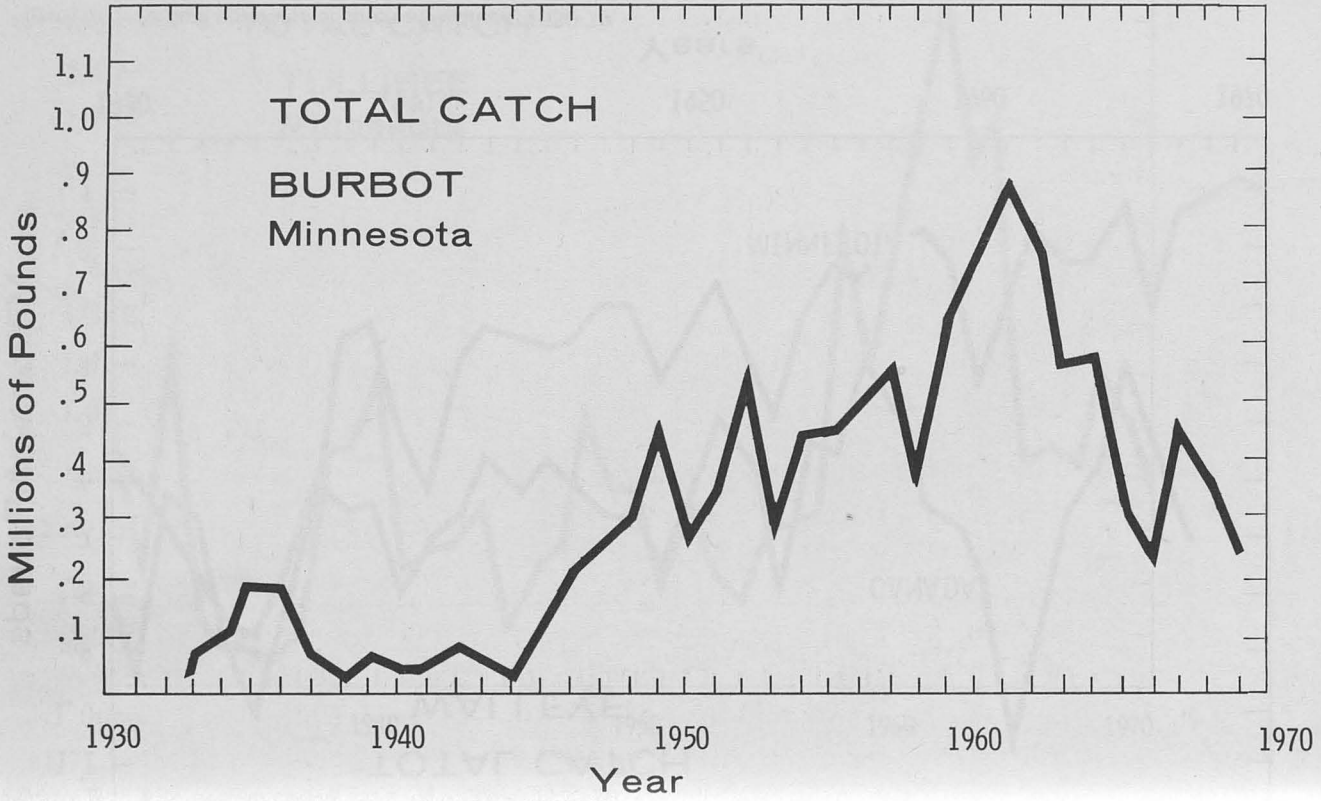


Figure 7. Annual commercial catch of burbot, 1930-70.

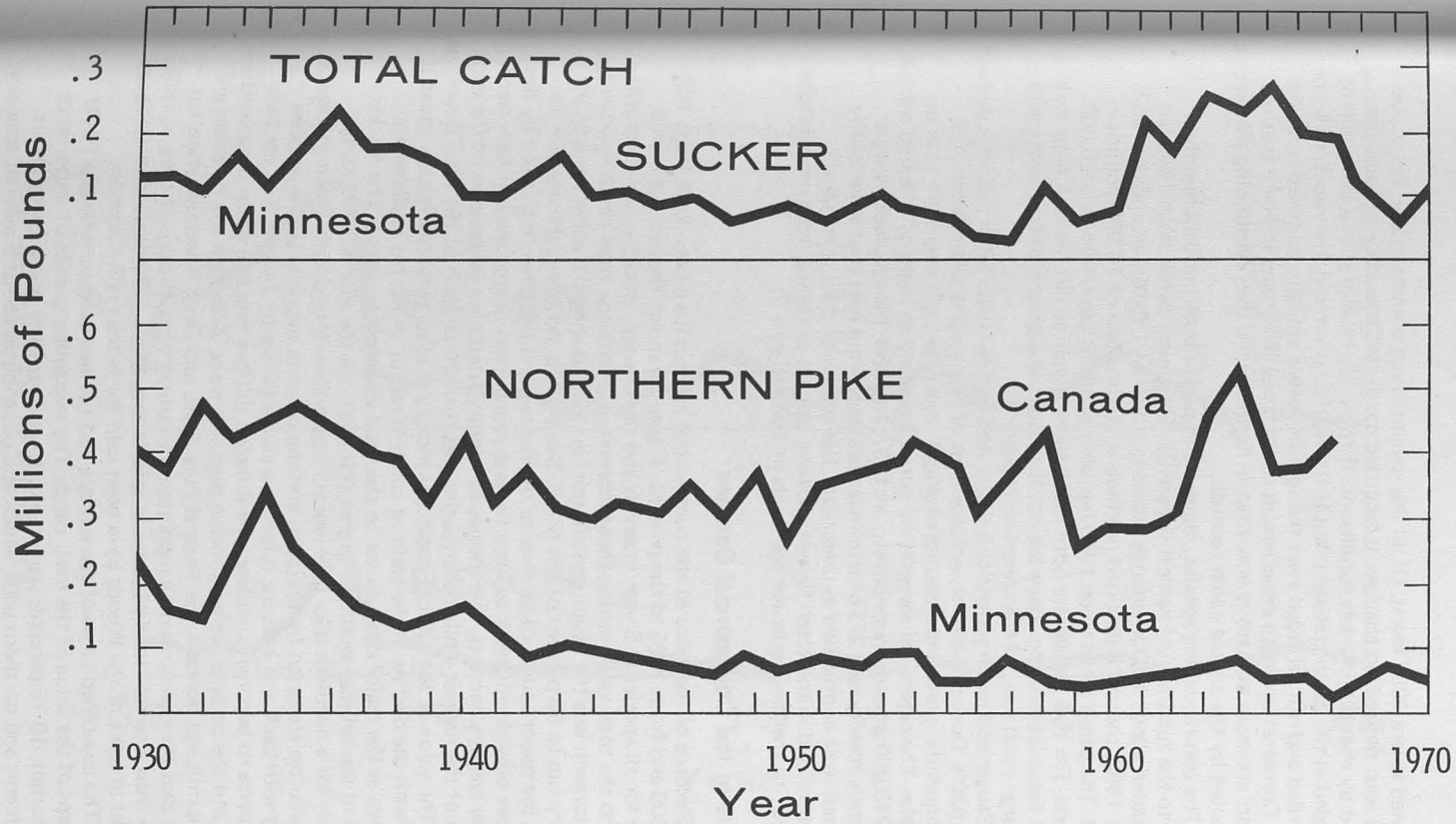


Figure 8. Annual commercial catch of common white sucker and northern pike, 1930-70.

declined to pre-1957 levels. Of all the species taken commercially, the sucker is the least desired; so changes in recorded catch statistics may be somewhat biased by changing market conditions. If there is a market, the suckers will be included in the catch statistics; but if the market is limited, the suckers may be discarded and not included even though they were actually removed from the lake. Conversations with experienced commercial fishermen indicate that the suckers are more numerous now than in earlier years, thus reinforcing the picture presented by the annual catch records.

The two remaining species, saugers and perch, both contribute only a little to the total annual harvest (figure 9). The sauger catch since 1940 has fluctuated about 70,000 pounds reaching a high of 145,000 pounds in 1962. After 1962, the catch declined reaching an alltime low of 13,000 pounds in 1969. The perch catch since 1940 has been stable at approximately 20,000 pounds. The two species are both much more numerous in the lake than their catch histories indicate. They are not harvested to a greater extent because of the large mesh sizes of the commercial gear.

Sauger and perch potential is illustrated well by their catch histories through the 1930's. During this time, enforcement of regulations was relaxed and consequently increasing amounts of illegal undersized gill nets were used on the lake. The catches of saugers and perch increased to highs of 415,000 pounds and 218,000 pounds, respectively, in 1937. In 1938, the regulations were diligently reenforced; 2/3 of the linear footage of gill nets that were legally licensed were confiscated as undersize. The results of their removal are demonstrated in the catch figures showing catches dropping from record highs in 1937 to the long term average levels in 1938 (figure 9).

Value of the Commercial Catches

Records of the value of the commercial catches have been kept from 1888 to 1909 and from 1925 to the present. Figure 10 shows the average annual value for all species at 5-year intervals and the average species percent contribution to the total value during those intervals. As with the total catch *in pounds,* the sturgeon was the major contributor *in value* during the early years of the fishery (up to 80 percent of the total). Since 1925, however, the walleye has been the major source of income to the fishery and has been outranked by the tullibee only during peak tullibee harvest years. Even during the last few years of low walleye harvests, this species has contributed over 30 percent of the total value of the harvest while contributing less than 10 percent of the total poundage.

The value of the tullibee catch has increased as its total catch has increased and, with the decline in the walleye catch in recent years, has replaced the walleye as the major contributor to the total value of the catch. The market value of the tullibee would be higher if it were not the intermediate host species for a northern pike tape worm. Copepods infested with *Traenophorus sp.* parasites are eaten by tullibees, and the parasite migrates to the muscles along with back and encysts, remaining viable for up to 3 years. For the parasitic cycle to become complete, the infested tullibee must be eaten by a northern pike and the parasite released to the digestive tract. Although the parasites are not harmful to humans, the Federal Pure Food and Drug Administration has ruled that the fish cannot be marketed for human consumption if they contain more than a certain level of parasite infestation. Since 1957 almost no tullibees caught in Lake of the Woods have been sold for human consumption.

The combined value of the walleye and tullibee catches make up 70-80 percent of the value of the total catch. The remaining species of importance are burbot, 10-15 percent; sauger, which until recently contributed about 5 percent; and northern pike, which also contributes about 5 percent annually.

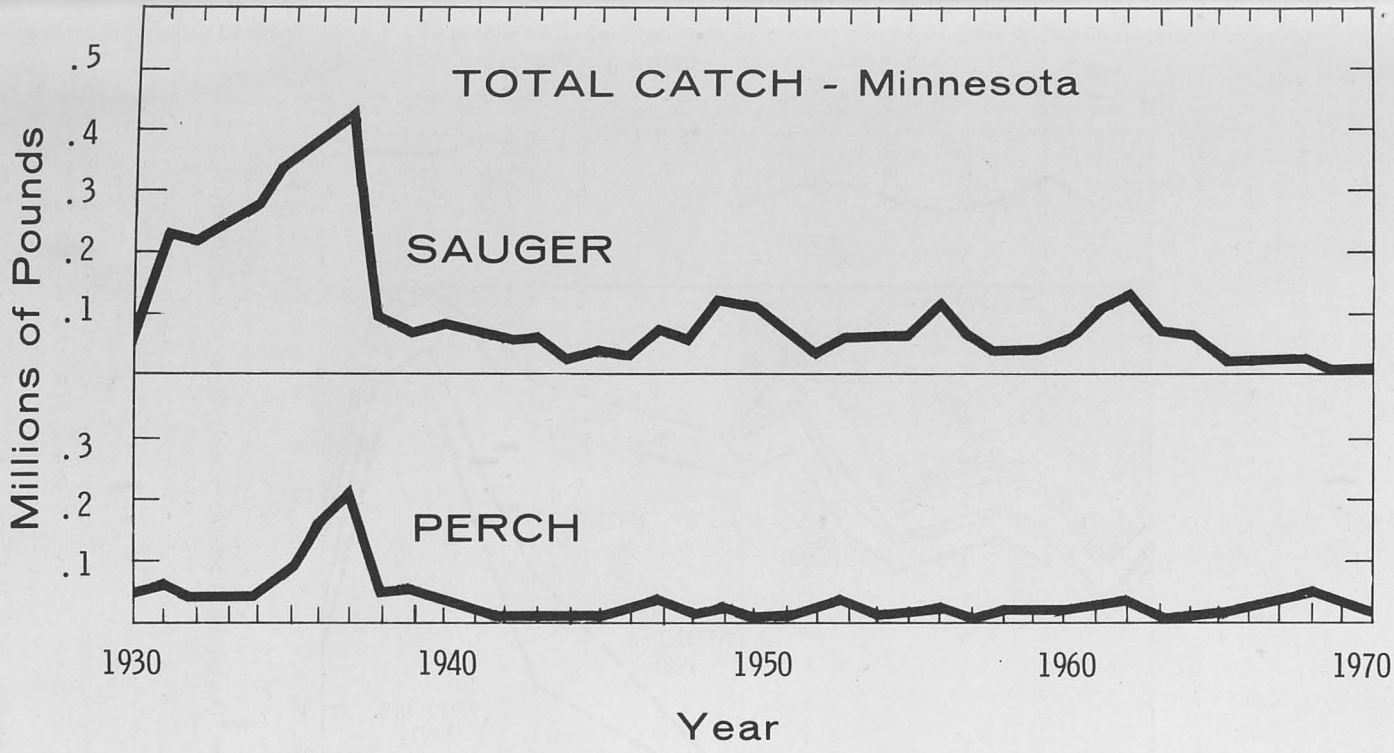


Figure 9. Annual commercial catch of sauger and yellow perch, 1930-70.

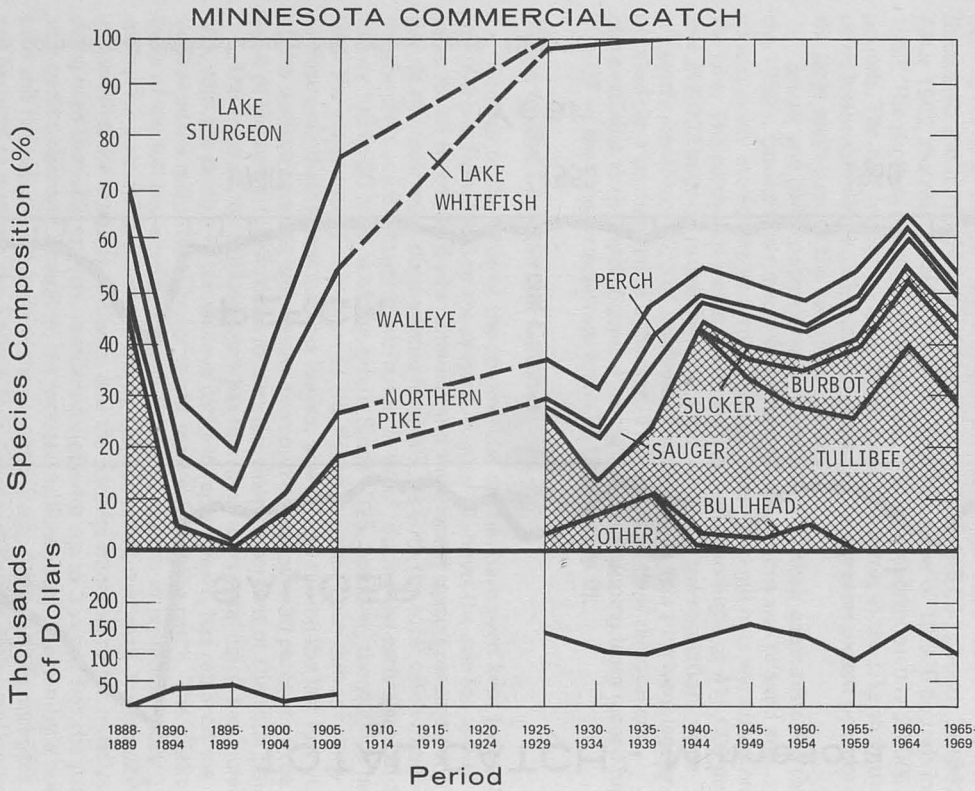


Figure 10. Value of the Minnesota commercial catch (in thousands of dollars) and percentage species contribution averaged over 5-year periods, 1888-1969.

Catch, Abundance, and Fishing Effort

As pointed out earlier, total catch or percent species composition may not accurately describe the status of the various fish populations in the lake if changes occurred in the type of fishing gear and in the amount of effort directed toward the catch of these species. In these cases, a more descriptive estimate of the abundance of the various populations would be some measure of the rate of fishing success or the catch per unit of effort. In Lake of the Woods, this problem is complicated further by the use of several different types of gear to harvest the various species.

A method to analyze this type of data was developed by Hile (1962). Using his method, we can pool the different fractions contributing to the total catch of a given species and analyze the sum as a single entry. To complete the computations, records must be available of both total catch and total effort expended to make that catch for a given species. Using the unweighted average catch per unit of effort for major producing gear per species for a selected base period, a calculation is made of the total annual catch that would have been expected based on the actual effort expended per gear during the season. The sum of the actual catches then is divided by the sum of the expected catches to provide the index of abundance for the population. This figure is in turn divided into the actual total catch for all gear to provide an estimate of the total pounds of fish that would have been harvested had the "fishing quality been exactly at the base-period 'normal' for all gear." The resulting figure from this latter computation represents the index of fishing intensity. For convenience, the index of abundance and the index of fishing intensity are expressed as a percentage of a base period average. In Lake of the Woods, although catch records are complete for most species since the turn of the century, records of annual effort have been recorded since only 1949. Therefore, our analyses are limited to from 1949 to the present.

Figure 11 shows the computations for the walleye harvest.Total fishing intensity has declined from a high of 47 percent above the 1958-1967 base period average (b.p.a.) in 1953 to a low of 40 percent below the b.p.a. in 1969. Walleye abundance, although fluctuating widely, has remained about the same since 1949, averaging 1 percent above the b.p.a. from 1949 to 1958, and 1 percent below from 1959 to 1968. Thus, although the relative abundance has remained about the same since 1949, a decline in the fishing intensity has caused a decline in the total catch of the species.

The computations for the tullibee show a different picture (figure 12). Here the fishing intensity declines until the advent of trawling in 1961. During the 4 trawling years, fishing intensity was the highest recorded since 1949. When the trawls were removed from the lake in 1965, the intensity returned to pre-trawling levels and thereafter declined to a low of 50 percent below the b.p.a. (1969). Relative tullibee abundance averaged 66 percent below the b.p.a. from 1949 through 1956 and then increased to 21 percent above the b.p.a. by 1958. Abundance remained high through the 4 trawling years, fell below the average in 1965-1967, and then rose again above the average in 1968 and 1969. Ten-year averages show that the relative abundance increased from 54 percent below the b.p.a. (1949-58) to only 1 percent below the b.p.a. (1959-68). The increase in relative abundance together with the increase in fishing intensity with trawling (1961-64) produced record tullibee catches which reached a high of 167 percent above the b.p.a. in 1962. Although similar high abundance levels were reached in 1969, low fishing intensities resulted in a tullibee catch 30 percent below the b.p.a. for that season.

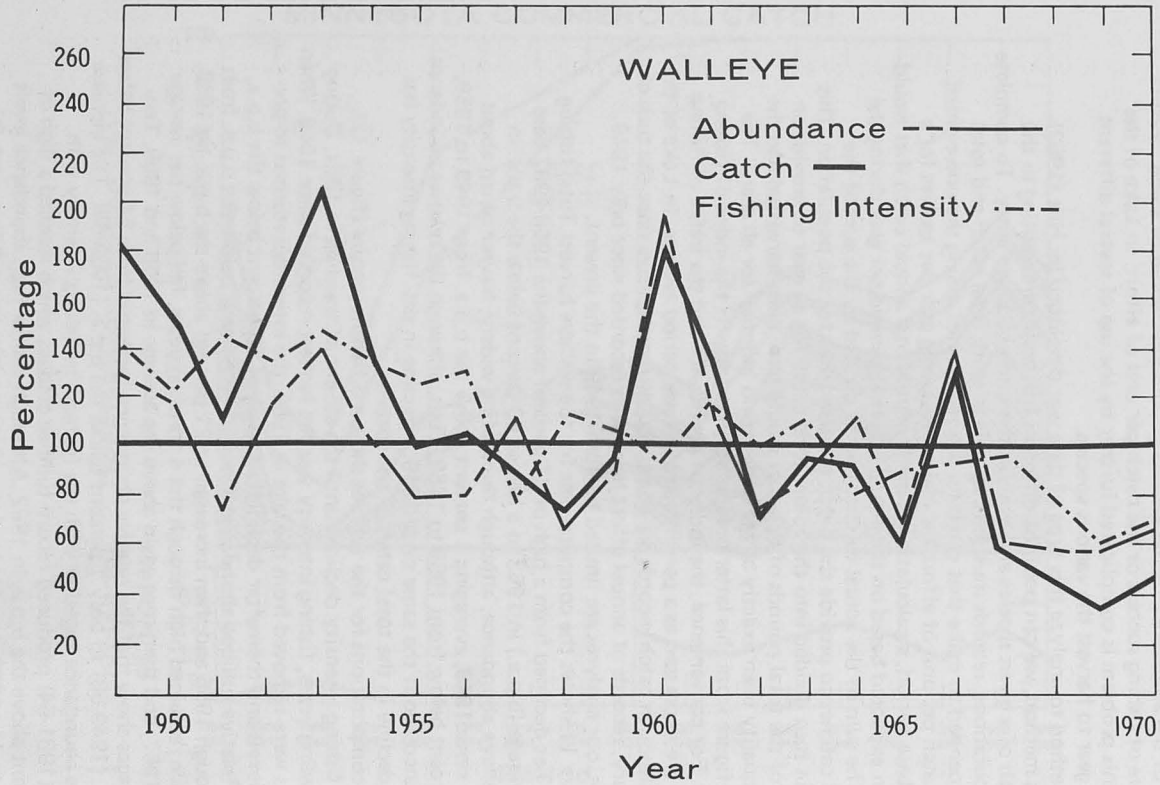


Figure 11. Landings, abundance index, and fishing intensity index for walleye in Lake of the Woods, expressed as percentages of the 1958-67 averages.

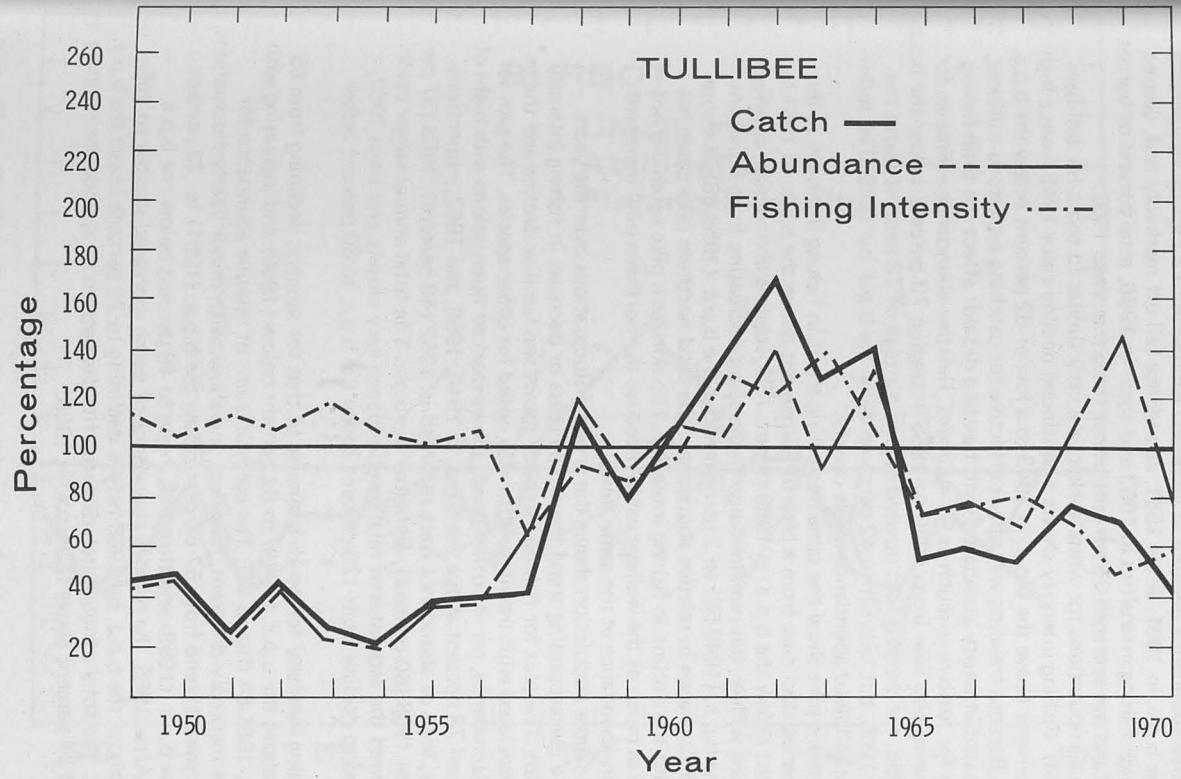


Figure 12. Landings, abundance index, and fishing intensity index for tullibee in Lake of the Woods, expressed as percentages of the 1958-67 averages.

Fishing intensity for burbot has increased since 1949 (figure 13) from 10 percent below the b.p.a. (1949-58) to the level of the b.p.a. (1959-68). Relative abundance estimates have also increased from 20 percent below the b.p.a. (1949-58) to the level of the b.p.a. (1959-68). These increases in fishing intensity and relative abundance resulted in increased catches with a high of 155 percent above the b.p.a. in 1961. After 1961, abundance fell off markedly and, despite record high fishing intensities in 1963 and again in 1966, total harvest of burbot declined and has averaged 39 percent below the b.p.a. since 1962.

The computations for white suckers are very similar to those for tullibees (figure 14). Fishing intensity shows a continued decline since 1949 from a high of 141 percent above the b.p.a. in 1943 to a low of 62 percent below the b.p.a. in 1969. Because trawling was not as effective for catching suckers as tullibees, the increased intensity associated with trawling did not affect the total fishing intensity for suckers as much as for tullibees. Relative abundance estimates for suckers were also low from 1949 to 1956 averaging 70 percent below the b.p.a. After 1956, the trend is first upward reaching a high of 78 percent above the b.p.a. in 1965, but falls off to 42 percent below the b.p.a. by 1969. The sucker catch has followed abundance levels closely.

Northern pike show the same decreasing trend in fishing intensity as the other species, declining from a high of 63 percent above the b.p.a. in 1951 to 34 percent below the b.p.a. in 1969 (figure 15). Relative abundance, although fluctuating widely, has remained nearly the same, increasing from 5 percent below the b.p.a. (1949-58) to 3 percent above the b.p.a. (1959-68). Because of the small change in relative abundance, the total northern pike catch has fallen with the decline in fishing intensity. The northern pike catch did not decrease as much as the walleye catch, because the northern pike increased slightly in abundance at the same time.

The sauger population shows the greatest fluctuations over the years without a corresponding trend toward increase or decrease in fishing intensity (figure 16). The plot for fishing intensity shows the familiar decline and the increase associated with trawling, both also noted for other species. The plot for relative abundance, on the other hand, shows marked fluctuations with highs of 65, 77, and 78 percent above the b.p.a. in 1949, 1956, and 1962, respectively. Similarly, lows of abundance were recorded in 1952 (40 percent), 1958 (37 percent), and 1968 (60 percent), all below the b.p.a. The total annual sauger catch has followed the estimates of relative abundance very closely and since 1962, continued to decline from 126 percent above the b.p.a. to 80 percent below (1969).

Fishing intensity for perch is similar to that for saugers, declining from 83 percent above the b.p.a. (1949) to 62 percent below (1969) and increasing with trawling, 1961-64 (figure 17). The computations of relative abundance for perch are markedly different, however, and show, with minor yearly fluctuations, first an upward trend from 57 percent below the b.p.a. (1951) to 23 percent above the b.p.a. (1959) and then a decrease to 48 percent below the b.p.a. (1965). After 1965, the relative abundance of perch increased sharply to 165 percent above the b.p.a. by 1968 before declining to 20 percent above the b.p.a. by 1970. The total annual catch of perch fits the pattern of abundance reaching a high of 77 percent above the b.p.a. in 1968.

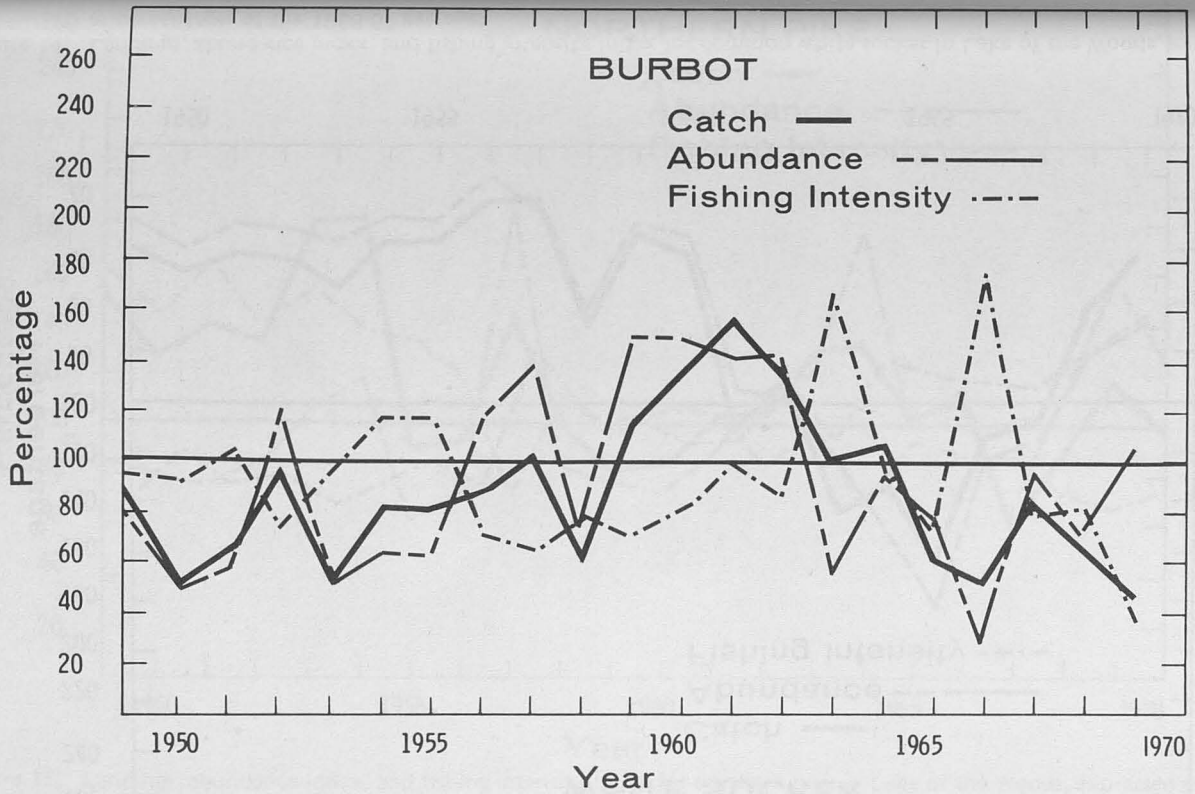


Figure 13. Landings, abundance index, and fishing intensity index for burbot in Lake of the Woods, expressed as percentages of the 1958-67 averages.

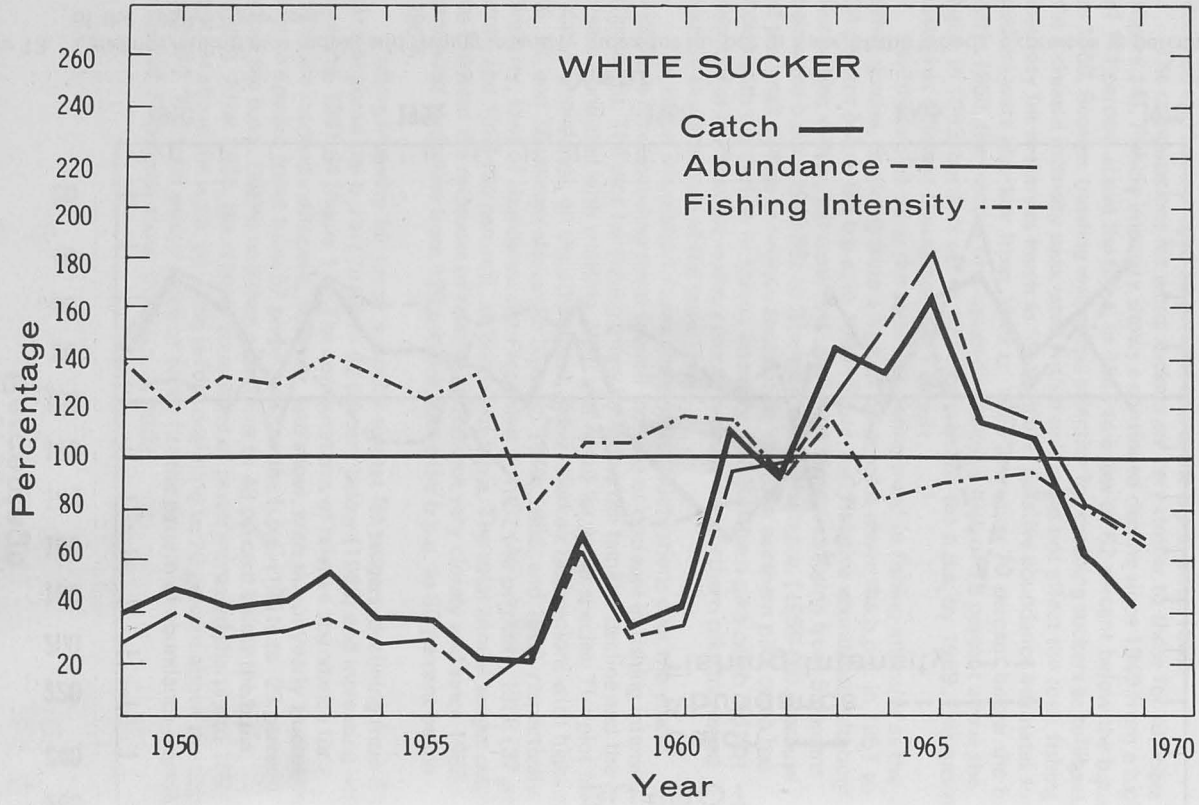


Figure 14. Landings, abundance index, and fishing intensity index for common white sucker in Lake of the Woods, expressed as percentages of the 1958-67 averages.

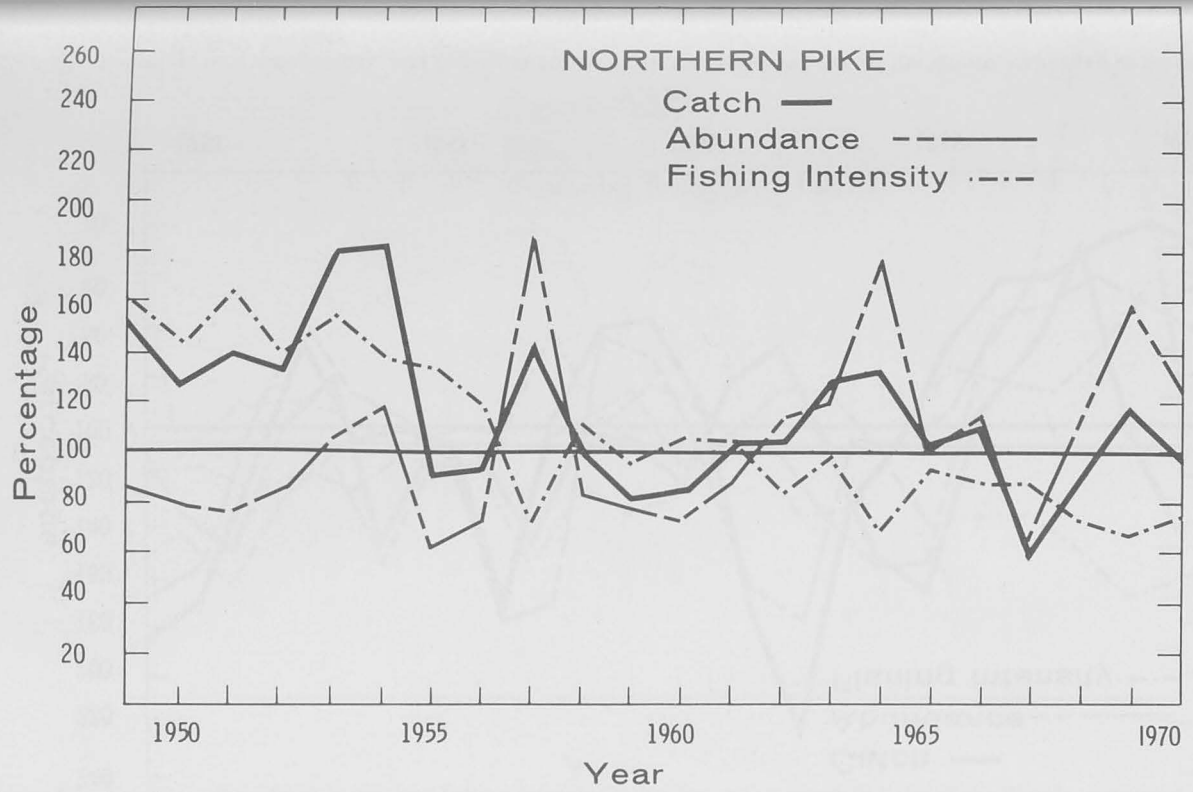


Figure 15. Landings, abundance index, and fishing intensity index for northern pike in Lake of the Woods, expressed as percentages of the 1958-67 averages.

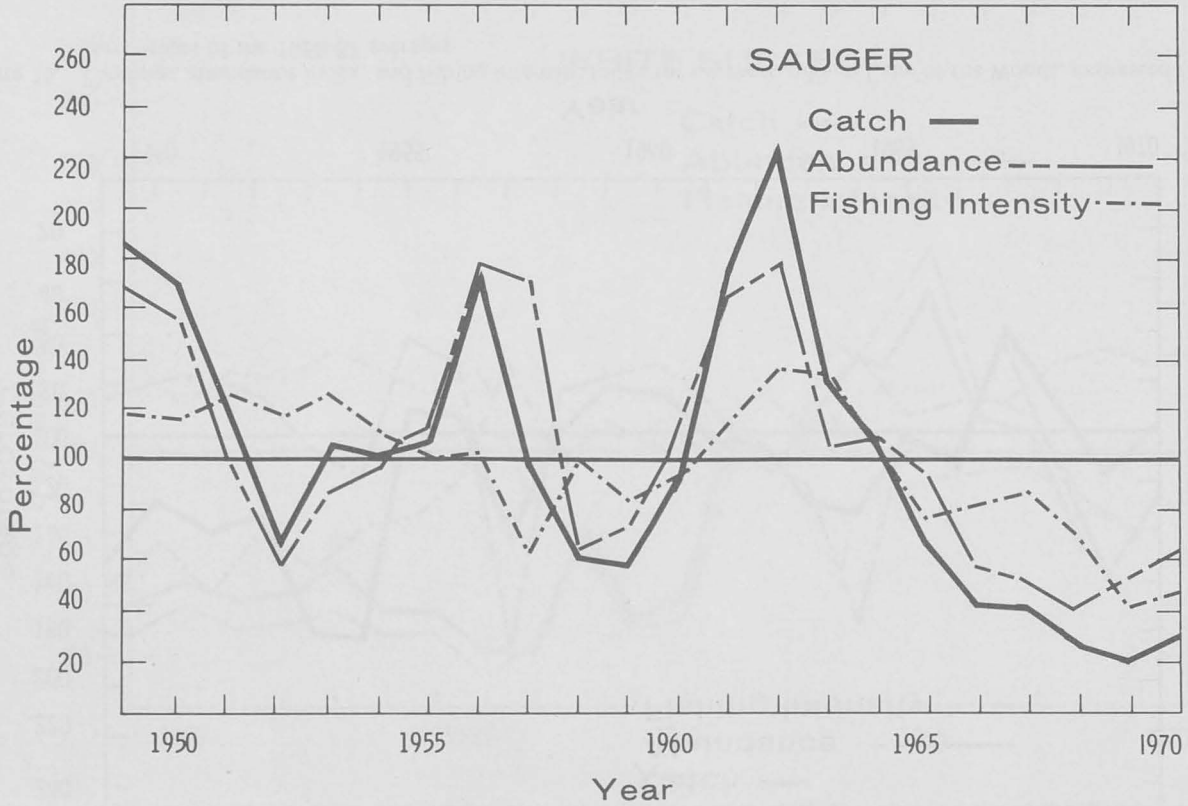


Figure 16. Landings, abundance index, and fishing intensity index for sauger in Lake of the Woods, expressed as percentages of the 1958-67 averages.

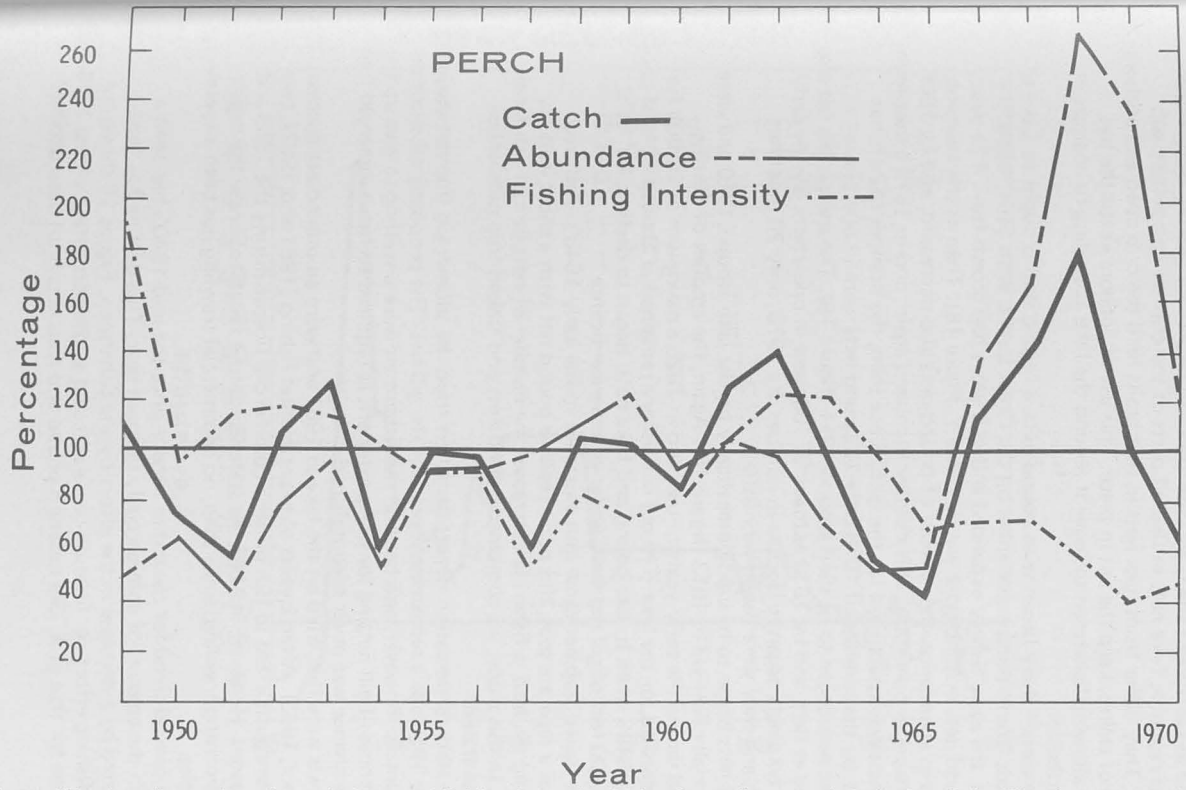


Figure 17. Landings, abundance index, and fishing intensity index for yellow perch in Lake of the Woods, expressed as percentages of the 1958-67 averages.

CHARACTERISTICS OF THE FISHING GEAR

Historical Review

Over the years six types of commercial nets have been licensed to fish in the Minnesota waters of Lake of the Woods: the gill, pound, fyke, staked trap, submerged trap, and trawl nets. All types except submerged trap nets are described in Carlander (1942) and Burrows and Heyerdahl (1969). Submerged trap nets resemble fyke nets in that all parts of the crib are completely submerged. They differ from fyke nets in that brails hold the crib open and anchors, in place of stakes, keep the net in place. This use of anchors keeps the net mobile, allowing fishermen to move it around the lake according to changes in fish distribution.

The early fishery began with pound nets, a fishing skill brought to Lake of the Woods from fishing experiences on the Great Lakes. With little regulatory restraint, the early fishery expanded and in 9 years had grown from 4 to over 190 pound nets in Minnesota waters (table 2, figure 18). Then as the sturgeon declined in abundance, the number of pound nets also decreased, and by 1907 only 50 were in operation. This number increased again, and in 1913 a maximum of 100 nets was established for the lake. Since then, the number of nets has declined; by the summer of 1970 only 12 pound nets were in operation.

Fyke nets began to be used around 1911 (figure 18). The use of this net also increased at first, and by 1930 as many as 100 were in operation. By the early 1940's, fyke nets began to decline in number. By 1970, only 20 nets were licensed, and they were fished very little.

Gill nets began to be used domestically on the lake around 1910 and were commercially licensed in 1913 (figure 18). Again, the amount of netting increased during the early years of use, and in 1925 a maximum of 90,000 feet was established for the lake. The gill net fishery remained at about this level until the mid-1940's when it, like pound and fyke nets, began to decline. By 1970, only 45,000 feet of gill net were under commerical license.

The staked trap net came into existence in the early 1940's. Although treated as a separate gear, this net is really a pound net with a short lead. By shortening the lead, a fisherman increases the number of nets he can fish from 6 to 10. In this study, we combined pound nets and staked-trap nets unless otherwise stated.

The state conservation department first tried the submerged trap net during the early 1950's as a replacement gear for the gill net. The proposed substitution was voluntary, however; and because the fishermen were unwilling to give up the conveniences of gill netting for the greater effort required to fish submerged trap nets, the change was never accomplished.

Trawls were first tried on the lake in 1961 and were an immediate success (Scidmore, 1963). After 2 years of experimental fishing (1961 and 1962), two trawls were authorized to fish under a commercial license during the 1963 and 1964 seasons. However, in 1965 the state legislature failed to renew the legislation authorizing trawling; since then, no commercial trawling has been allowed on the lake.

The general trend for the entire fishery since the mid-1940's has been a decline in the amount of commercially licensed gear. This decline has been accentuated by a decrease in the effort by the fishermen. Figure 19 shows the average fishing effort per licensed gear expressed as the percentage of the 1958-67 average for that gear. Gill nets and pound and trap nets both have declined

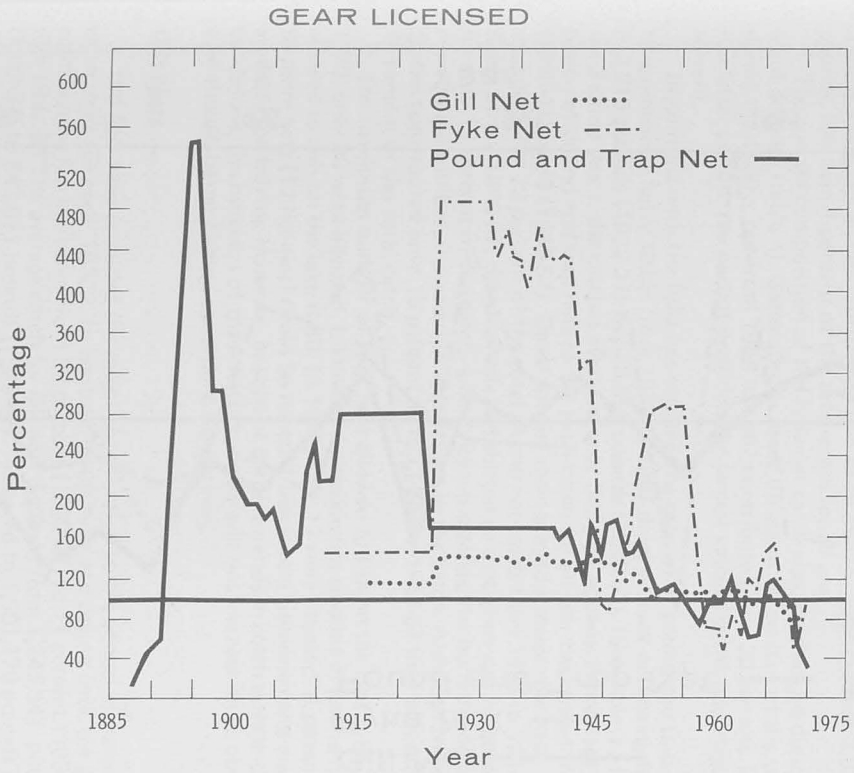


Figure 18. Amount of Minnesota commercial fishing gear licensed to fish in Lake of the Woods, 1885-1970, expressed as percentages of the 1958-67 averages.

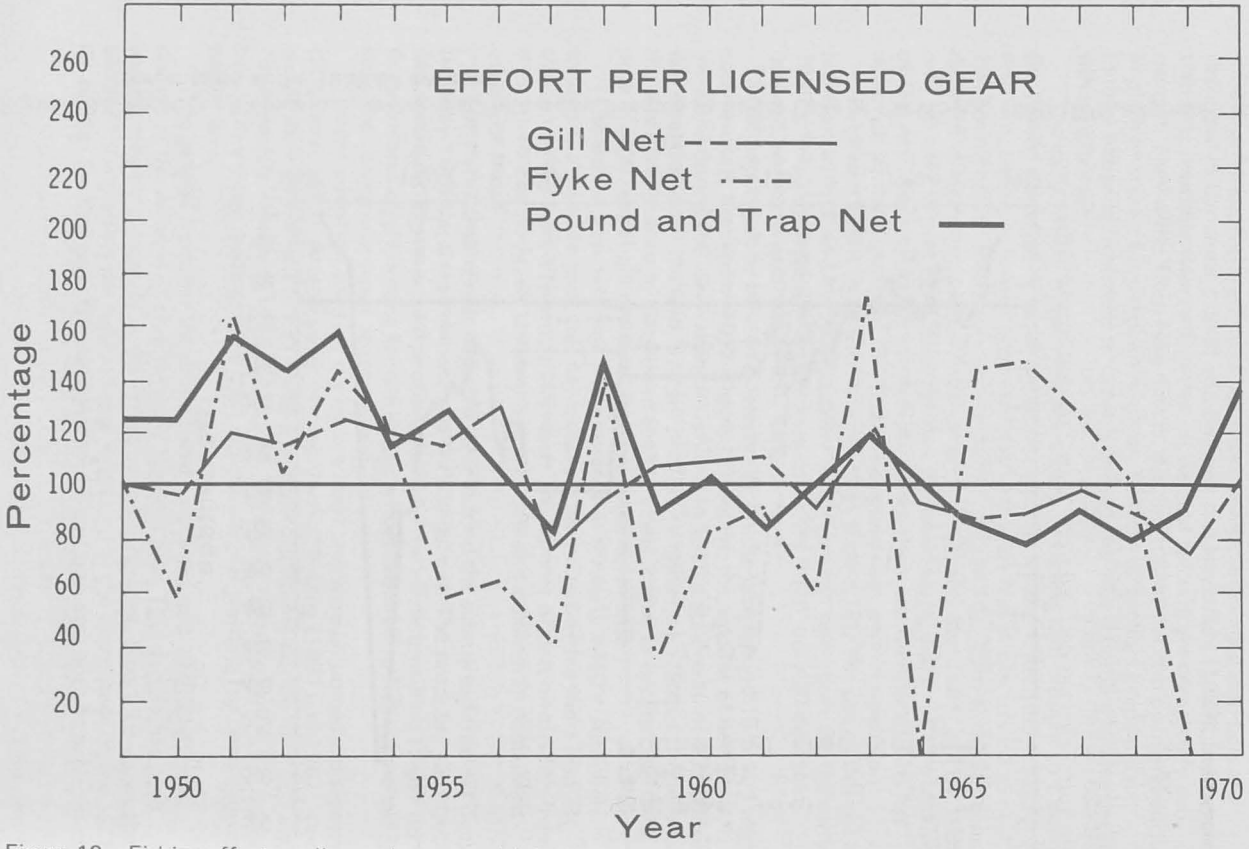


Figure 19. Fishing effort per licensed commercial fishing gear, expressed as percentages of the 1958-67 averages.

in average effort. Thus, not only has less gear been licensed, but licensed gear have been used less. Although the reduction in the number of gear licensed could be considered permanent, the decrease in effort per licensed gear is temporary. If good fishing conditions should prevail in future seasons, the total effort expended per license would probably increase, as indicated by the 1970 season.

Entrapment Nets

Although fyke nets have outnumbered pound nets in certain years, the fyke net catches have never amounted to as much as the pound net catches (table 3). The average fyke nets catch declined from 253,330 pounds (1932-37) to 28,420 pounds (1958-67). Likewise, the percentage contribution of fyke nets to the total catch has declined from 12 to 2 percent for the same periods. The 3 study years saw an even further decline to an average total catch of 2,931 pounds, less than 1 percent of the total catch for all gear.

The species composition of the fyke net catch also has changed during the last 4 decades (table 4). Game species made up about 50 percent of the catch during the 1930's, but from 1958 to 1967 contributed only 20 percent. During this latter period, the burbot provided the largest catches in the fyke nets, 52 percent.

In contrast with the fyke net catches, the catches of pound and trap nets have remained fairly stable from 1932 to 1967 despite fewer nets being fished: 612,215 pounds (1932-37) to 573,857 pounds (1958-67). (See table 3.) During the 3 study years, the catches averaged only 399,569 pounds. Percentage contribution of pound and trap nets to the total catch for all gear has ranged from 24 (1938-41) to 39 (1949-57). Game species again played a major role and accounted for 73 percent of the total pound net catch from 1933 to 1937 (table 5). By 1958-67, the emphasis had shifted so that game species accounted for only 13 percent of the catch. Like fyke net catches, the burbot, and even more so the tullibee, increased in importance in the catch. Although these two species contributed only 15 percent in 1933-37, by 1958-67 they accounted for 84 percent of the total catch.

The maximum number of fyke nets allowed to fish on the lake is 80. In 1970, only 20 were licensed. Likewise, the maximum amount of pound nets allowed to fish on the lake is 50. In 1970, only 12 were licensed. A potential of 98 more nets (12 licenses) could be fished if there were fishermen and equipment available for fishing. However, in light of current trends in catch rates and market conditions, the numbers of these nets probably will not increase much above 50 even though better fishing conditions may prevail.

Gill Nets

Gill nets have provided the major contribution to the annual commercial catch since the early 1930's. In contrast to the fyke and pound nets, the gill nets' contribution has increased from 59 percent (1932-37) to 71 percent (1958-67). (See table 3.) The average catch for gill nets declined from 1,245,541 pounds (1932-37) to 843,071 pounds (1949-57), increased to 1,501,170 pounds (1958-67), and then declined to 987,550 pounds during the 3 study years. As with entrapment nets, game species accounted for a large portion of the catch, but declined from a high of 75 percent (1933-37) to a low of only 17 percent (1958-67) (See table 6.) The tullibee showed the greatest change for nongame species increasing from a low of only 8 percent of the total catch (1933-37) to a high of 68 percent (1958-67). Suckers also showed a slight increase in percentage contribution to the total catch.

Table 3. Average contribution to the total annual catch of all species by individual gear, expressed as total pounds and percent of the total

Period	Type of net						Total	
	Gill nets		Pound & trap nets		Fyke nets			
	Pounds	Percent	Pounds	Percent	Pounds	Percent	Pounds	Percent
1932-37	1,245,541	59	612,215	29	253,330	12	2,111,086	100
1938-41	1,193,928	66	434,156	24	180,898	10	1,808,982	100
1945-49	880,704	59	579,477	38	40,083	3	1,500,264	100
1949-57	843,071	56	587,143	39	77,799	5	1,508,013	100
1958-67	1,501,170	71	573,857	27	28,420	2	2,103,447	100
1968-70	987,550	71	399,569	29	2,931	(trace)	1,390,050	100

Table 4. Species composition of the marketed commercial catch of fyke nets, expressed as a percentage of the total catch per gear

Period	Walleye	Sauger	N.Pike	Tullibee	Perch	Burbot	Sucker	Misc.
	——————————percent of total catch——————————							
1933-37	31	10	15	2	7	9	9	17
1938-41	21	3	22	11	4	5	13	21
1945-49	8	3	9	8	4	20	9	39
1949-57	10	3	10	tr	4	31	9	33
1958-67	9	3	8	1	4	52	6	17
1968-70	16	4	29	5	11	13	18	4

Table 5. Species composition of the marketed commercial catch of pound and trap nets, expressed as a percentage of the total catch per gear

Period	Walleye	Sauger	N.Pike	Tullibee	Perch	Burbot	Sucker	Misc.
	——————————percent of total catch——————————							
1925-32	46	3	10	22	1	1	5	12
1933-37	51	12	10	3	1	12	5	6
1938-41	39	4	11	21	1	6	11	7
1945-49	15	3	4	35	tr	37	4	2
1949-57	11	5	2	40	1	38	2	1
1958-67	7	4	2	53	1	31	2	tr
1968-70	5	1	3	55	1	33	2	tr

Table 6. Species composition of the marketed commercial catch of gill nets, expressed as a percentage of the total catch per gear

Period	Walleye	Sauger	N.Pike	Tullibee	Perch	Burbot	Sucker	Misc.
	percent of total catch							
1933-37	42	20	13	8	7	1	7	2
1938-41	25	5	5	57	2	1	5	tr
1945-49	28	6	6	45	2	5	6	2
1949-57	29	6	7	42	1	9	6	tr
1958-67	12	2	3	68	1	3	11	tr
1968-70	8	1	4	73	2	3	9	tr

Although gill nets are as dependent on the game fish catch as the entrapment nets are, the fact that gill nets account for about 80 percent of the total walleye catch by the commercial industry has led the state conservation department to restrict the continuation of the gill net fishery. This restriction continually reduces the amount of gill nets under license. In 1970, only 45,000 feet of gill netting was licensed although the state laws permit up to 90,000 feet to be fished. This reduction in total allowable netting has been accomplished through the regulatory powers of the commissioner of the conservation department.

Trawl Nets

As already mentioned, the trawl nets have had only limited exposure and use on the lake; hence, including their contribution in the average summations for the other nets would be misleading. A more accurate description of their potential contribution can be made by using the data for only those years when trawling was allowed. Of the 4 years trawls were fished (1961-64), only the last 3 years are useful for these comparisons.

On this basis, two trawl nets averaged 976,793 pounds or 31 percent of the total catch of the commercial fishery from 1962 to 1964 (table 7). Game species made up only 5 percent of the catch (table 8). Of the nongame species, the tullibee made the largest contribution, 86 percent. Through this catch selectivity, trawl fishing increased the tullibee catch by 37 percent while increasing the catch of walleyes by only 4 percent.

Experimental Trawling

Although no trawls have operated commercially since 1964, one trawl was operated experimentally on a limited schedule during the study period. A maximum schedule of 66 days, spaced through the season, was established for trawling each summer, 1968-70. University research personnel and a conservation officer were present for all fishing trips and kept records of all fish captured, the area of the lake fished, and the duration of fishing. In addition, interested persons were invited to ride along on the fishing trips to observe the fishing operations.

The actual number of fishing trips ranged from 32 days in 1970 to 48 days in 1968. Table 9 shows the total 1968-70 catch made by the trawl net. When the percentage contribution of individual species is compared to similar information for the earlier trawling period (1962-64), the figures are very nearly the same (table 9). The most noticeable difference is the lack of saugers in the 1968-70 catch. Part of this lower catch can be attributed to the use during the current

Table 7. Average contribution to the total annual catch of all species by individual gear, expressed as total pounds and percent of the total

Period		Type of net				
		Gill	Pound & trap	Fyke	Trawl	Total
1962-64	lb.	1,570,327	585,061	36,548	976,793	3,168,729
	Percent	50	18	1	31	100

Table 8. Species composition of the marketed commercial catch of trawl nets, expressed as a percentage of the total catch

Period	Walleye	Sauger	N. Pike	Tullibee	Perch	Burbot	Sucker	Misc.
	percent of total catch							
1962-64	1	4	trace	86	1	7	1	trace
1968-70	2	1	trace	89	trace	7	1	trace

Table 9. Summary of experimental commercial trawl catch, Lake of the Woods, 1968-1970 (Numbers in parentheses are the percentage of the total catch.)

Species	1968	1969	1970	1968-70 total	1962-64 total
Walleye	1,921 (1.3)	2,458 (2.2)	1,971 (2.4)	6,350 (1.9)	(0.7)
Sauger	1,046 (0.7)	652 (0.6)	465 (0.6)	2,163 (0.6)	(3.9)
N. Pike	246 (0.2)	104 (0.1)	124 (0.2)	474 (0.1)	(trace)
Tullibee	135,594 (90.0)	100,673 (89.7)	70,859 (87.6)	307,126 (89.3)	(86.0)
Perch	697 (0.5)	145 (0.1)	560 (0.7)	1,402 (0.4)	(0.9)
Burbot	9,755 (6.5)	7,806 (7.0)	6,181 (7.6)	23,742 (6.9)	(7.6)
Sucker	1,400 (0.9)	427 (0.4)	731 (0.9)	2,558 (0.8)	(0.9)
Misc.	20 (trace)	8 (trace)	2 (trace)	30 (trace)	(trace)
Total	150,679	112,273	80,893	343,845	

survey of trawl nets with larger mesh sizes than those used earlier, part to possible differences in the area of the lake that received the most fishing, and part to the general lakewide decline in abundance of the sauger population discussed in the previous section on commercial catches.

A major criticism of the trawl was that the operation of the net along the bottom of the lake damaged spawning areas, undersized fish, aquatic vegetation, and fish food organisms and resulted in a general decline in the lake's water quality. To test this assertion, areas were established in the lake and samples of water and bottom organisms were collected before trawling, after trawling, and in areas where no trawling occurred. In addition, the light penetration into the lake was measured and related to possible growth of aquatic vegetation.

Although the action of the net stirred up some of the bottom sediments, it had little or no effect on the water quality of the lake in terms of oxygen content, pH, total alkalinity, or hydrogen sulfide concentration in the water. This result was further substantiated through discussions with water quality scientists at the Limnological Research Center, University of Minnesota (J. Shapiro and R. Megard, personal communication) of the potential changes that might be expected through this agitation of bottom sediments.

The predominant organisms living in the bottom sediments were the larvae of the burrowing mayfly, *Hexagenia sp.*, and the midge fly, *Chironimus sp.* Extensive sampling of both trawled and untrawled areas of the lake bottom showed the action of the trawl to have no effect on either the numbers of these organisms present (table 10) or their physical condition. This result was not totally unexpected for these organisms live in burrows in the lake bottom. They

Table 10. Mean number of organisms per square foot of bottom substrate sampled with a "Peterson Dredge" in 1968 and 1969 at depths of 37 and 27 feet, respectively, before and after being trawled

Sampling days		Chironimus				Hexagenia	
		1968 (37 feet)		1969 (27 feet)			
		Before	After	Before	After	Before	After
1	$\bar{x}$ No./ft.^{2}	9.7	–	5.1	–	8.8	–
	Range	1-21	–	1-10	–	3-14	–
	Sample Size	21	–	20	–	20	–
2	$\bar{x}$ No./ft.^{2}	–	7.6	4.7	3.6	9.8	9.1
	Range	–	1-14	1-8	1-11	7-13	3-17
	Sample Size	–	12	6	10	6	10
3	$\bar{x}$ No./ft.^{2}	–	8.9	1.3	3.5	9.0	9.1
	Range	–	0-17	0-4	0-8	0-15	6-14
	Sample Size	–	12	10	10	10	10
4	$\bar{x}$ No./ft.^{2}	–	10.9	2.6	2.4	7.0	7.2
	Range	–	2-47	1-6	1-5	0-13	0-10
	Sample Size	–	12	10	10	10	10
5	$\bar{x}$ No./ft.^{2}			2.9	2.6	10.3	10.4
	Range			0-5	0-7	7-15	6-14
	Sample Size			10	10	10	10
6	$\bar{x}$ No./ft.^{2}			1.3	1.3	6.0	7.4
	Range			0-3	0-3	0-13	0-13
	Sample Size			10	10	10	10

periodically move about and are available to the fish for food. Dislodging them from their burrow with the trawl would do little more than force them to build a new burrow, already a common behavior pattern.

The light penetration measurements in the lake showed that 1 percent of the surface light, the minimum amount necessary to sustain plant growth, occurred at depths less than 15 feet in the early spring and less than 10 feet during most of the summer. Consequently, the areas of the lake bottom where trawling occurred (deeper than 20 feet) did not support plant life. Therefore, the action of the trawl could not have damaged any plant life. This absence of plant life was substantiated further by the bottom sampling program which did not show any plants in the bottom samples.

The question about destroying spawning areas can be answered directly by the fact that the soft bottom areas of the lake, depths greater than 15 feet where the trawling occurred, are not used by any of the major fish species for spawning.

Finally, data on the destruction of undersized fish species will be treated in detail in the following sections.

Comparison of the Different Types of Gear

As already shown, the gill net catches have made the largest contribution to the fishery's total catch since the early 1930's (59-71 percent, table 3). This can be explained in that more gill netters than other fishermen have contributed to the total catch during this time. Table 11 gives the percentage contribution to the catch by the different species from the separate gear, excluding trawls, during the past 23 years (1949-70). With the exception of burbot where pound and trap nets average 73 percent of the season's catch, gill nets averaged 62 percent or greater on all remaining species. For all species combined, gill nets contributed 65 percent, pound and trap nets 32 percent, and fyke nets 3 percent since 1949.

The numbers in parentheses in table 11 indicate the percent contribution to the catch by the different species from the separate gear including trawls from 1962 to 1964 and 1968 to 1970. Adding two trawls during the first period increased the total fishery catch of burbot by 29 percent, tullibees by 36 percent, saugers by 38 percent, and perch by 44 percent, but increased the catch of walleyes and suckers by only 4 percent and northern pike by less than 1 percent.

Although a 44 percent increase in perch is greater than the 4 percent increase in suckers, the actual weight increase is greater for suckers, 8,550 pounds compared to 8,978 pounds for perch. Table 12 shows the average catch in weight by species for the various gear over several different periods. These averages may lean toward the low side, particularly in the latter years, because they do not reflect changes in total effort per gear as discussed in the previous section on fishing effort. All gear licensed are included in these averages whether or not they were fished.

The shifts in species contribution discussed in the earlier sections on the history of the commercial catch can be seen for each separate gear type. However, although game fish show a decline in average catch per gear, catches of nongame fish increased. This increase was greater than the accompanying decrease so that the total catch of all species by an individual gear increased. During the early 1960's when tullibees, burbot, and common suckers were more abundant, the highest total catches per gear since the early 1930's were recorded. During this time (1958-67), gill nets averaged 70,095 pounds; pound and trap nets, 129,320 pounds; and fyke nets, 13,796 pounds per license per year. These average catches can be contrasted with the average trawl catch during 1962-64 of 488,396 pounds. This table shows the potential impact of trawling.

Table 11. Average contribution to total species catch by each gear, expressed as a percentage of the total

Species	Type of net	1949-57	1958-67	1968-70	1949-70
Walleye	Gill	77	81 (80)*	80 (78)*	79
	Pound and Trap	20	18 (15)	19 (19)	19
	Fyke	3	1 (1)	1 (1)	2
	Trawl		(4)	(2)	
Sauger	Gill	62	59 (38)	70 (67)	62
	Pound and Trap	35	39 (23)	29 (28)	36
	Fyke	3	2 (1)	1 (1)	2
	Trawl		(38)	(4)	
N. Pike	Gill	72	73 (81)	77 (77)	73
	Pound and Trap	18	23 (17)	22 (22)	21
	Fyke	10	4 (2)	1 (1)	6
	Trawl		(trace)	(trace)	
Tullibee	Gill	60	77 (47)	76 (69)	70
	Pound and Trap	40	23 (17)	24 (21)	30
	Fyke	trace	trace (trace)	trace (trace)	trace
	Trawl		(36)	(10)	
Perch	Gill	68	68 (36)	79 (78)	70
	Pound and Trap	16	25 (15)	20 (19)	20
	Fyke	16	7 (5)	1 (1)	10
	Trawl		(44)	(2)	
Burbot	Gill	24	19 (10)	21 (20)	21
	Pound and Trap	69	75 (50)	79 (75)	73
	Fyke	7	6 (11)	trace (trace)	6
	Trawl		(29)	(5)	
Sucker	Gill	69	93 (94)	91 (90)	82
	Pound and Trap	20	6 (2)	8 (8)	12
	Fyke	11	1 (trace)	1 (1)	6
	Trawl		(4)	(1)	
Total	Gill	56	71 (50)	71 (66)	65
	Pound and Trap	39	27 (18)	29 (26)	32
	Fyke	5	2 (1)	trace (trace)	3
	Trawl		(31)	(8)	

* The numbers in parentheses represent the percentage of the total catch when the 1962-64 and 1968-70 trawl catches are included.

Table 12. Average weight of catch per gear by species

Period	Net type	Walleye	Sauger	N. Pike	Tullibee	Perch	Burbot	Sucker	Total
		lb.							
1925-37	Gill	17,176	7,192	6,540	8,444	2,720	100	2,812	46,096
	Pound	25,176	3,606	5,004	7,464	480	2,880	2,382	51,456
	Fyke	7,640	2,378	4,596	453	1,818	3,654	2,737	27,955
1938-41	Gill	13,432	2,536	2,640	34,524	1,284	268	2,600	57,732
	Pound	13,908	1,188	4,464	7,014	270	1,860	4,026	35,262
	Fyke	11,465	2,395	6,340	14,595	1,405	1,490	3,295	46,405
1945-49	Gill	9,012	1,932	1,932	14,481	645	1,608	1,932	32,187
	Pound & trap	12,600	2,520	3,360	29,392	trace	31,072	3,360	83,984
	Fyke	1,154	432	1,297	1,154	577	2,884	1,297	14,418
1949-57	Gill	10,572	2,079	2,436	14,999	510	3,330	1,968	35,961
	Pound & trap	12,804	5,472	2,890	46,663	542	44,523	2,646	116,138
	Fyke	1,551	480	1,442	1	547	4,698	1,436	15,123
1958-67	Gill	8,730	1,398	1,998	47,697	543	2,115	7,521	70,095
	Pound & trap	9,332	4,521	2,986	69,148	972	39,512	2,140	129,320
	Fyke	1,233	429	1,107	65	600	7,213	791	13,796
	Trawl	3,635	18,974	58	419,783	4,275	36,991	4,489	488,396
1968-70	Gill	4,587	631	2,710	43,043	1,088	2,079	5,099	59,253
	Pound & trap	6,511	1,588	4,502	79,118	1,588	46,935	2,832	143,129
	Fyke	283	73	510	88	197	222	312	1,759
	Trawl	8,473	2,886	632	409,782	1,870	31,678	3,413	458,779

By using the average catch per trawl license by species and extrapolating from one to more than one trawl license, we can estimate the potential changes that could occur in the commercial catch if trawls were substituted for the present methods (table 13). The table shows that it would take the catches from only seven trawls to equal or exceed the existing catch. In this catch, there would be 87 percent fewer walleyes, 85 percent fewer suckers, 94 percent fewer miscellaneous species, and virtually 100 percent fewer northern pike. At the same time, the catch of saugers would increase 34 percent, tullibee 28 percent, perch 51 percent, and burbot 1 percent.

Analysis of the catch records indicate, however, that the lake may not be able to support seven trawls. As pointed out earlier, tullibee contribute 85-90 percent of the trawl catch. Because of this high dependence on a single species, the trawl catch could be severely limited if tullibee abundance should decline. Trawling began on the lake when the abundance of tullibees was high. Before trawling, the average tullibee catch by all fishermen from 1930 to 1959 was only 644,000 pounds, which is less than the 3-year average of 839,566 pounds (1962-64) for just two trawls. The 1936 season recorded the lowest total catch for the fishery since 1930, 103,000 pounds, only 1/4 of the average catch for one trawl from 1962 to 1964.

Although their mobility and selective fishing might allow for the catches of trawl nets to be fairly constant from year to year, the trawls allowed to fish on the lake should be carefully controlled, either by limiting the catch or the total

Table 13. Trawl catch, expressed as a percentage per trawl of the total fishery catch by other methods, 1962-1964

		Number of trawls						
		1	2	3	4	5	6	7
		lb. (percent)						
Walleye	202,606	3,635 (1.8)	7,270 (3.6)	10,905 (5.4)	14,540 (7.2)	18,175 (9.0)	21,810 (10.8)	25,445 (12.6)
Sauger	99,206	18,974 (19.1)	37,948 (38.3)	56,922 (57.4)	75,896 (76.5)	94,870 (95.6)	113,844 (114.8)	132,818 (133.9)
N. Pike	70,206	58	116	174	232	290	348	406
	(trace)							
Tullibee	2,297,986	419,783 (18.3)	839,566 (36.5)	1,259,349 (54.8)	1,679,132 (73.1)	2,098,915 (91.3)	2,518,698 (109.6)	2,938,481 (127.9)
Perch	19,777	4,275 (21.6)	8,550 (43.2)	12,825 (64.8)	17,100 (86.5)	21,375 (108.1)	25,650 (129.7)	29,925 (151.3)
Burbot	256,062	36,991 (14.4)	73,982 (28.9)	110,973 (43.3)	147,964 (57.8)	184,955 (72.2)	221,946 (86.7)	258,937 (101.1)
Sucker	215,336	4,489 (2.1)	8,978 (4.2)	13,467 (6.3)	17,956 (8.3)	22,445 (10.4)	26,934 (12.5)	31,423 (14.6)
Other	7,550	63 (0.8)	126 (1.7)	189 (2.5)	252 (3.3)	315 (4.2)	378 (5.0)	441 (5.8)
Total	3,168,729	488,396	976,792	1,465,188	1,953,584	2,441,980	2,930,376	3,418,772

number of licenses. Based on the present knowledge about trawling, it is estimated that the maximum number of trawls allowed to fish on Lake of the Woods should not exceed five, if no limits are placed on the trawl catches and if all other commercial fishing is phased out.

Finally, there remains the question of how the trawls would have performed during the 3 study years had they been allowed to fish commercially. The species composition of the trawl catches during 1962-64 and 1968-70 were nearly the same (table 11). Table 12 shows the estimated average seasonal catch per trawl from 1968 to 1970, based on the catch per unit of effort measured through the sampling program and on the expected total effort estimated from 1962-64 experience. Again, the comparisons are similar. The estimates indicate that the trawl catch for the major species in the catch, the tullibee, would have approximated 98 percent of the average 1962-64 catch: 409,782 and 419,783 pounds, respectively.

The greatest difference in estimated catches occurred with the saugers, where the anticipated catch would have been only 15 percent of the former level. Reasons for this have been discussed and seem to be largely a reflection of a general lakewide decline in sauger abundance. The walleye, in contrast, showed an estimated increase in catch of 133 percent. This anticipated increase might be on the high side because of the inclusion of undersized walleye in the 1968-70 samples, but not in the 1963-64 samples. Even with the increased catch, however, the total walleye catch with a trawl would not measurably exceed the individual catches of walleye with gill, pound, or trap net licenses.

If trawls were used as replacement gear for nets now in operation, a one-to-one substitution of commercial licenses would not measurably increase the total walleye catch, but would markedly increase the catch of nongame species, particularly the tullibee.

STATUS OF THE FISH POPULATIONS

As discussed briefly above, the status of the exploited fish species in Lake of the Woods has changed a great deal since the inception of the commercial fishery in the late 1800's. The changes from 1887 to 1949 have been documented by Carlander (1942) and Burrows (1951). Since 1949, however, only the limited summaries in Scidmore (1963) relating to the feasibility of trawling have been reported. The current survey approach will be to relate the status of the present day fishery, in terms of individual species, to these past changes as well as to changes since the 1940 surveys.

Carlander (1942) reported 37 species of fish in Lake of the Woods. Although no attempt was made to validate the present species complement, two changes were noted. Several dozen specimens of fish referred to locally as goldeye (*Hiodon alisoides* Rafinesque) were identified by James Underhill, zoology department, University of Minnesota, as mooneye (*Hiodon tergisis* LeSueur). Also, two specimens of ninespine stickleback (*Pungitius pungitius* Linnaeus) were collected during the summer of 1969. This was the first recorded capture of the species for the lake.

WALLEYE

Although the annual commercial harvest of walleye has declined from over 40 percent (early 1920's) to less than 10 percent (present day) of the total fishery catch in pounds, the species still contributes 40 percent or more of the total value of the harvest and continues to be the most important species in the fishery. In addition, the walleye accounts for over 80 percent of the angler's

creel. Because of the intense interest in this species, management policies established for the lake are predicated on the maintenance of a satisfactory walleye fishery. All other species are considered incidental. This was the situation in the late 1930's also and resulted in the Carlander survey.

Three decades have passed since that survey and changes have occurred in both the commercial and sport fishery. Although commercial fishing has declined on the lake, sport fishing has increased. Interpreting these changes, a concerned citizens' group petitioned the Minnesota State Legislature in 1947 to readjust the regulations for commercial fishing, stating that ". . .the total depletion of game fish in Lake of the Woods will take place within the next 3 or 4 years unless definite steps are taken now to correct this condition." Over 6 million pounds of walleye have been harvested by the Minnesota commercial fishery since then, and commercial fishing in Canadian waters, contiguous to Minnesota, has landed over 7 million pounds during the same period. A conservative estimate of the total walleye harvest since 1947 by sport and commercial interests from the southern half of the lake would exceed 20 million pounds, certainly a far cry from the predicted total depletion and a credit to the reproductive potential of the species.

Description of Growth

Current growth rates for walleye were obtained by the scale method, validated by Carlander (1942). Scale samples were selected from 789 fish collected with various types of gear during the 3 years and varying in fork length from 2.2 to 23.9 inches. Body lengths at subsequent 10 millimeter scale length intervals were averaged and the computed mean body lengths were then plotted against the corresponding mean scale length. A line was fitted by eye to the plotted data and a body-length intercept arrived at by extrapolation. The resulting curve paralleled a similar curve constructed by Carlander (1942) using standard lengths and computed as a second degree parabola. From the fitted line, a corrected nomograph was constructed (Carlander and Smith, 1944) by appropriate projection from the curve at points representing successive body lengths.

Using the nomograph, growth rates were back calculated for 391 fish representing 12 year classes. Table 14 shows the growth histories determined by this method. The growth rates computed in the present study and those made by Carlander (1942) are in close agreement through age group IX (table 14). Currently, age groups X through XII show somewhat less growth than Carlander observed, but the sample size is small and the range observed encompasses the average value reported by Carlander. Consequently, there appears to be little, if any, difference in growth rates for present day walleye and those observed 3 decades ago.

Because changes in population status frequently cause changes in growth rates, the lack of change observed in growth rate would tend to indicate that the population status of Lake of the Woods walleye has not changed during the same time period. However, population status changes of other species, particularly sauger, could affect the growth rates of walleyes. This will be discussed in later sections.

Growth in weight was computed by constructing a body length-body weight relationship from 381 fish varying from 6.1 to 23.9 inches in fork length, weighing from 1.2 ounces to 5 pounds, 2.5 ounces. The weights were averaged

Table 14. Average calculated fork lengths in inches of walleye in Lake of the Woods, 1956-67 year classes, and average fork lengths in inches for walleyes observed by Carlander (1942)

Year class	No. in sample	Age group											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
		inches											
1967	12	4.1											
1966	56	6.0	7.9										
1965	1	4.9	6.8	8.1									
1964	50	6.0	7.9	10.3	11.7								
1963	57	6.7	9.0	10.1	12.2	13.5							
1962	19	6.4	8.8	11.0	12.4	14.1	15.1						
1961	104	6.5	8.7	11.3	13.1	14.6	15.9	17.1					
1960	51	5.9	9.0	11.2	13.3	14.5	15.9	17.1	18.0				
1959	23	5.8	8.8	11.3	13.0	14.4	15.9	17.0	18.1	18.9			
1958	15	6.0	9.0	11.4	13.3	15.4	16.8	17.5	19.1	19.9	20.6		
1957	2	5.5	9.6	13.0	15.4	17.3	18.8	19.8	20.7	21.5	22.1	22.7	
1956	1	6.3	8.4	10.9	13.2	14.2	15.5	16.5	17.6	18.3	19.2	20.5	21.0
Grand average	(391)	5.8	8.5	10.9	13.1	14.8	16.3	17.5	18.7	19.7	20.6	21.6	21.0
Grand average (Carlander, 1942)		6.1	8.8	10.9	12.8	14.3	14.6	17.4	18.9	20.0	21.7	22.7	23.1

for successive 0.4-inch body length intervals. The data were then transformed to logarithms and a simple linear regression calculated. This relationship can be described by the formula:

$$\log W = 2.3177 + 3.1068 \log L$$

By applying the formula against the average size of walleye at each annulus, as computed above, the average weight of the walleye at successive ages was calculated (table 15).

The growth in weight found during the current study and that found by Carlander (1942) are in close agreement. The percentage increments in weight for older age groups during the Carlander survey are somewhat larger than those observed during the current study. However, the average weights of Carlander's younger age groups are somewhat smaller than those for similar age groups in the current study. Overall, the information on growth in weight would support the conclusion (from comparisons of growth in length) that little or no change in walleye growth rates has occurred since the early 1940's.

Length Distribution of the Commercial Catch

Table 16 shows the length-frequency distribution of walleye with the various commercial gear. Yearly frequencies per gear were adjusted to a common sample size of 5,000, and then unweighted averages were computed for the 3 collection years, 1968-70 (figures 20, 21, and 22). The figures show that the commercial gear vary greatly in the length-frequency distribution of walleyes they capture.

The gill nets are the most selective gear with only 13 percent of the catch, in numbers, being smaller than the legal size of 15 inches fork length. The pound and trap nets are the least selective with 88 percent of the catch, in numbers, being undersize. However, because these nets hold the fish alive until the net is lifted, most of the undersized fish are returned to the lake alive. A certain number of these undersize fish die in the nets, depending upon the weather, the activity of loons and cormorants, and the strength of the recruiting year classes.

Trawl nets were more selective in catching walleyes than pound and trap nets but less selective than gill nets. Size selection in trawl catches also varied with the mesh of the net. When the mesh of the cod or tail end of the net was 3 1/8-inches (stretch measure), 60 percent of the walleye catch were undersize, but only 44 percent were too small when a larger cod size of 3 1/2-inches (stretch measure) was used. Although no mesh regulations were established for the body of the net when the trawl operated under commercial license (1963-64), in the current study the mesh size in the body was also important in determining the size of fish captured.

To eliminate the influence of undersize fish in the catches, which usually are returned to the lake alive, and to facilitate comparisons of the influence of the various gear on the walleye population, length-frequency distributions were constructed for only those fish that contributed to the marketable catch (those removed from the lake). For commercial gill nets this tabulation included fish as small as 14.2 inches, because they were observed in the catches even though the legal minimum is 15.0 inches. In the distribution for pound and trap nets where sorting is most effective, about 50 percent of the fish caught in the 14.6- to 14.9-inch length interval were kept for sale. The distributions for all gear then were transformed by size interval to a percentage of the total sample to account for differences in sample size (figures 23, 24, and 25).

Table 15. Growth in weight of walleye in Lake of the Woods, expressed as calculated weight at time of annulus formation

Age group	1968-1970				1939-1941			
	Fork length (inches)	Weight (oz.)	Increment	Percentage increment	Fork length (inches)	Weight (oz.)	Increment	Percentage increment
I	5.8	1.13	1.13	–	6.1	1.23	1.23	–
II	8.5	3.71	2.58	228	8.8	3.77	2.54	206
III	10.9	8.04	4.33	117	10.9	7.48	3.71	98
IV	13.1	14.24	6.20	77	12.8	12.06	4.58	65
V	14.8	20.81	6.57	46	14.3	16.44	4.38	46
VI	16.3	28.08	7.27	35	14.6	22.54	6.10	36
VII	17.5	35.00	6.92	25	17.4	31.01	8.47	38
VIII	18.7	43.00	8.00	23	18.9	40.78	9.77	33
IX	19.7	50.59	7.59	18	20.0	52.49	11.71	30
X	20.6	58.12	7.53	15	21.7	61.16	8.67	25
XI	21.6	67.30	9.18	16	22.7	71.64	10.48	26

Table 16. Length-frequency distribution by gear for Lake of the Woods walleye

Length (inches)	Gill net				Pound & trap net			
	1968	1969	1970	Average per 5,000	1968	1969	1970	Average per 5,000
	number							
5.8-6.1	1			1				
6.2-6.5								
6.6-6.9	5			4				
7.0-7.3	2			2				
7.4-7.7	10			9				
7.8-8.1	11			10				
8.2-8.5	8			7				
8.6-8.9	11			10				
9.0-9.3	3	1		4		5	2	4
9.4-9.7	2	6		7	17	22	4	22
9.8-10.1	5	3	1	8	31	77	3	63
10.2-10.5	2	4		5	27	220	38	165
10.6-10.9	3	5		7	54	317	74	249
11.0-11.3	5	10		14	70	356	241	327
11.4-11.7	7	11	5	21	141	259	420	342
11.8-12.1	4	2	3	8	254	219	613	414
12.2-12.5	9	4	8	20	285	205	684	437
12.6-12.9	15	2	11	26	278	130	682	385
13.0-13.3	11	3	12	25	375	133	730	438
13.4-13.7	14	5	9	26	433	105	739	445
13.8-14.1	29	6	11	42	479	116	661	449
14.2-14.5	74	26	14	103	452	108	427	367
14.6-14.9	166	106	59	304	451	87	232	299
15.0-15.3	301	319	159	726	307	57	130	194
15.4-15.7	282	338	213	783	202	38	74	125
15.8-16.1	272	288	238	753	126	37	45	86
16.2-16.5	149	223	200	546	61	20	38	48
16.6-16.9	89	148	149	371	48	8	24	31
17.0-17.3	86	80	143	298	36	9	25	27
17.4-17.7	68	50	113	223	26	8	16	20
17.8-18.1	62	35	78	167	11	5	7	10
18.2-18.5	51	17	52	114	16	2	7	10
18.6-18.9	44	10	35	84	14	4	6	10
19.0-19.3	30	11	20	57	5	1	8	5
19.4-19.7	27	16	19	58	6	1	1	3
19.8-20.1	15	10	13	36	7	1	2	4
20.2-20.5	10	8	7	24	9	1	2	5
20.6-20.9	6	5	8	18	4	1	2	3
21.0-21.3	11	2	2	14	1	1	2	2
21.4-21.7	6	5	8	18	7	1	3	4
21.8-22.1	7	4	2	12	1			
22.2-22.5	3	1	7	11	3		2	2
22.6-22.9	4	2	6	12	1			
23.0-23.3	3		4	7	2			1
23.4-23.7		1	2	3	1		1	1
23.8-24.1	1		1	2			1	
24.2-24.5	1		1	2				
24.6-24.9								
25.0-25.3								
25.4-25.7		1		1	2			1
25.8-26.1					1			
26.2-26.5					1			
26.6-26.9					1			
27.0-27.3	3			3	1			
27.4-27.7					2			1
27.8-28.1								
28.2-28.5		1		1	1			
Total	1,928	1,769	1,610	5,007	4,250	2,554	5,947	4,999

Table 16. (continued)

Length (inches)	Trawl net						
	3 1/8" mesh				3 1/2" mesh		
	1968	1969	1970	Average per 5,000	1968	1969	Average per 5,000
	number						
5.8 – 6.1							
6.2 – 6.5							
6.6 – 6.9	3			8			
7.0 – 7.3	3			8			
7.4 – 7.7	3			8			
7.8 – 8.1	6	1		18			
8.2 – 8.5	9			25	1		8
8.6 – 8.9	7			19	2		17
9.0 – 9.3	10	1		29	4		34
9.4 – 9.7	18	2	1	54	9		77
9.8 – 10.1	44	8	1	135	9	3	100
10.2 – 10.5	56	8	3	171	9	15	195
10.6 – 10.9	26	19	4	107	8	21	234
11.0 – 11.3	6	29	7	73	5	22	216
11.4 – 11.7	4	27	14	75	7	17	194
11.8 – 12.1	11	27	37	124	3	14	136
12.2 – 12.5	14	22	51	142	5	1	51
12.6 – 12.9	27	26	71	211	6	4	83
13.0 – 13.3	40	31	96	288	7	3	84
13.4 – 13.7	43	53	86	319	16	4	168
13.8 – 14.1	47	61	94	354	10	9	156
14.2 – 14.5	49	90	86	397	17	11	232
14.6 – 14.9	65	92	95	456	18	11	240
15.0 – 15.3	29	110	94	385	20	37	462
15.4 – 15.7	22	106	90	341	15	35	404
15.8 – 16.1	22	73	72	276	9	25	274
16.2 – 16.5	9	57	91	239	10	20	242
16.6 – 16.9	7	47	55	170	8	15	186
17.0 – 17.3	4	33	43	122	12	12	197
17.4 – 17.7	2	13	36	74	5	4	74
17.8 – 18.1	2	14	30	68	13	8	174
18.2 – 18.5	3	7	16	41	4	3	58
18.6 – 18.9	3	1	18	34	10	2	101
19.0 – 19.3	1	5	14	30	7	4	92
19.4 – 19.7	3	4	5	22	7	4	92
19.8 – 20.1	1	4	8	20	5		43
20.2 – 20.5		1	7	11	5	2	58
20.6 – 20.9	1	4	5	16		1	8
21.0 – 21.3	1	4	4	15	3	1	34
21.4 – 21.7	2	5	4	19	1	2	24
21.8 – 22.1	1	4	4	23	3	1	34
22.2 – 22.5	1	3	2	14		1	8
22.6 – 22.9		3		5	4	1	42
23.0 – 23.3		4	2	9	2		17
23.4 – 23.7		3	2	8	1	2	24
23.8 – 24.1		2	2	6	1		8
24.2 – 24.5	1	1	1	6			
24.6 – 24.9		3	1	6	2		17
25.0 – 25.3			2	3	1	1	16
25.4 – 25.7			2	3	2		17
25.8 – 26.1		1		2		1	8
26.2 – 26.5					3	1	34
26.6 – 26.9	1			3	1		8
27.0 – 27.3	1	1	1	6	1		8
27.4 – 27.7		1		2	1		8
27.8 – 28.1							
28.2 – 28.5							
Total	608	1,011	1,257	5,000	292	318	4,997

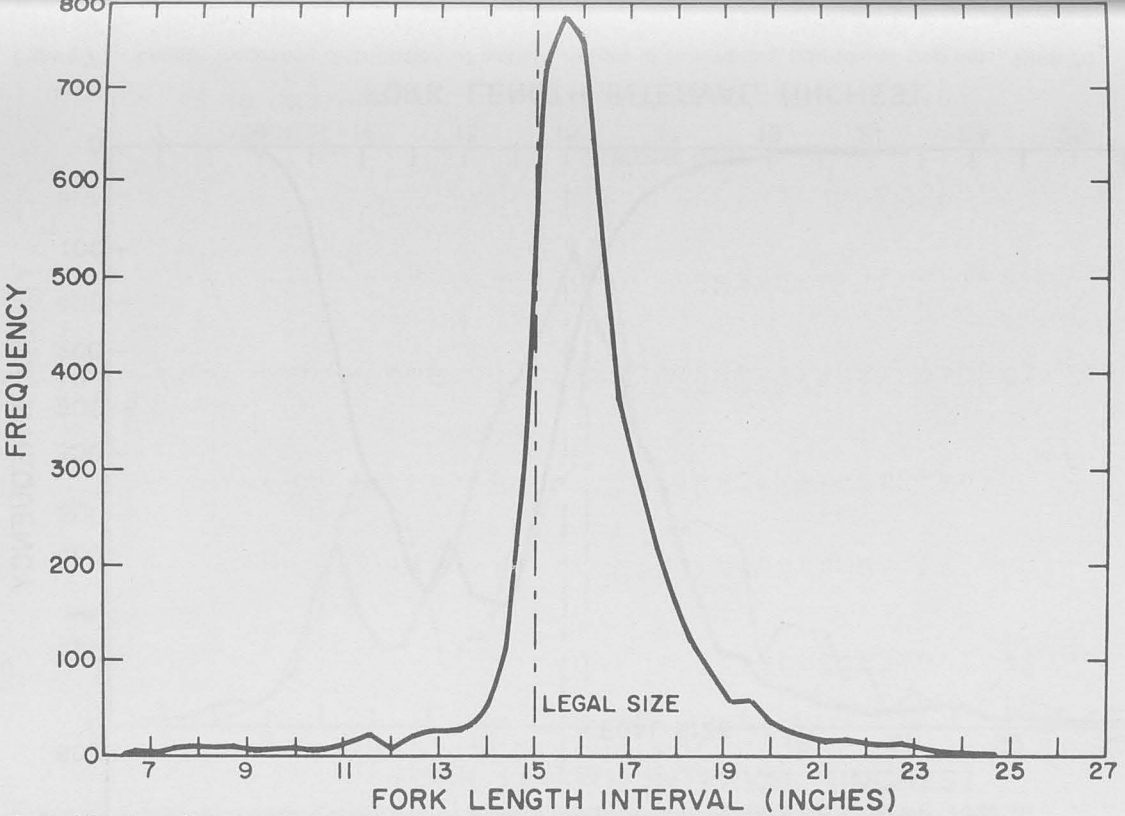


Figure 20. Length-frequency distribution of walleye caught in commercial gill nets, 1968-70.

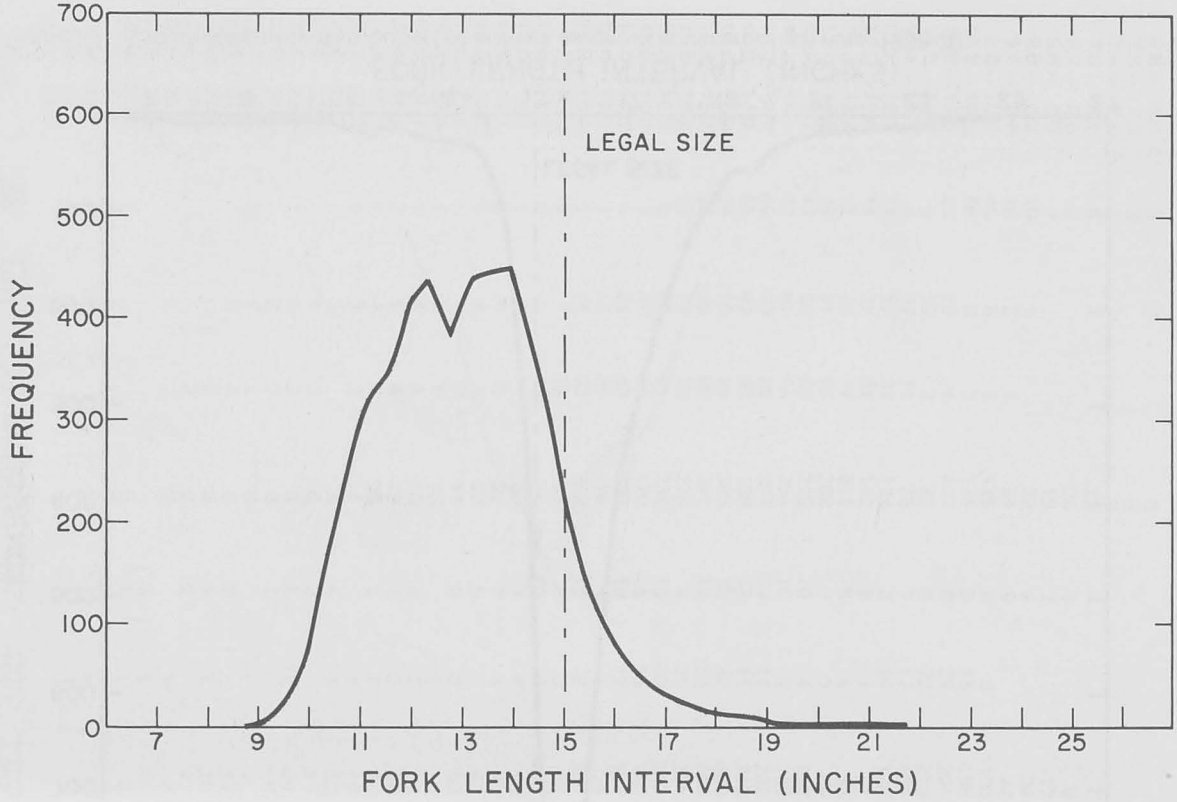


Figure 21. Length-frequency distribution of walleye caught in commercial pound and trap nets, 1968-70.

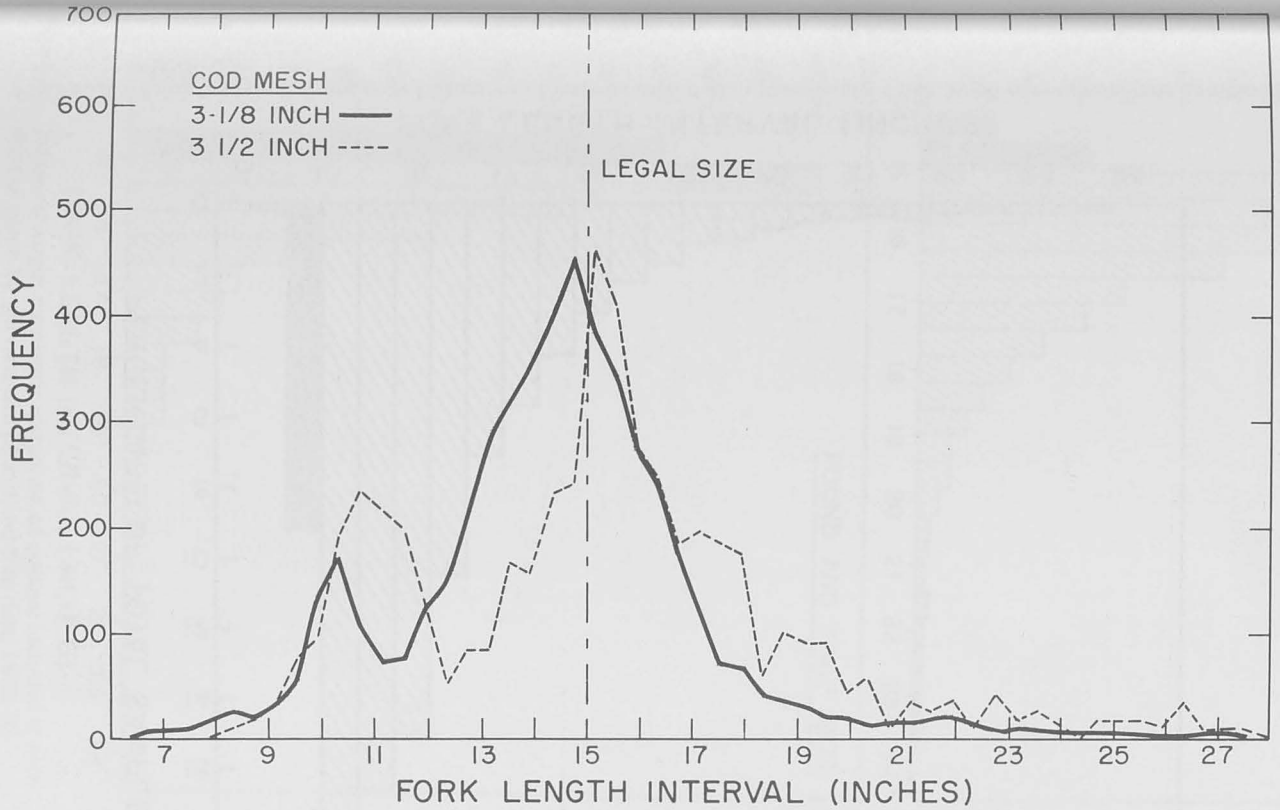


Figure 22. Length-frequency distribution of walleye caught in commercial-sized trawl nets, 1968-70.

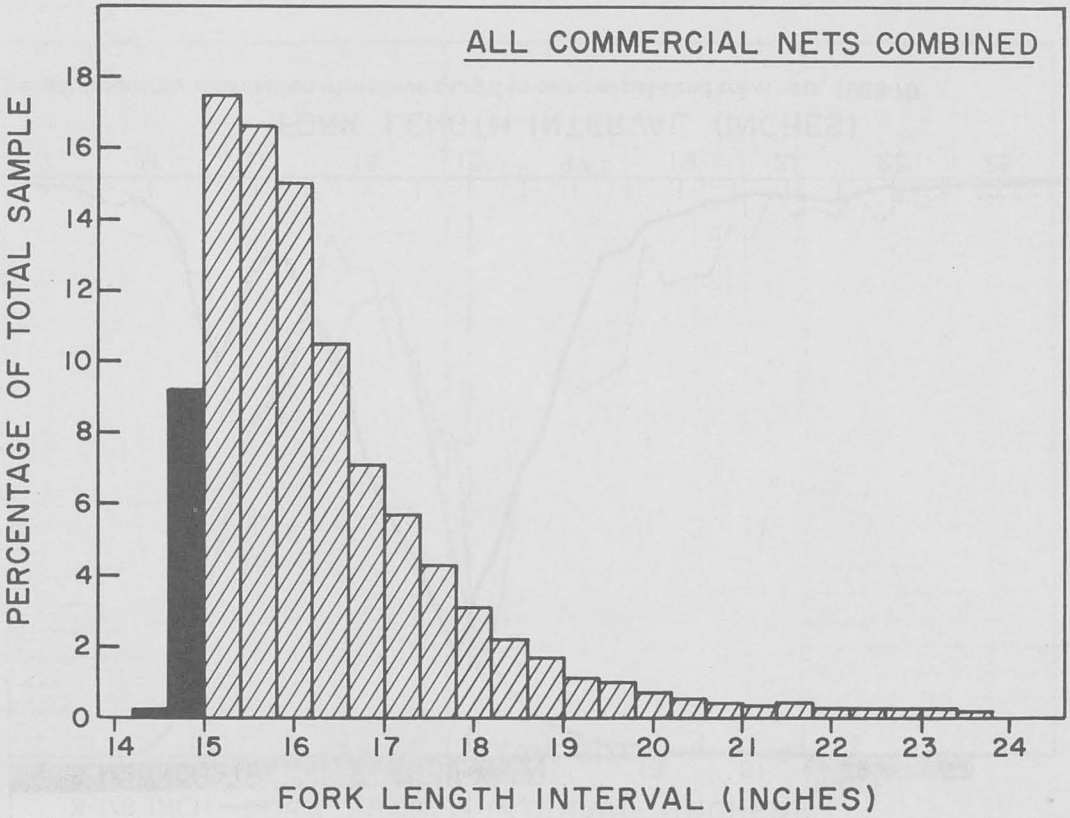


Figure 23. Adjusted length-frequency histogram of walleye included in commercial catch by all commercial nets combined, 1968-70.

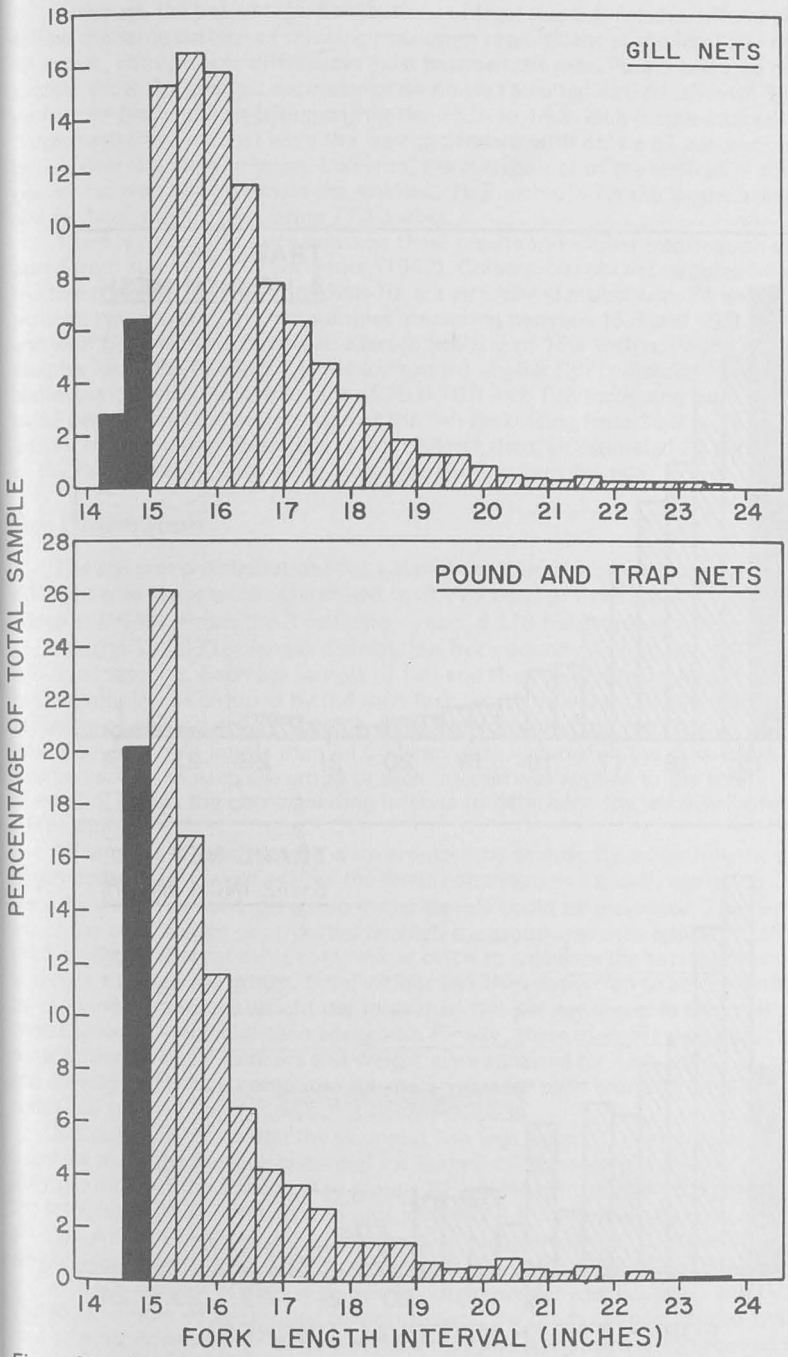


Figure 24. Adjusted length-frequency histogram of walleye included in commercial catch by gill nets and pound and trap nets, 1968-70.

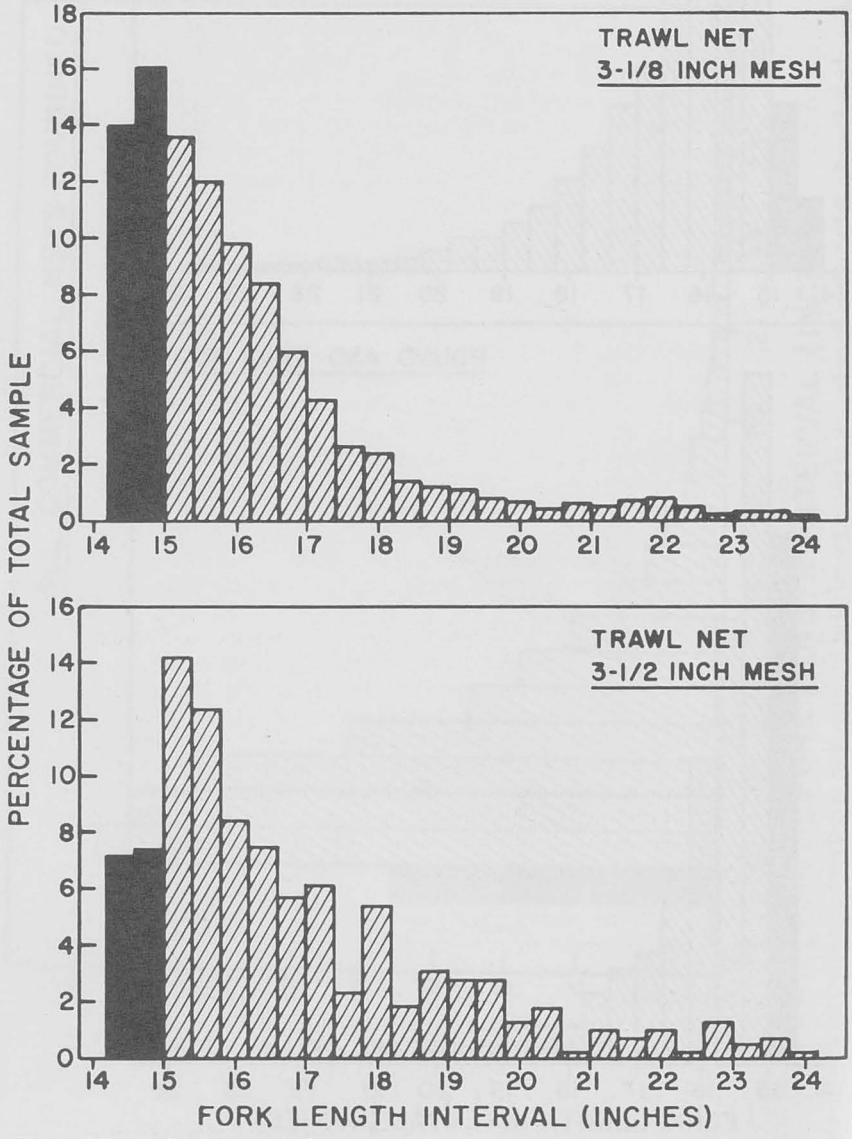


Figure 25. Adjusted length-frequency histogram of walleye included in commercial-sized trawl nets, 1968-70.

Although the percentage distributions of legal size fish for the different gear follow the same pattern of showing maximum recruitment at the legal size of 15 inches, considerable differences exist between the gear. Pound and trap net catches show the greatest dependence on newly recruited individuals with 82 percent of the legal fish falling within the 15.0- to 16.9- inch length interval. Large mesh trawl catches were the least dependent with only a 57 percent contribution over the same interval. Likewise, the average size of the walleye in the pound and trap net catch was the smallest, 15.9 inches, with the largest average size for large mesh trawls being 17.1 inches.

There is little difference between these results and similar information computed from summaries in Carlander (1942). Commercial gill net samples from the two periods, 1939-41 and 1968-70, are virtually identical with 74 and 73 percent, respectively, of their samples measuring between 15.0 and 16.9 inches and with both samples having an average fish size of 16.4 inches. Pound net samples for 1968-70 show a tendency toward smaller fish compared to the earlier period with the percentage of 15.0-16.9-inch fish increasing from 77 to 82 percent and the average size of the fish decreasing from 16.3 to 15.9 inches. In calculating these figures for 1939-41 data, an estimated 25 percent of the fish in the 14.0- to 14.9- inch interval were kept for sale.

Age Distribution

The age group distributions for Lake of the Woods walleye harvested by the different gear types were determined by the method of Fridriksson (1934) and Ketchen (1949). From the 3 collection years, 4,178 fish were sampled for age analysis and 15,203 for length distribution from pound and trap net, gill net, and trawl samples. Each age sample of fish and the corresponding length distribution sample was grouped by 0.4-inch fork length intervals. To eliminate the influence of undersize fish that may have been captured but returned to the lake alive, only fish longer than 14.5 inches were included in the calculations. The percentage of each age group in each interval was applied to the total number of fish in the corresponding interval to determine the age distribution of the sample.

All samples for each season were arranged by month. By projecting the body length-body weight curve against the length distribution for each age group, the total weight of each age group in the sample could be estimated. The percentage of the total weight contributed by each age group was then applied to the total weight of that month's commercial catch to calculate the total contribution in weight for each age group. Total weight was then converted to total numbers by applying the average weight per individual fish per age group to the total contribution in weight of each age group. Finally, these monthly periods of total contribution in both numbers and weight were summed for each collection year, and unweighted means computed for the 3 years for each gear and for all gear combined (table 17).

Although gill nets catch the youngest fish (age group III), the pound and trap nets show the greatest potential for harvest of these age groups not yet fully recruited to the fishery. Age groups III and IV contributed 15.4 percent of the total catch by pound and trap nets and only 4.4 percent of the total catch by gill nets. All types of gear show maximum recruitment at age VI. When all gear are combined, the distribution is similar with maximum recruitment at age VI and with 6.8 percent of the catch being contributed by age groups III and IV. The total number of age groups contributing to the catch per gear ranged from four to nine; however, for all gear types only three age groups were required to

contribute 80 percent or more of the total catch. For all gear combined age groups V, VI, and VII contributed 83.9 percent of the average total catch over the 3 study years.

Changes in regulations governing the size of commercially legal walleyes since the Carlander study prohibit a direct comparison of the age composition of the commercial catches during the two study periods, but several similarities can be noted. As expected, younger age groups made greater contributions when the fishermen were allowed to keep smaller fish. The number of age groups contributing to the catch, however, was about the same ranging from five to ten. Similarly the three largest age groups together contributed about 80 percent of the total catch.

Table 17. Age distribution of walleye, expressed as a percentage of the total number of fish caught/gear/season, averaged over 3 years

		age group												
Net	Year	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Gill	1968	4.6	2.4	56.7	9.6	18.4	5.8	1.8	0.6	0.1				
	1969			18.2	59.1	8.0	13.2	1.0	0.3	0.2				
	1970		6.2	8.4	29.8	46.1	3.2	6.1	0.1	0.1				
	$\bar{x}$	1.5	2.9	27.8	32.8	24.2	7.4	3.0	0.3	0.1				
Pound & trap	1968		6.0	53.3	11.7	24.1	3.0	1.0	0.5				0.4	
	1969		0.6	18.2	68.8	7.9	3.5	0.4		0.4		0.2		
	1970		39.7	7.4	25.1	23.5	3.5	0.8						
	$\bar{x}$		15.4	26.3	35.2	18.5	3.3	0.8	0.2	0.1		0.1	0.1	
Trawl (3-1/8")	1968			89.5	2.8	6.6	1.1							
	1969			12.6	74.8	5.3	4.9	1.5	0.3			0.4		0.2
	1970		9.9	4.2	31.9	45.1	6.3	1.1	0.4	1.0				0.1
	$\bar{x}$		3.3	35.5	36.5	19.0	4.1	0.9	0.2	0.3		0.1		0.1
Trawl (3-1/2")	1968			51.6		25.4	9.3	7.3	0.8		2.4		3.2	
	1969			14.1	72.9	1.5	3.5	3.5	3.5			1.0		
	$\bar{x}$			32.9	36.4	13.4	6.4	5.4	2.2		1.2	0.5	1.6	
All gear combined	1968	3.6	3.2	56.1	10.0	19.6	5.1	1.6	0.6	0.1			0.1	
	1969		0.1	18.1	61.6	7.9	10.9	0.9	0.2	0.2		0.1		
	1970		13.4	8.2	28.8	41.2	3.3	4.9	0.1	0.1				
	$\bar{x}$	1.2	5.6	27.5	33.5	22.9	6.4	2.5	0.3	0.1				

Total Annual Mortality Rate

Using the analysis of catch curves as described in Ricker (1958), total annual mortality rate was estimated for Lake of the Woods walleye fully recruited to the commercial fishery. This computation for age groups VI through IX caught in pound and trap nets gave an estimate of the instantaneous mortality rate of $i = -1.16$, which when converted with the tables in Ricker (1958) results in a total annual mortality estimate of 69 percent. Although walleye angling fisheries reported in the literature show total annual mortality rates in the range of 25-35 percent, the high value obtained in the current study is similar to the value of 70 percent reported by Smith and Pycha (1962) for walleyes from the commercial fishery on Red Lakes, Minnesota.

Carlander computed similar total annual mortality rates during the 1939-41 study. Because of changes in regulations governing the minimum size limit for walleye since the Carlander study these values cannot be compared with those from the current study. However, if the entire pound and trap net sample from

1968 to 1970 is used, including those fish not yet fully recruited to the commercial gear, an approximation can be made that more closely resembles Carlander's data. Such a computation with 1968-70 data yields a value of 60 percent ($i = -0.91$); similar estimates using 1939-43 data yield a value of 56 percent ($i = -0.83$).

It would appear that even though commercial fishing intensity for walleyes has declined by a factor of 1/2 or more of the levels existing during the Carlander survey, the total annual mortality rate for walleyes has remained the same or may have increased only slightly. This can be attributed to the increase in angling intensity for walleyes over the same period. Data are not available that would allow the quantification of this increase. Information from the 1968-70 creel census indicates, however, that anglers are harvesting as many commercially legal-size walleyes as are being landed by the commercial industry and that the total angling and commercial catch of walleyes approximates the average commercial catches observed during the 1940's.

If natural annual mortality rates can be assumed to approximate 20 percent as indicated from the Red Lakes study (L.L. Smith, Jr., personal communication, and Kennedy, 1949) and if anglers and commercial fishermen are exerting an equal effect on the harvestable population, then the component of mortality due to angling would approximately 25 to 30 percent and would be well within the range of values reported for other waters and discussed above.

Size and Age at Maturity

No data were collected from 1968 to 1970 on the size or age at maturity of Lake of the Woods walleye, but with the small changes in both growth rate and age structure (as measured from the commercial catches and discussed above), it is doubtful that any changes in the rate of maturation would have occurred either. It is also well documented that male walleyes mature at a smaller size and younger age than female walleyes. Because of this, any analysis considering size limits and implications with respect to maintaining adequate spawning stocks for maximum recruitment of new fish to the population must be concerned with females.

Carlander (1942) considered this question and came to the conclusion that most female walleyes in Lake of the Woods experience at least one season of commercial fishing before reaching maturity. Samples collected by Canadian biologists working on Lake of the Woods in 1969 confirm this. Only 3 percent of the mature females collected in the spawning run were younger than age class VI in contrast to mature males where 51 percent were younger than age class VI (V. Macins, Ontario Department of Lands & Forests, personal communication). Likewise, D. Schupp (personal communication) found only 50 to 52 percent of the female walleyes to be mature at 15.8-inches fork length.

The high mortality rate of adult walleyes and the recruitment of immature females to the fishery suggest that it would be possible to overharvest the spawning stock and thereby reduce the recruitment of new fish to the population. All data assembled thus far indicate that this point has not yet been reached; although Regier et al. (1970) pointed out that very abundant year classes may be cause for concern, the extremely abundant 1966 year class in Lake of the Woods walleye appears rather to demonstrate the ability of the walleye population to maintain itself in the face of high exploitation rates.

Critical Size at Harvest and Maximum Sustained Yield

The prime objective of all commercial fisheries is to catch the maximum poundage of fish with a minimum of expense and effort. Fisheries' biologists have spent a lot of time developing fishing theory with this goal in mind. One of these concepts, the critical size at harvest for obtaining maximum yield (Ricker, 1945), says simply that a fish should be allowed to continue to grow until the instantaneous rate of increase to the population is exceeded by the instantaneous rate of loss due to natural mortality. Where it has not been possible to harvest all of the fish when they reach the "critical size," the size limit has been adjusted downward and referred to as the "optimum size" at harvest.

The estimation of the instantaneous rate of increase to the population can easily be made using the growth rate information derived from the preceding analyses. Table 18 shows the instantaneous growth in weight (Ricker, 1958) for Lake of the Woods walleye to decrease from g—1.19 during the 2nd year of life to g=0.14 during the 10th year of life. The difficulty with this approach is obtaining a comparable estimate of the instantaneous rate of loss due to natural mortality. In Lake of the Woods, additional complexity is introduced by the presence of the angling fishery.

If we consider natural mortality to be near the 20 percent level observed in the Red Lakes fishery, this would give an instantaneous rate of loss of g—0.22. When this is compared to table 18, we observe the critical size at harvest to be about 16.3 inches, the size of age class VII at the time of annulus formation. If, however, we consider natural mortality to approximate the 4 percent level observed by Olson (1957) in Many Point Lake, Minnesota, the walleye should not be harvested until they are at least 11 years old and average 21.6 inches or more in fork length.

In the combined sport-commercial fishery, the major problem in interpreting this data is that anglers are not interested in harvesting the greatest number of pounds of fish but rather in catching as many acceptable size fish as possible. The size at harvest in this situation becomes the smallest size which will be acceptable to the angler and yet not reduce the spawning population such as to limit maximum potential recruitment.

Because of this conflict in interpretation of maximum harvest between sport and commercial fishermen, it is meaningless to attempt any calculation of the maximum sustained harvest of walleyes by the commercial industry. To increase the size limit for commercially acceptable fish and thereby capitalize

Table 18. Instantaneous growth rate, g, for Lake of the Woods walleye, sexes combined

Age group	Fork length (in.)	Weight (oz.)	Wt / Wt—1	g = 1n Wt / Wt—1
I	5.8	1.13	—	—
II	8.5	3.71	3.28	1.19
III	10.9	8.04	2.17	0.77
IV	13.1	14.24	1.77	0.57
V	14.8	20.81	1.46	0.38
VI	16.3	28.08	1.35	0.30
VII	17.5	35.00	1.25	0.22
VIII	18.7	43.00	1.23	0.21
IX	19.7	50.59	1.18	0.17
X	20.6	58.12	1.15	0.14
XI	21.6	67.30	1.16	0.15

on the growth potential of the population would more than likely readjust both angling and natural annual mortality rates thereby minimizing the expected increase in the commercial catches.

If similar size limits were imposed on both the angling and commercial industries, however, then the total pounds of walleyes harvested could increase. Without similar size limits, a sustainable yield for the combined fishery for fish larger than 15.0-inches fork length would appear to approximate the long-term average commercial catch level of around 300,000 pounds, only half of which the commercial fishery could expect to land. In addition, any increase in angling effort would probably lower the expected commercial catch even more.

TULLIBEE

Second in importance to walleye since the 1930's, the tullibee population has consistently yielded the greatest number of pounds of fish to the annual commercial harvest. With good levels of abundance in the late 1950's and early 1960's, record high catches were taken amounting to more than 60 percent of the total fishery catch and 40 percent of the total value. Utilization of this species, however, is dependent on a healthy mink industry, because a high rate of parasite infestation *(Triaenophorus sp.)* has limited its sale for human consumption. During the last several years, mink ranching has declined to borderline profit levels (Stam, 1972). Should the depressed market fail to recover, the tullibee resource might diminish in importance.

Description of Growth

Growth rates for tullibee were obtained using the scale method validated by Carlander (1942). Scale samples used to construct a body length-scale length relationship were selected from 664 fish collected with various types of gear over the 3 study years and varying in fork length from 2.7 to 17.0 inches. As was done for walleye, a line was fitted by eye to the plotted data and a body-length intercept arrived at by extrapolation. From the fitted line a nomograph was constructed as previously described.

Using the nomograph, growth rates were back calculated for 663 fish representing eight year classes (table 19). Comparing the growth rates computed from the present study with those made by Carlander (1942), we see that although the younger fish from the current study appear to grow at a faster rate, both groups of fish reach approximately the same size by age VI (figure 26). Following this point, growth observed in 1942 appears to be considerably greater, averaging 1.2 inches more by age VIII.

Changes in growth rates can be the consequence of changes in population abundance. As indicated earlier, estimates of abundance during the current study reached the highest level recorded since 1949. Similar abundance estimates did not exist before 1949 so comparisons cannot be made on that basis; however, because the total amount of gear licensed from 1939 to 1941 was twice that licensed from 1968 to 1970, the total fishing effort would be expected to have been greater as well. Total catch for the two periods are approximately the same. This indicates either a shift by the fishermen in fishing habits or a change in the abundance of the species. Familiarity with the fishing industry would tend to support the latter.

Growth in weight was computed by constructing a body length-body weight relationship from 1,779 fish varying from 4.8 to 17.0 inches in fork

Table 19. Average calculated fork lengths in inches of tullibee in Lake of the Woods, 1960-67 year classes, and average fork lengths in inches for tullibee observed by Carlander (1942)

Year class	Number in sample	Age group I	II	III	IV	V	VI	VII	VIII
1967	17	5.0							
1966	103	4.1	8.1						
1965	23	4.4	6.7	9.0					
1964	215	3.9	7.2	8.8	10.3				
1963	114	4.6	7.2	9.5	10.7	11.4			
1962	137	4.7	7.6	9.8	11.0	11.7	12.1		
1961	45	5.1	8.0	10.3	11.4	12.0	12.5	12.8	
1960	9	4.6	7.5	10.0	11.2	11.8	12.2	12.6	12.9
Grand average $\bar{x}$	663	4.6	7.5	9.6	10.9	11.7	12.3	12.7	12.9
Range		3.9 – 5.1	6.7 – 8.1	8.8 – 10.3	10.3 – 11.4	11.4 – 12.0	12.1 – 12.5	12.6 – 12.8	–
Carlander 1942	1379	4.6	6.8	8.7	10.4	11.7	12.5	13.5	14.2

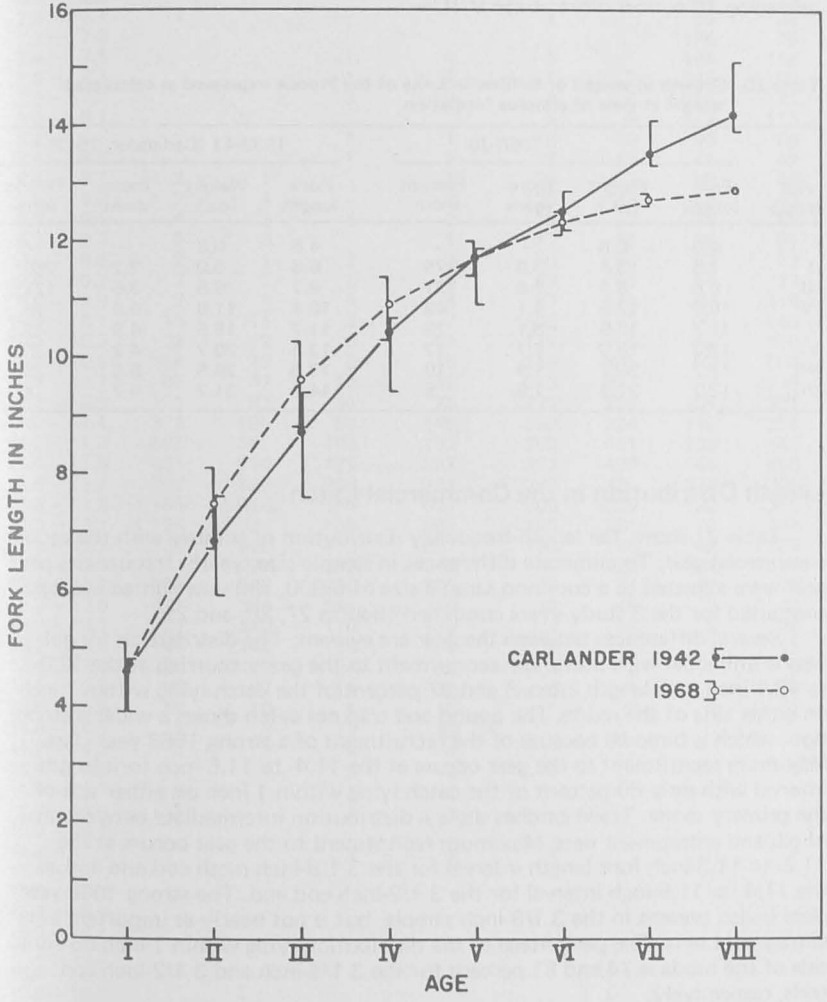


Figure 26. Growth rate of Lake of the Woods tullibee as reported by Carlander (1942) and as computed during the current study (1968), expressed as fork length, in inches, at each annulus.

length and weighing from 0.9 to 52.4 ounces. The data were transformed to logarithms and a simple linear regression calculated. This relationship can be described by the formula:

$$\log W = -2.1809 + 3.1585 \log L$$

By applying the formula against the average size of tullibee at each annulus as computed above, the average weight of tullibee at successive ages was computed (table 20).

Comparing growth in weight during the current study with that observed by Carlander (1942), we find the same trend as was observed with growth in length. Both groups of samples show similar growth through age V, averaging about 1 pound; thereafter the fish observed in 1942 show greater growth in weight, averaging 10 ounces more at age VIII.

Table 20. Growth in weight of tullibee in Lake of the Woods expressed as calculated weight at time of annulus formation

	1968-70				1939-41 (Carlander, 1942)			
Age group	Fork length	Weight (oz.)	Increment	Percent incre.	Fork length	Weight (oz.)	Increment	Percent incre.
I	4.6	0.8	—	—	4.6	0.8	—	—
II	7.5	3.8	3.0	375	6.8	3.0	2.2	250
III	9.6	8.4	4.6	121	8.7	6.6	3.6	124
IV	10.9	12.5	4.1	49	10.4	11.6	5.0	76
V	11.7	15.6	3.1	25	11.7	16.5	4.9	42
VI	12.3	18.3	2.7	17	12.5	20.7	4.2	25
VII	12.7	20.2	1.9	10	13.5	26.5	5.8	28
VIII	12.9	21.2	1.0	5	14.2	31.2	4.7	18

Length Distribution in the Commercial Catch

Table 21 shows the length-frequency distribution of tullibee with the various commercial gear. To eliminate differences in sample size, yearly frequencies per gear were adjusted to a common sample size of 5,000, and unweighted averages computed for the 3 study years combined (figures 27, 28, and 29).

Several differences between the gear are evident. The distribution for gill nets is unimodal with maximum recruitment to the gear occurring at the 12.0- to 12.1-inch fork length interval and 87 percent of the catch lying within 1 inch on either side of the mode. The pound and trap net catch shows a wider distribution, which is bimodal because of the recruitment of a strong 1968 year class. Maximum recruitment to the gear occurs at the 11.4- to 11.5-inch fork length interval with only 60 percent of the catch lying within 1 inch on either side of the primary mode. Trawl catches show a distribution intermediate between that of gill and entrapment nets. Maximum recruitment to the gear occurs at the 11.2- to 11.3-inch fork length interval for the 3 1/8-inch mesh cod end and at the 11.4- to 11.5-inch interval for the 3 1/2-inch cod end. The strong 1968 year class is also present in the 3 1/8-inch sample, but is not nearly as important as in entrapment nets. The percentage of the distribution lying within 1 inch on either side of the mode is 74 and 81 percent for the 3 1/8-inch and 3 1/2-inch cod ends, respectively.

Differences can be seen between the Carlander (1942) sample and the present study sample for both the gill net samples and the entrapment gear

Table 21. Length-frequency distribution, by gear, for Lake of the Woods tullibee

Length (inches)	Gill net				Pound and trap net			
	1968	1969	1970	Average per 5,000	1968	1969	1970	Average per 5,000
	number							
5.0 – 5.1								
5.2 – 5.3								
5.4 – 5.5								
5.6 – 5.7								
5.8 – 5.9								
6.0 – 6.1							1	1
6.2 – 6.3								
6.4 – 6.5		1					2	1
6.6 – 6.7		1					6	4
6.8 – 6.9							16	10
7.0 – 7.1	1				1		55	34
7.2 – 7.3							124	75
7.4 – 7.5			1	1	1		194	118
7.6 – 7.7			1	1	1	2	245	150
7.8 – 7.9			3	2	4	7	224	141
8.0 – 8.1					5	8	177	113
8.2 – 8.3			1	1	12	20	90	69
8.4 – 8.5			1	1	16	17	44	42
8.6 – 8.7	2	1		1	26	23	28	40
8.8 – 8.9	2	4		1	20	32	15	32
9.0 – 9.1	4	2	1	2	38	32	24	48
9.2 – 9.3	3	3		1	47	35	36	61
9.4 – 9.5	2	1	2	2	66	50	37	77
9.6 – 9.7	2	2	2	2	49	61	44	77
9.8 – 9.9	2	4	4	4	57	111	64	114
10.0 – 10.1	15	11	3	7	82	147	70	145
10.2 – 10.3	22	12	8	11	111	165	88	179
10.4 – 10.5	44	12	8	15	119	205	97	204
10.6 – 10.7	95	37	16	35	213	222	123	276
10.8 – 10.9	201	83	34	75	272	236	104	301
11.0 – 11.1	372	185	53	140	326	324	119	374
11.2 – 11.3	601	368	103	252	352	431	137	443
11.4 – 11.5	831	600	175	387	317	482	144	450
11.6 – 11.7	992	859	293	541	273	421	134	396
11.8 – 11.9	1,145	1,018	384	657	208	329	120	315
12.0 – 12.1	1,128	1,034	436	687	160	281	76	244
12.2 – 12.3	1,139	949	412	657	155	186	49	186
12.4 – 12.5	871	796	353	540	87	123	31	114
12.6 – 12.7	595	592	240	379	63	71	17	72
12.8 – 12.9	421	370	141	240	48	45	7	48
13.0 – 13.1	287	242	110	170	27	19	6	26
13.2 – 13.3	145	146	53	90	8	16	1	11
13.4 – 13.5	80	79	34	52	4	2		3
13.6 – 13.7	25	37	11	19	6	1	1	4
13.8 – 13.9	17	19	5	10		2	1	1
14.0 – 14.1	8	8	12	10				
14.2 – 14.3	4	3	4	4		1		
14.4 – 14.5	3	2	3	3	1			1
14.6 – 14.7	2		1	1				
14.8 – 14.9	1		1	1				
15.0 – 15.1								
15.2 – 15.3			1	1	1			1
15.4 – 15.5		1						
15.6 – 15.7								
15.8 – 15.9								
16.0 – 16.1								
16.2 – 16.3								
16.4 – 16.5								
16.6 – 16.7								
16.8 – 16.9								
17.0 – 17.1	1							
Total	9,063	7,482	2,910	5,003	3,176	4,107	2,751	5,001

Table 22. (continued)

Length (inches)	Trawl net						
	3 1/8" – mesh				3 1/2" – mesh		
	1968	1969	1970	Average per 5,000	1968	1969	Average per 5,000
	number						
5.0 – 5.1		1					
5.2 – 5.3		1					
5.4 – 5.5							
5.6 – 5.7			1	1			
5.8 – 5.9							
6.0 – 6.1	1		1	1			
6.2 – 6.3		1	1	1			
6.4 – 6.5		2		1			
6.6 – 6.7		2		1			
6.8 – 6.9		1	3	2			
7.0 – 7.1	1		5	3	1		
7.2 – 7.3			9	5			
7.4 – 7.5			15	8	1		
7.6 – 7.7	1		11	7			
7.8 – 7.9			20	11			
8.0 – 8.1			7	4			
8.2 – 8.3	1		2	1	1		
8.4 – 8.5	5	2		2	4	1	2
8.6 – 8.7	8	10	3	8	6	1	4
8.8 – 8.9	23	13	3	13	11	3	8
9.0 – 9.1	41	18	3	21	22	2	11
9.2 – 9.3	59	24	7	31	32	2	14
9.4 – 9.5	79	39	22	50	36	4	18
9.6 – 9.7	92	49	25	60	36	7	22
9.8 – 9.9	120	91	34	87	38	15	32
10.0 – 10.1	132	133	77	128	74	21	52
10.2 – 10.3	183	181	82	163	131	19	72
10.4 – 10.5	252	222	129	225	283	50	166
10.6 – 10.7	378	252	163	295	444	75	256
10.8 – 10.9	477	335	181	364	636	88	344
11.0 – 11.1	534	439	269	465	725	174	478
11.2 – 11.3	559	602	335	562	833	229	584
11.4 – 11.5	520	559	347	542	673	283	586
11.6 – 11.7	392	587	347	509	620	283	566
11.8 – 11.9	321	505	249	405	542	277	529
12.0 – 12.1	307	377	219	343	465	202	412
12.2 – 12.3	234	316	175	275	371	152	318
12.4 – 12.5	159	213	96	173	249	105	217
12.6 – 12.7	97	129	68	111	172	64	140
12.8 – 12.9	50	69	30	55	86	36	74
13.0 – 13.1	37	39	17	34	45	21	42
13.2 – 13.3	18	27	3	16	25	15	27
13.4 – 13.5	8	7		5	9	5	10
13.6 – 13.7	5	8	5	7	4	5	8
13.8 – 13.9	4	3		2	3	3	4
14.0 – 14.1	3			1	3		1
14.2 – 14.3		2		1			
14.4 – 14.5						2	1
14.6 – 14.7							
14.8 – 14.9							
15.0 – 15.1							
15.2 – 15.3							
15.4 – 15.5							
15.6 – 15.7					1		
15.8 – 15.9							
16.0 – 16.1							
16.2 – 16.3							
16.4 – 16.5							
16.6 – 16.7							
16.8 – 16.9							
17.0 – 17.1							
Total	5,101	5,259	2,964	4,999	6,582	2,143	4,998

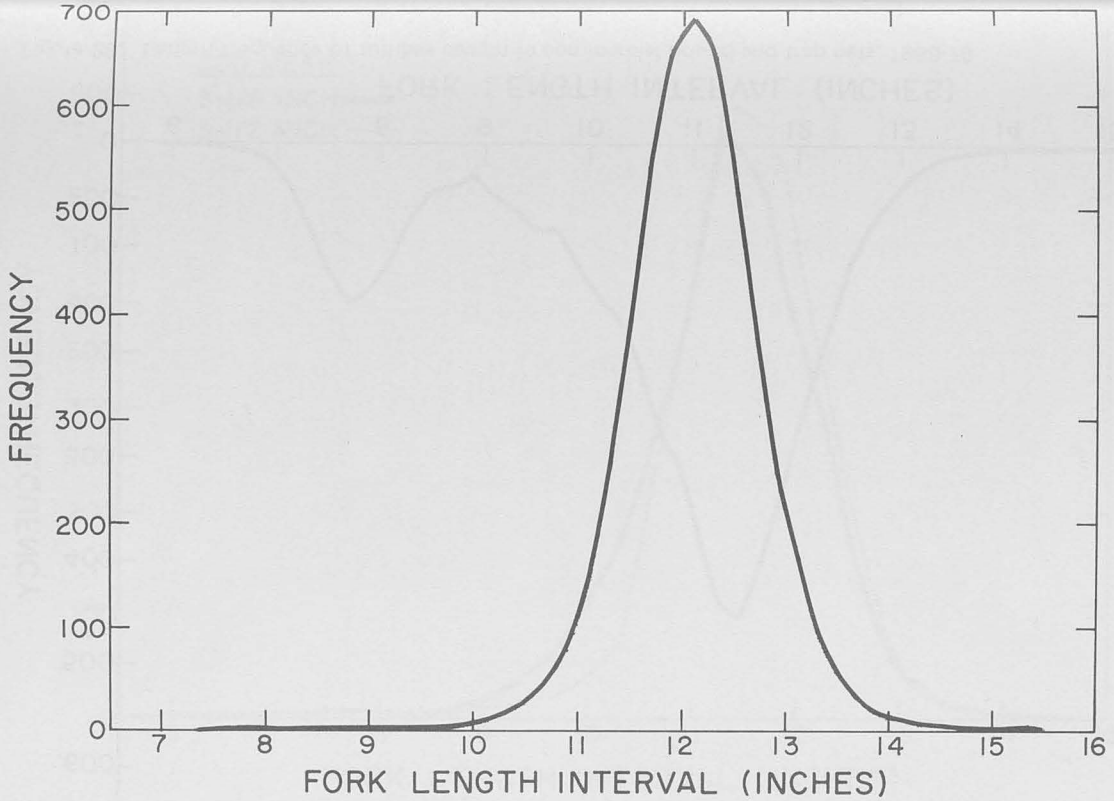


Figure 27. Length-frequency of tullibee caught in commercial gill nets, 1968-70.

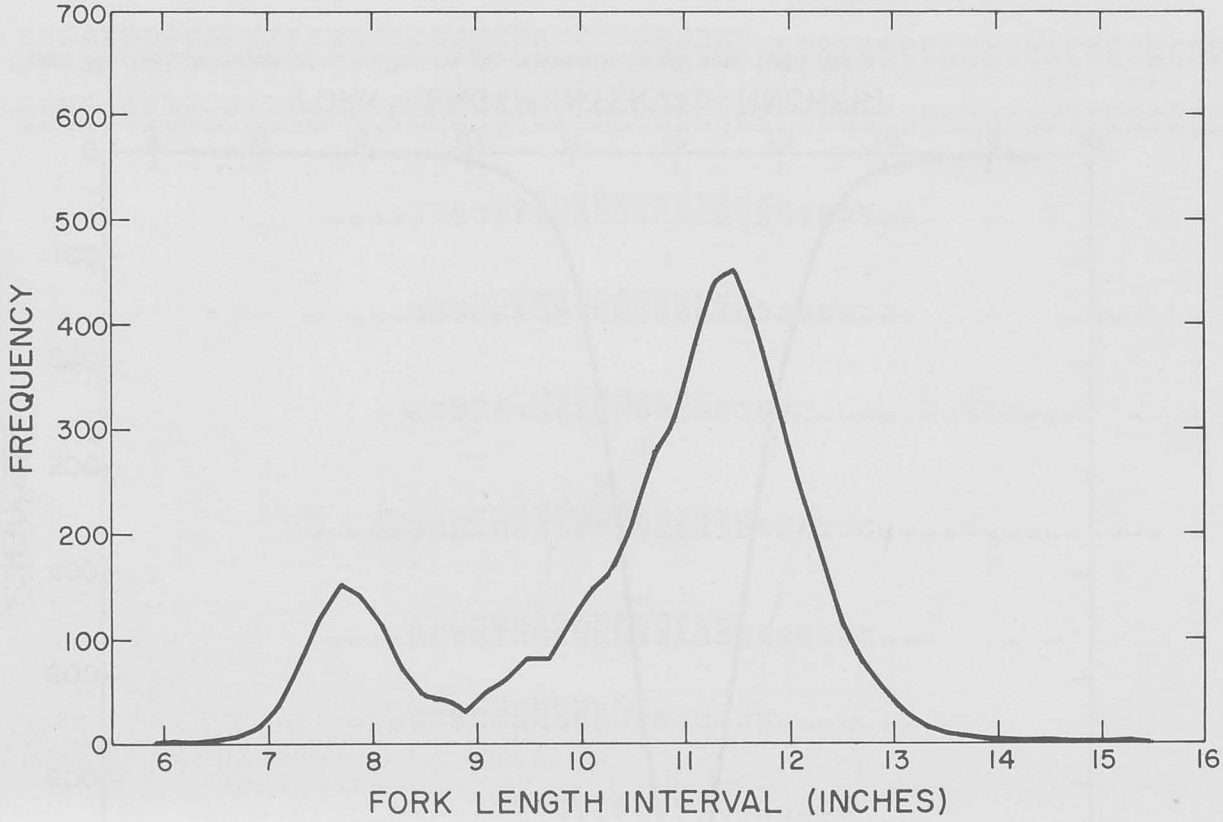


Figure 28. Length-frequency of tullibee caught in commercial pound and trap nets, 1968-70.

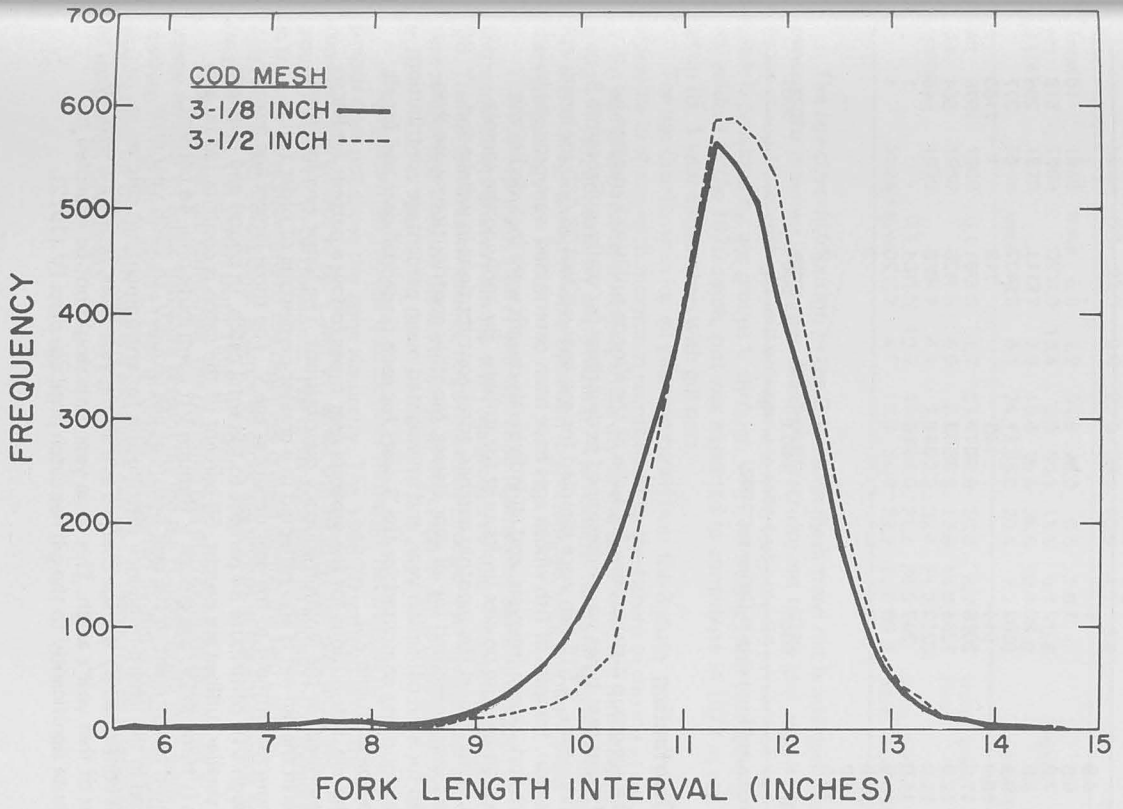


Figure 29. Length-frequency of tullibee caught in commercial-size trawl nets, 1968-70.

samples (table 22). The trend in both gear types is for the 1942 samples to show distributions with a smaller size of maximum recruitment. This trend, most pronounced in the pound and fyke net sample, is related to a major shift in the age class composition of the catch (to be discussed later).

Table 22. Length-frequency distribution, by gear, for Lake of the Woods tullibee

Fork length interval (inches)	Gill net		Pound, fyke, & trap nets	
	1939 – 41*	1968 – 70	1939 – 41*	1968 – 70
5.0 – 5.9	1			
6.0 – 6.9	1			16
7.0 – 7.9	2	4	20	518
8.0 – 8.9	30	4	1111	296
9.0 – 9.9	102	11	1437	377
10.0 – 10.9	511	143	718	1105
11.0 – 11.9	2068	1977	791	1978
12.0 – 12.9	1294	2503	426	664
13.0 – 13.9	713	341	368	45
14.0 – 14.9	247	19	104	1
15.0 – 15.9	29	1	20	1
16.0 – 16.9	2		3	
17.0 – 17.9				
18.0 – 18.9			3	
Total	5000	5003	5001	5001

* Computed from data in Carlander, 1942.

Age Distribution

The age-group distributions for Lake of the Woods tullibees harvested by the different gear types were determined as described for walleye. From the 3 collection years, 3,515 fish were sampled for age analysis and 35,660 for length distribution. Samples of fish whose ages have been determined were grouped by 0.2-inch fork length intervals, and all individuals caught were included in the distribution because no size limits exist for tullibee. By applying the sample distributions against the monthly catches, total contributions in weight and numbers were computed for all year classes. Monthly contributions were then summed for each collection year, and unweighted mean percentage contribution per age group was computed for the 3 years for each respective gear and for all gear combined (table 23).

The age distributions for the separate gear types follow a pattern similar to that described for the length-frequency distributions. The larger average size of tullibee in the gill net is also reflected in a greater percentage of older fish. Maximum recruitment to the gear occurs at age V. The three largest age groups, V through VII, contribute 84 percent to the total catch. In pound and trap nets where smaller tullibee are caught, 56 percent of the catch is contributed by age groups II through IV; age groups V through VII contribute only 44 percent. Maximum recruitment to the gear occurs at age group V. In 1968 year class observed in the length-frequency distribution for entrapment net catches in 1970 is confirmed by the age analysis as a strong year class, providing over 50 percent of that year's catch. This same year class would not be expected to contribute significantly to the gill net catch until age class IV (1972).

Table 23. **Age distribution of tullibee, expressed as a percentage of the total number of fish caught / gear / season, averaged over 3 years**

		Age group										
	Year	I	II	III	IV	V	VI	VII	VIII	IX	X	
Gill net	1968		0.1	1.2	30.8	27.9	26.7	11.9	1.4	trace		
	1969		trace	1.7	1.8	56.6	20.3	17.7	1.9			
	1970		0.1	1.4	3.4	29.9	44.3	16.6	4.3			
	Mean		0.1	1.4	12.0	38.1	30.4	15.4	2.5	0.1		100.0
Pound and trap net	1968	0.4	11.3	3.4	52.8	24.3	6.8	1.0				
	1969		5.7	18.2	3.4	50.4	11.9	9.2	1.2			
	1970		52.9	7.2	12.5	9.7	13.9	3.8				
	Mean	0.1	23.3	9.6	22.9	28.1	10.9	4.7	0.4			100.0
Trawl net 3 1/8"	1968	trace	6.8	1.2	54.9	26.0	9.5	1.6				
	1969		0.9	15.4	2.3	55.1	15.8	9.7	0.8		trace	
	1970		2.7	7.8	15.0	26.5	36.0	10.4	1.6			
	Mean	trace	3.5	8.1	24.1	35.9	20.4	7.2	0.8		trace	100.0
All gear combined	1968	0.1	3.3	1.7	37.5	26.9	20.8	8.7	1.0	trace	trace	
	1969		1.5	6.9	2.3	54.9	17.9	14.9	1.6	trace		
	1970		19.7	4.1	7.8	22.2	32.4	11.3	2.5			
	Σ	0.1	24.5	12.7	47.6	104.0	71.1	34.9	5.1	trace	trace	
	Mean	trace	8.2	4.2	15.9	34.7	23.7	11.6	1.7	trace	trace	100.0

The age-class distribution in the 3 1/8-inch mesh trawl net is intermediate between the previous gear types. Maximum recruitment to the gear appears to be age group V, as with gill and entrapment nets, but only 64 percent of the catch is provided by age groups V through VII. The strong 1968 year class is not evident in the 1970 catch, but was expected to contribute in 1971 as age group III, 1 year earlier than with gill nets.

The age distribution for all gear combined over the 3 study years is unimodal in shape with maximum recruitment to the fishery occurring at age V. Six age groups contributed significantly to the catch with the three largest groups, IV-VI, collectively contributing 74 percent to the total catch. Although fish as old as age group X were observed in the samples, very few were older than age group VII.

The 1968 (present study) and the 1939 (Carlander) age distributions in entrapment nets are very similar with age groups IV and V dominating (table 24). Thereafter, in both studies, recruitment of stronger year classes over the next several years causes the dominance in the catch of age groups as young as II.

A comparison of the age distributions in the gill net catches for the two periods does not show the same similarity. The 1968-70 samples show the dominant age groups to be V and VI, while the 1938-41 samples show age groups III and IV to be dominant. The difference may be caused by differences in the year class strengths of the older age groups during the two periods. This is indicated by a greater absence of older age groups in the entrapment nets from 1939 to 1943 than from 1968 to 1970.

When all gear are combined, the resulting age distributions show that a greater number of older fish were present during the current study than were observed in the early 1940's. This is further supported by the currently depressed growth rates for older fish and the increased catches at lower fishing intensities by the present day fishery.

Table 24. Age class composition of the commercial catch of tullibee at Lake of the Woods, 1939-41

Pound nets *	Percentage of total catch in each age class									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1939		4	13	35	34	11	2	1		
1940		7	34	23	23	11	1	1		
1941		37	45	9	7	1	1			
1942	7	41	48	3	1					
1943	1	53	36	7	3					
$\bar{x}$	1.6	28.4	35.2	15.4	13.6	4.6	4.6	0.4		
Gill nets †										
1939-41	0.2	3.1	32.7	34.5	22.2	5.5	5.5	0.5	0.1	0.1

* Carlander, 1944
† Carlander, 1942

Total Annual Mortality Rate

Using the analysis of catch curves as previously described, total annual mortality rate was estimated for tullibee fully recruited to the commercial gear. The four age groups, V through VIII, used for the computation gave an estimate of i= -0.976, which when transformed (Ricker, 1958) gave a total annual mortality rate of 62 percent. This value compares favorably with similar estimates reported for tullibee by Miller (1949) who computed an annual rate of 70 percent for a lake where no fishing was permitted, and annual rates in excess of 60 percent for two lakes where fishing was permitted.

Similar estimates can be computed from data presented in Carlander (1942 and 1944). Data were averaged for 5 years (1939-43) for tullibee taken in commercial pound nets, and a catch curve analysis was computed for age groups III through VII. This analysis provided an estimate of i = -.878 or a total annual mortality rate of 58 percent. This value, somewhat lower than the 1968-70 estimate, is for younger fish which may not have been fully recruited to the gill nets. Gill net data for 1939-41 show full recruitment at age IV. Consequently, age groups IV-VII were used to estimate i = -1.173, or a 69 percent total annual mortality rate.

It would appear that total annual mortality rate for Lake of the Woods tullibee has not changed appreciably over the last 30 years despite the fact that fishing intensity has declined during the same period. In contrast to the situation observed with walleye where increased angling intensity replaced commercial fishing intensity, anglers take virtually no tullibee. Thus, the trade-off must have caused an increased rate of natural annual mortality for which we have no data.

Size and Age at Maturity

No information was collected during the current study on the size and age of tullibee at maturity; however, ovary development and egg formation was very apparent in age group I females. This observation agrees with the observations by Carlander (1942), who reported that spawning occurred in some fish during their 2nd year of life with the majority of the females spawning 1 year later (age group II). With the dominant age groups in the commercial catches being IV through VI, most tullibee harvested by the commercial fishery have spawned at least once, and many have spawned several times.

Critical Size at Harvest and Maximum Sustained Yield

Using Ricker's (1958) definition of the critical size at harvest, as described above for walleye, instantaneous growth rates "g" were computed for the 1968-70 tullibee samples (table 25). Instantaneous growth rate follows the typical pattern of decrease, falling from a high of 1.541 during the 2nd year of life to 0.049 during the 8th year of life.

Arriving at an instantaneous rate of natural mortality to be used to determine the critical size at harvest is more difficult. Data were not available from the current study to allow for its direct computation. However, with a total annual mortality rate of 62 percent and with the current rate of tullibee harvest, natural mortality rates probably approximate 20 percent per year or less. Tullibees show values of "g" in this range for fish in their 5th year of life or older.

Considering that the age distributions showed maximum contribution at age group V, the current fishing practices would appear to be harvesting the tullibee at the critical size. However, in contrast to walleyes where a large proportion of the fish captured may be immature, virtually all tullibee of age group V or older have matured and spawned at least once. This indicates that a still greater tullibee catch could be made with total annual mortality rates for fish older than age group V approaching 100 percent. Assuming continued year class support and no change in the size at harvest, sustained harvests in the range of 2 million pounds per year possibly could be maintained without adversely affecting the tullibee population.

SAUGER

Although classified as a game fish and considered a high quality market fish, the sauger is harvested only lightly by the commercial and sport fishery. An excellent population of sauger exists in Lake of the Woods. However, its small size and the excellent population of large walleye in the lake have caused the sport fishermen not to be interested in the sauger.

In contrast, the sauger is a desired species in the commercial industry but is caught in relatively small amounts because the mesh size of the nets is adjusted to harvest the walleye. At these larger mesh sizes, the sauger is caught only through accidental entanglement. Consequently, although the sauger population greatly outnumbers the walleye population, it remains only a minor component in the total fishery harvest.

Table 25. Instantaneous growth rate, "g," for Lake of the Woods tullibee, sexes combined

Age group	Fork length (in.)	Weight (oz.)	"g"
I	4.6	0.82	–
II	7.5	3.83	1.541
III	9.6	8.35	0.779
IV	10.9	12.47	0.399
V	11.7	15.60	0.223
VI	12.3	18.26	0.157
VII	12.7	20.20	0.104
VIII	12.9	21.23	0.049

Description of Growth

Growth rates for sauger were estimated by computing the average fork length at capture for each age class sampled during June in 1968 and 1969. These two seasons experienced cool spring temperatures and growth after the formation of the annulus was considered minimal. For the computation, 410 fish were selected varying in fork length from 5.4 to 14.8-inches and including 10 age classes, II through XI (table 26). Although not directly comparable, the grand average calculated fork lengths from Carlander (1942) are included in table 26.

For all age groups except IV, growth appears to be slower during the current study than during Carlander's study. The differences are small through age group IV, but by age group IX there is an inch or more difference in the annual fork lengths. The reason or reasons for the current decline in growth rate are not readily apparent.

Growth in weight was computed by constructing a body length-body weight relationship from 454 fish varying from 5.4 to 15.9 inches (fork length) and weighing from 0.7 to 29.5 ounces. Individual weights were averaged over a 0.2-inch body-length interval. The data were transformed to logarithms, and a simple regression was calculated. This relationship can be described by the formula:

$$\log W = -2.3472 + 3.083 \log L$$

By applying the formula against the average length at capture of sauger at each annulus, the average weight at successive ages was computed (table 27).

Comparing current growth in weight for saugers with that reported by Carlander (1949), we see the same trend that was exhibited for growth in length, namely smaller fish per age class (table 27). The exponents for weight increase are nearly the same, 3.083 for 1968-70 and 3.058 for 1939-41, so that the differences in the weights are a reflection of differences in length. By age group IX, the difference amounts to 4.2 ounces. At age V, it amounts to 18 percent of the weight observed in 1939-41 and could be a contributing factor in the recent decline of the sauger catch by the commercial fishery.

Table 26. Growth rate for Lake of the Woods sauger, expressed as fork length in inches

Age class	Length at capture, June (1968, 1969)		Grand average calculated length*	
	Sample no.	Inches	Sample no.	Inches
I	–	–	883	4.7
II	23	6.5	876	6.9
III	37	7.6	755	8.8
IV	27	10.4	626	10.3
V	86	11.0	397	11.7
VI	98	12.0	163	12.6
VII	72	12.4	52	13.5
VIII	43	12.9	12	13.4
IX	19	13.1	5	14.4
X	3	13.6	2	14.3
XI	2	13.6	–	–

*Carlander (1942), grand average calculated fork length, 1939-41.

Table 27. Growth in weight of sauger, expressed as calculated weight at time of annulus formation

Age group	1968-70				1939-41*			
	Fork length (inches)	Weight (ounces)	Increment	Percentage increment	Fork length (inches)	Weight (ounces)	Increment	Percentage increment
I	–	–	–	–	4.7	0.6	0.6	–
II	6.5	1.4	1.4	–	6.9	1.8	1.2	200
III	7.6	2.3	0.9	64	8.8	3.7	1.9	106
IV	10.4	6.1	3.8	165	10.3	6.0	2.3	62
V	11.0	7.3	1.2	20	11.7	8.9	2.9	48
VI	12.0	9.5	2.2	30	12.6	11.2	2.3	26
VII	12.4	10.6	1.1	12	13.5	13.8	2.6	23
VIII	12.9	11.9	1.3	12	13.4	13.5	(-0.3)	–
IX	13.1	12.5	0.6	5	14.4	16.7	3.2	–
X	13.6	14.0	1.5	12	14.3	16.4	(-0.3)	–
XI	13.6	14.0	–	0	–	–	–	–

* Computed from Carlander, 1949: log W = -5.0339 + 3.058 log L.

Length Distribution of the Commercial Catch

Table 28 shows the length-frequency distribution of sauger in the various commercial gear. Yearly frequencies per gear were adjusted to a common sample size of 5,000, and unweighted averages were calculated for the 3 collection years, 1968-70 (figures 30, 31, and 32). In contrast to the walleye and tullibee catches, where considerable differences existed in the size of fish captured by the different gear, the length-frequency distributions for sauger caught by different gear are very similar. Only those fish caught by the trawl using the 3 1/8-inch mesh cod show a marked difference (figure 32).

Commercial gill nets, pound and trap nets, and trawl nets using a 3 1/2-inch mesh cod end all show maximum recruitment to the gear at about the legal size of 12 inches, fork length. Also, the proportions of legal size fish in the catches for the three gears are 56, 56, and 53 percent, respectively. The fact that the distribution for the 4-inch (stretch) meshed gill net resembles the distribution for the 2 1/2-inch (stretch) meshed pound net demonstrates the inefficiency of this sized gill net for harvesting sauger.

The length-frequency distributions for the two different trawl nets clearly show the change that can result from reducing the mesh size of the net. By decreasing the size of the mesh in the cod end only 1/2-inch (stretch), the point of maximum recruitment is increased from the 12.0- to 12.1-inch fork length interval to the 13.0- to 13.1-inch interval and the proportion of legal sized fish in the catch increases from 53 to 78 percent. The same results could be accomplished by reducing the mesh size of the gill net. Data from Carlander (1942) indicate that a reduction in mesh size from 4 to 3 1/4 inches (stretch) would increase the size of maximum vulnerability from the 11 3/4- to 12 1/4-inch size interval to the 13 1/4- to 13 3/4-inch size interval and increase the proportion of legal size fish in the catch from 55 to 92 percent.

The potential change that would occur in the annual catch of saugers as a result of such mesh changes has already been demonstrated. As discussed in an earlier section, the use of illegal small meshed gill nets during the middle 1930's increased sauger catches by a factor of five times the long-term average.

The length-frequency distributions also show a greater percentage of undersize saugers than walleye in the catches. Commercial gill nets catch the greatest number of fish less than 10 inches. These fish are too small to be gilled. Rather, they are entangled by their teeth or spiney fins and many times may be simply shaken out of the net unharmed. As the length of time they are entangled in the net increases, the rate of mortality also increases.

Few fish between 10 and 12 inches in length were returned to the lake. In this size range, the mortality rate was greater than for the smaller fish because of a greater chance for gill damage when entangled in the net. Consequently, these fish either were included in the commercial catches or discarded. This means that as much as 40 percent of the current sauger catch by gill nets could be undersized.

When the distributions observed during the current study are compared with those reported by Carlander (1942), little changes are observed. Commercial gill net samples from 1939 to 1941 show the same tendency for undersize fish to become entangled in the nets, and the point of maximum recruitment for all gear lies in the 12.0- to 12.9-inch fork length interval.

Age Distribution

The age group distributions for Lake of the Woods saugers harvested by the different gear types were determined as described for walleye. During the 3 collection years, 2,542 fish were sampled for age analysis and 3,238 for length

Table 28. Length-frequency distribution, by gear, for Lake of the Woods sauger (1)

Length (inches)	Gill net				Pound and trap net			
	1968	1969	1970	Average per 5,000	1968	1969	1970	Average per 5,000
	number							
5.4 – 5.5	2			4				
5.6 – 5.7								
5.8 – 5.9	5			11				
6.0 – 6.1	5			11		1		2
6.2 – 6.3	6			13				
6.4 – 6.5	5			11				
6.6 – 6.7	5	2		15				
6.8 – 6.9	6			13				
7.0 – 7.1	2	1		7				
7.2 – 7.3	7	2		19		1		2
7.4 – 7.5	4	2		13				
7.6 – 7.7	2	1		7				
7.8 – 7.9	4	1		11				
8.0 – 8.1	5	3		17				
8.2 – 8.3	5	2		15				
8.4 – 8.5	3	4		15				
8.6 – 8.7	2	5	18					
8.8 – 8.9	3	2		11				
9.0 – 9.1	7	3		22				
9.2 – 9.3	8			17				
9.4 – 9.5	7			15	2			2
9.6 – 9.7	16		1	37		2	1	6
9.8 – 9.9	14	5		41	2	1		4
10.0 – 10.1	19	6	1	57	2	3	3	14
10.2 – 10.3	19	4	1	52	7	5	2	24
10.4 – 10.5	26	9	3	85	10	10	11	50
10.6 – 10.7	24	7	8	93	14	11	20	74
10.8 – 10.9	24	13	9	110	46	21	14	112
11.0 – 11.1	31	45	11	202	76	50	35	237
11.2 – 11.3	43	47	16	248	98	48	57	299
11.4 – 11.5	31	67	34	327	121	93	69	430
11.6 – 11.7	39	64	43	346	159	82	91	490
11.8 – 11.9	38	77	29	347	171	81	66	451
12.0 – 12.1	53	66	44	405	131	81	93	463
12.2 – 12.3	58	64	37	388	124	76	93	447
12.4 – 12.5	41	52	37	325	114	69	58	356
12.6 – 12.7	43	41	37	305	139	49	56	339
12.8 – 12.9	43	36	24	251	115	46	49	296
13.0 – 13.1	33	31	23	215	84	37	51	252
13.2 – 13.3	24	28	26	199	72	31	26	181
13.4 – 13.5	24	22	25	183	61	32	12	144
13.6 – 13.7	17	19	19	141	41	17	12	96
13.8 – 13.9	15	9	12	92	38	16	9	85
14.0 – 14.1	8	5	23	105	25	10	11	65
14.2 – 14.3	5	2	6	35	10	7	4	31
14.4 – 14.5	4	4	12	57	6	5	4	23
14.6 – 14.7	4	1	6	31	4	1	3	12
14.8 – 14.9	3	2	6	31	4		4	12
15.0 – 15.1	2	1	3	17				
15.2 – 15.3			1	3				
15.4 – 15.5			1	3				
15.6 – 15.7					1		1	3
15.8 – 15.9			2	7			1	2
16.0 – 16.1					1			1
Total	784	756	500	5,003	1,678	886	856	5,005
Percent legal				56				56

Table 28. (continued) Length-frequency distribution, by gear, for Lake of the Woods sauger (2)

Length (inches)	Trawl net						
	3 1/8" mesh				3 1/2" mesh		
	1968	1969	1970	Average per 5,000	1968	1969	Average per 5,000
	number						
5.4 – 5.5							
5.6 – 5.7							
5.8 – 5.9	1			2			
6.0 – 6.1							
6.2 – 6.3							
6.4 – 6.5	2			5			
6.6 – 6.7	2			5			
6.8 – 6.9	1			2			
7.0 – 7.1	1			2			
7.2 – 7.3							
7.4 – 7.5							
7.6 – 7.7							
7.8 – 7.9							
8.0 – 8.1					1		6
8.2 – 8.3	2			5			
8.4 – 8.5	1			2	1		6
8.6 – 8.7							
8.8 – 8.9		1		3			
9.0 – 9.1	2			5			
9.2 – 9.3			1	4			
9.4 – 9.5	4		1	13	2		12
9.6 – 9.7	2	1		8	1		6
9.8 – 9.9	2	2	2	23	3		17
10.0 – 10.1	5	1	1	19	2	1	40
10.2 – 10.3	11	4	1	43	5	1	57
10.4 – 10.5	14	2	2	47	7	2	98
10.6 – 10.7	23	6	2	82	15	1	114
10.8 – 10.9	25	4	3	84	18	3	188
11.0 – 11.1	36	6	7	133	26	10	435
11.2 – 11.3	33	12	4	133	31	4	291
11.4 – 11.5	39	9	7	150	36	2	262
11.6 – 11.7	48	11	6	173	31	9	434
11.8 – 11.9	34	16	9	169	47	4	382
12.0 – 12.1	43	23	12	226	51	6	462
12.2 – 12.3	28	31	12	217	23	5	274
12.4 – 12.5	49	32	13	274	29	2	222
12.6 – 12.7	34	39	18	282	25	2	200
12.8 – 12.9	43	26	17	256	13	4	189
13.0 – 13.1	45	45	34	393	20	5	257
13.2 – 13.3	27	41	28	313	9	4	166
13.4 – 13.5	42	38	30	347	13	7	275
13.6 – 13.7	22	30	39	310	8	2	103
13.8 – 13.9	22	32	32	288	7	3	126
14.0 – 14.1	26	27	29	268	2	2	69
14.2 – 14.3	17	20	38	261	8	1	74
14.4 – 14.5	9	16	12	123	2	4	126
14.6 – 14.7	7	14	13	166	1		6
14.8 – 14.9	3	8	13	87	3	1	46
15.0 – 15.1		3	11	55			
15.2 – 15.3	3	1	5	31		1	28
15.4 – 15.5	3	1	2	18		1	28
15.6 – 15.7	2		3	17			
15.8 – 15.9							
16.0 – 16.1			1	4			
Total	713	502	409	4,998	440	87	4,999
Percent legal				78			53

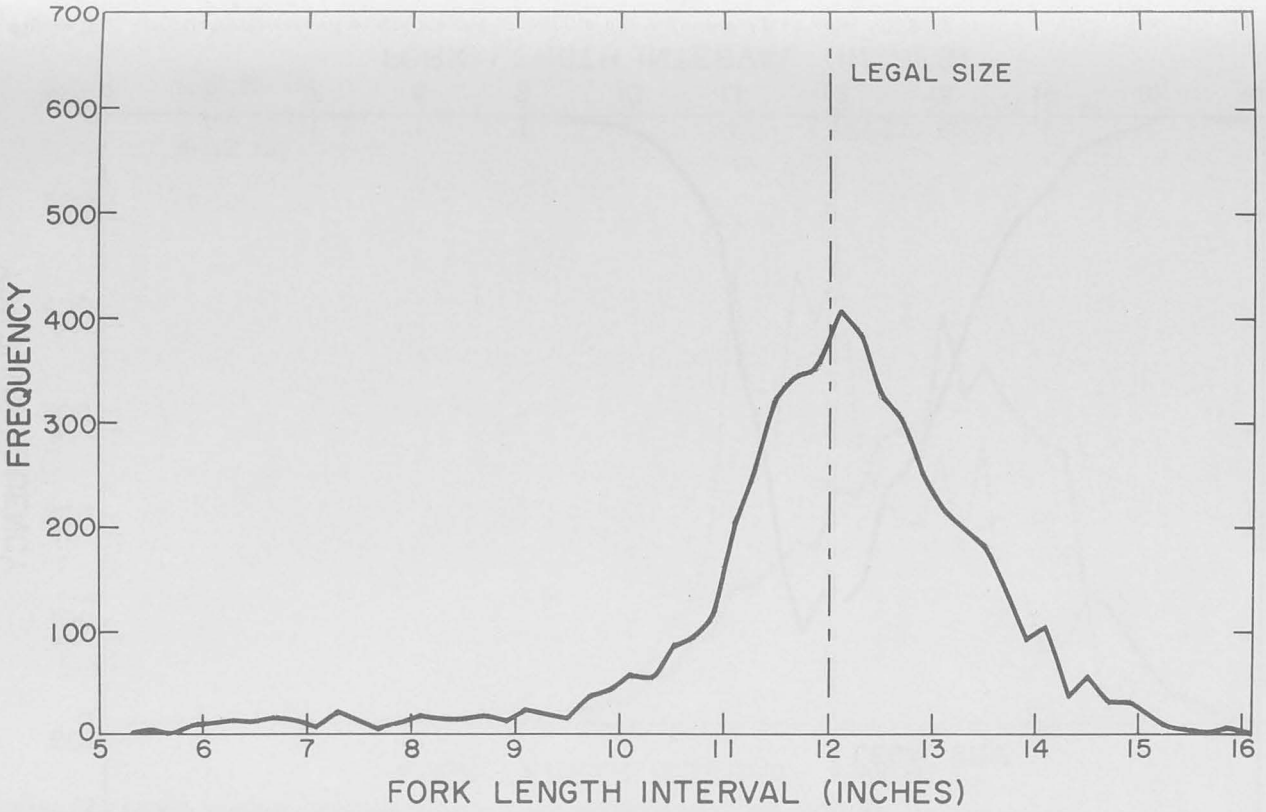


Figure 30. Length-frequency of sauger caught in commercial gill nets, 1968-70.

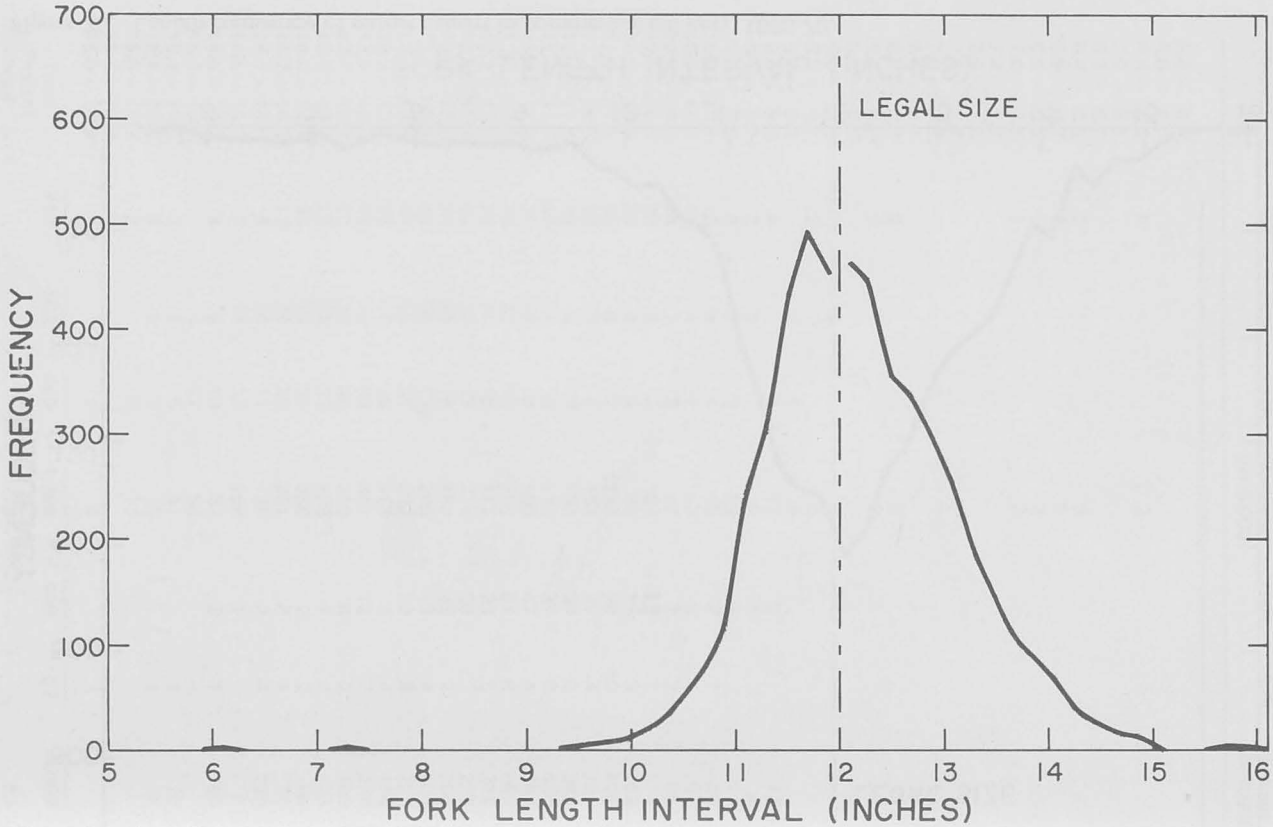


Figure 31. Length-frequency of sauger caught in commercial pound and trap nets, 1968-70.

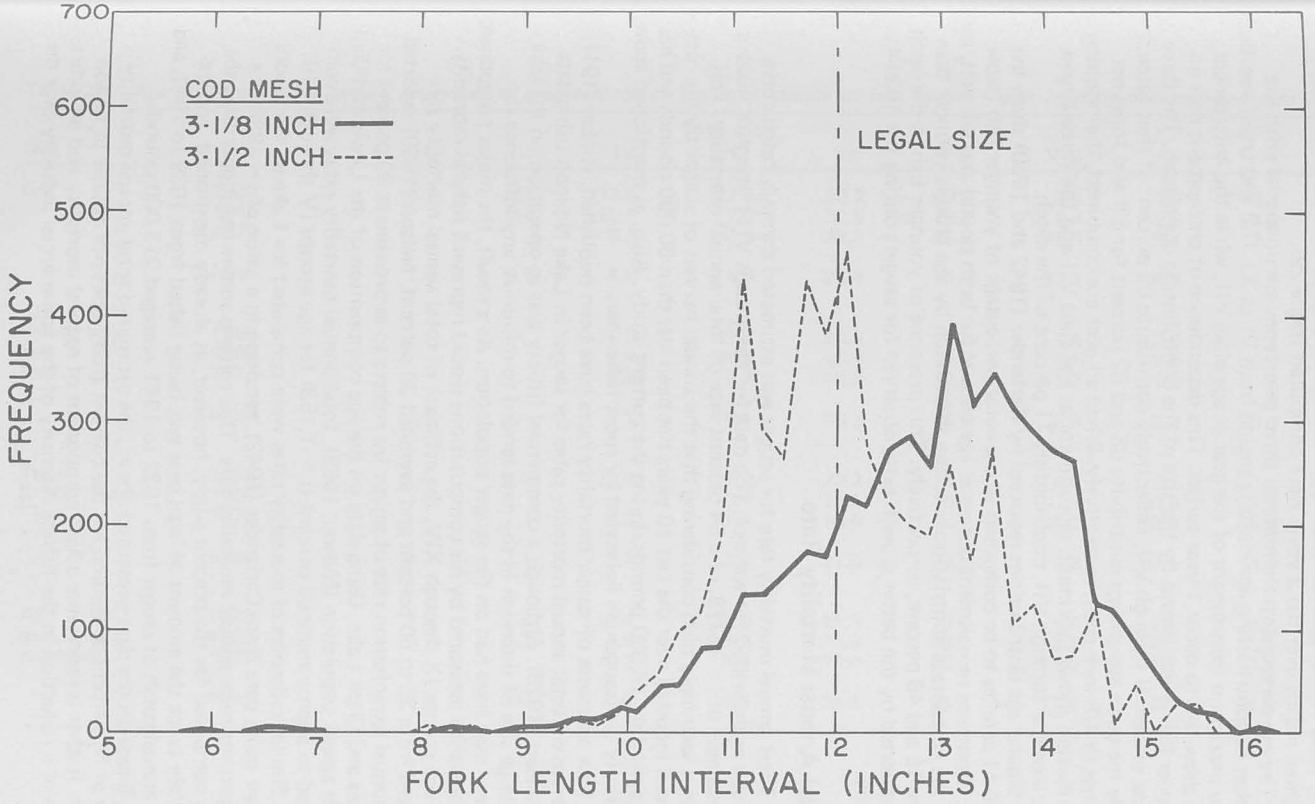


Figure 32. Length-frequency of sauger caught in commercial-size trawl nets, 1968-70.

distribution. Samples of aged fish were grouped by 0.2-inch fork length intervals; all fish were included in the distribution that were observed as being included in the commercial catches. Age distributions were computed for each of the 3 years, 1968-70, for separate gear types and for all gear combined. Then, unweighted means over the 3 years were computed (table 29).

The age class distribution for all three gear types are unimodal with the number of contributing age classes ranging from VI to XI. Gill and trawl nets both show maximum recruitment of the gear at age class VII, while the entrapment nets show this to occur 1 year earlier. This dependence of entrapment nets on younger fish is also shown by the size of the contributing age classes. The three largest classes, V through VII, collectively contribute 82 percent of that catch, while the same age groups contribute 68 and 62 percent for gill and trawl net catches (3 1/8-inch cod), respectively. When all gear are combined, the resulting distribution shows maximum recruitment at age class VII and the three largest age classes, V through VII, contributing 71 percent of the catch.

Similar age distributions reported by Carlander (1942 and 1950) show the 1939-41 catches to be composed of a greater percentage of younger fish (table 30). Maximum recruitment occurs at age class V for both pound and gill nets, and and the percentage contributions to the total catch by age groups younger than V are 16 and 46 percent, respectively. This presence of younger fish in the catch is supported by the better growth rates observed for saugers during the 1939-41 survey.

Total Annual Mortality Rate

Total annual mortality rate for sauger was estimated through catch curve analysis as described for walleye. The data for age groups VII through X yielded an estimate of i = -0.778, or a 54 percent rate of total annual mortality. This value is seemingly high considering that the annual harvest of sauger by the commercial industry over the last 10 years has been less than 60,000 pounds and has averaged only 16,000 pounds during the current study. Also, as mentioned above, relatively few sauger are harvested by sport fishermen.

Few estimates of sauger mortality rates have been published. Ricker (1947) reported on total annual mortality rates for sauger in Lake Nipigon using data from Hart (1928). Although a commercial fishery was in operation on the lake, the large size of the mesh in the nets tended to minimize any influence the fishery may have had on the sauger population. As a result, the major component of mortality measured by his computations would represent natural mortality. For age groups IX through XIV, the estimate of total annual mortality rate ranged from 26 to 60 percent and averaged 39 percent. Nelson (1969) reported an annual exploitation rate of sauger by anglers to approximate 20 percent for Lewis and Clark Lake. Using data on the age composition of the Lewis and Clark Lake sauger population (Nelson, 1968), total annual mortality rates were computed to approximate 68 percent (i = -1.153) for age groups IV through VIII.

Similar estimates of mortality rates were computed for Lake of the Woods sauger using data from Carlander (1942), resulting in a value of i = -.989 or a 63 percent total annual mortality rate. This value is somewhat higher than the rate computed for the present study; however, as already mentioned, approximately twice the amount of legal gear was being fished from 1939 to 1941, and the annual catch of sauger from 1932 to 1941 averaged 213,000 pounds.

Based on the data presented above, the estimated total annual mortality rate of 54 percent computed for the current study does not appear to be too high. Rather it represents a high component of natural mortality and an indication of a reduction in the fishing intensity of the commercial industry over the

Table 29. Age distribution for sauger, expressed as a percentage of the total sample of fish caught / gear / season and averaged over 3 years

Net	Year	Age class I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Gill	1968		5.7	2.1	13.9	22.6	20.2	17.4	8.9	7.9	0.4	0.7	0.2
	1969			0.6	10.4	17.0	30.6	28.2	9.4	2.8	1.0		
	1970				0.5	4.3	28.3	35.5	18.1	9.1	3.3	0.7	0.2
	Mean		1.9	0.9	8.3	14.6	26.4	27.0	12.1	6.6	1.6	0.5	0.1
Pound and trap	1968				11.5	22.1	29.5	26.0	5.4	2.6	1.6	1.3	
	1969				1.1	23.3	45.9	16.2	9.5	2.6	0.9	0.4	0.1
	1970				2.7	9.7	45.3	29.1	11.7	1.5			
	Mean				5.1	18.4	40.2	23.8	8.9	2.2	0.8	0.6	–
Trawl 3 1/8" mesh	1968		1.0	6.2	21.0	27.2	23.2	15.4	4.8	1.1			0.1
	1969					9.4	25.1	40.2	7.7	10.6	7.0		
	1970				0.2	1.8	16.6	32.0	24.2	18.4	6.8		
	Mean		0.3	2.1	7.1	12.8	21.6	29.2	12.2	10.1	4.6		
All gear combined	1968		2.2	2.8	15.4	23.9	24.3	19.6	6.4	3.9	0.7	0.7	0.1
	1969			0.2	3.8	16.6	33.9	28.2	8.9	5.3	3.0	0.1	
	1970				1.1	5.3	30.0	32.2	18.0	9.7	3.4	0.2	0.1
	Mean		0.7	1.0	6.8	15.3	29.4	26.6	11.1	6.3	2.4	0.3	0.1

Table 30. Age class composition of the commercial catch of sauger at Lake of the Woods, 1939 – 41

Pound nets*	Percentage of total catch in each age class									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1939				12	59	20	7	2		
1940			1	13	42	37	5	2		
1941			3	16	31	32	14	2	1	1
$\bar{x}$			2	14	49	24	9	1	1	
Gill nets†										
1939 – 41	1	12	14	19	29	15	7	2	1	

*Carlander, 1942.
†Carlander, 1950.

last 30 years. This may, in part, explain the increase in older age groups in the commercial catches and the depression in growth rates discussed above.

Harvest Potential for Sauger

Although accurate data were not available for estimating the "critical size" at harvest for maximum sustained yield of sauger, the data did indicate that the sauger resource is not being utilized fully. A decrease in fishing intensity over the last 30 years has been accompanied by a decrease in the rate of total annual mortality, an increase in the average age at capture, and a decrease in the annual growth rate. The combined commercial and sport harvest of sauger over the last 10 years has averaged only 65,000 pounds, although the commercial harvest alone from 1930 to 1939 averaged 235,000 pounds.

Test netting with experimental gill nets of varying mesh sizes from 1968 to 1970 showed sauger to outnumber walleyes in the lake by a factor of 4, yet they have yielded only 10 to 15 percent of the walleye catch in the past 10 years (1961-1970). It seems reasonable, considering the above evidence, that the contribution to the fishery by the sauger resource in Lake of the Woods could be increased by a factor of at least four without having a detrimental effect on the population.

OTHER COMMERCIAL SPECIES

The remaining species of commercial importance are the burbot, yellow perch, northern pike, common white sucker, and black bullhead. Except the burbot, these species have contributed only 10 percent or less of the total commercial harvest from 1961 to 1970. Because of the low rate of catches for these species during the current study, it was not possible to collect the samples needed for the detailed analyses presented above for walleye, tullibee, and sauger. Samples were collected for burbot. However, a recognition of the potential impact of the burbot population to the fishery and to the other fish species in the lake allowed for an expansion of the burbot sampling beyond the conclusion of the current study. Because of this continued sampling, the results of the burbot analysis will be presented in a forthcoming study by K. M. Muth, principal investigator, Department of Entomology, Fisheries, and Wildlife, University of Minnesota.

INTERSPECIES RELATIONSHIPS

The question of interspecies relationships becomes important when considering the management for maximum sustained yield of a multiple species fishery such as that on Lake of the Woods. It receives additional emphasis when considering the singular importance of walleye in the combined commercial and sport fishery on the lake. Commercial fishermen have long argued that the benefits of harvesting nongame species thereby maintaining the "natural balance" of the fish populations, more than offsets the angler's loss of game fish that are caught in the commercial nets. In fact, this harvest and assumed control of nongame species has often been cited by biologists as a desirable management objective. They base their opinion on a general knowledge of the environmental carrying capacity for all species in a lake and the potential factors that may serve to limit a particular species of interest. Unfortunately, actual data in support of the above management approach are not well documented (Larkin, 1956), particularly concerning the importance of food or space in determining the production of a desired species.

Lake of the Woods provides a case in point. Does the annual commercial harvest of several million pounds of fish species, not desired by the sport fisherman, adversely affect the sport fishing for walleye or is the reverse true? Equally important, is it possible to increase the production of a given species by reducing the competition being exerted by other species? In an attempt to obtain some answers to these questions, the current study selected two species, sauger and burbot, for detailed analysis of their interspecific relationships with, and their effect on the production of, the walleye. These two species were chosen over tullibee and sucker because of their demonstrated similarities in feeding habits and their potential interpredation.

Carlander (1942) attempted to enumerate, through a qualitative study of the similarity of feeding habits, the potential benefits to the walleye population that could be derived by expanding the commercial harvest of sauger. However, competition can exist only when the demand for the desired food is in excess of the supply. Using this approach, W. A. Swenson, principal investigator, Department of Entomology, Fisheries, and Wildlife, University of Minnesota, established both laboratory and field studies as part of the current survey to obtain quantitative estimates of food abundance and feeding rates by walleye and sauger. The results of these studies are to be reported later in a different publication. A second study, already mentioned, was initiated to examine the role of the burbot in the lake community. This report by K. M. Muth will also be reported later.

Until the analyses have been completed for the above two species, the question about the influence of the commercial harvest of game and nongame species on the combined fishery for walleye and on the production of the walleye population in the lake cannot be fully answered. Because no data exist for a similar fishery in other waters, the authors can only speculate about the changes that might occur should the management program be altered for the commercial fishery. However, as noted above, results of basic research on the population dynamics of fish communities tend to support the continued existence of the commercial industry as a means of maintaining a balanced use of the fishery resource.

IMPLICATIONS FOR MANAGEMENT

Current Efficiency of Species Utilization

Of the eight fish species taken in the commercial fishery, only the walleye population appears to be harvested at a rate that indicates maximum utilization. Because the reduction in commercial fishing pressure during the past 30 years has been more than matched by increasing sport fishing pressure, total mortality rates of vulnerable stock appear to have even increased slightly. There is little question that the total poundage of harvestable walleyes could be increased through appropriate regulations controlling the minimum size at harvest. However, the sport fishermen would be the most severely affected by this management approach. They probably would not tolerate the required restrictions. The very strong 1966 year class and continued support by subsequent year classes indicate that the total fishing rate now being exerted does not affect recruitment through reduction of brook stocks. Available data on the present combined commercial and sport fisheries, therefore, indicate that the maximum sustainable use of the walleye resource is now being made.

All other species appear to be harvested at a rate somewhat below their potential maximum yield. Lack of interest by the angler and controls on permissible methods of commercial harvest cause this underharvest. The brief use of trawls on the lake brought the utilization of the tullibee resource to a maximum, but the elimination of trawling and a decline in the demand for commercial fish have returned the level of harvest to less than the potential maximum.

Alternatives in Harvest Technique and Consequences of Changes

The only well investigated harvest technique that is capable of increasing the yield of the commercial fishery without adversely affecting the sport fishery is the bottom trawl. If this gear is permitted, it should be restricted to two fishing units until it is demonstrated that full harvest cannot be made by sustained use of this amount of gear and that use of additional units would not be economically unsound. In general, very little has been done to develop alternate methods of harvest in an attempt to maximize the yield of all the fish resources in the lake.

Effect of Discontinuing Commercial Fish Removal

The effect of discontinuing commercial fishing has been discussed in some detail in earlier sections of this report. Basically, almost no direct information is available about the advantages and/or disadvantages of a balanced fish harvest in a fishery such as that on Lake of the Woods. The consequences of discontinuing the harvest of two million pounds of tullibee annually and the present catches of burbot and suckers can only be estimated. Basic fishing theory indicates that such a change could exercise a negative effect that would reduce the quality of sport fishing on the lake and would inflict an economic loss (Stam, 1972), through termination of commercial operations.

Length of the Fishing Season

The current commercial fishing season from June to the first week of November provides the industry with nearly the maximum opportunity for harvesting the desired species. Beginning the season (present season *June 1 — November 7*) earlier in May would increase the fishing pressure on walleye to a

level where overutilization could be anticipated because the fish have concentrated during this time for spawning.

Extending the commercial fishing season into the autumn could also increase the fishing pressure on walleye to a detrimental level. The September-November walleye catch approaches two thirds of the season's total (figure 33). The contribution of the November catch would be considerably more if the season were allowed to extend beyond the first week of the month. The actual effect of such an extension would be variable since the lake may freeze over early in November or late in December.

Extending the fall season would increase the catch of the commercial species more than the walleye catch because perch, tullibee, and burbot have a larger harvest potential than walleye at this time (figure 33). These species are particularly vulnerable to the pound nets in the latter part of November just before the freezeover. However, because the ice cover can come almost overnight, gear could be lost and the removal of pound net stakes prevented, thus creating a potential boating hazard the following open-water season. Consequently, the commercial fishing season is terminated early in November.

Closed Areas

Closed areas for commercial fisheries usually are established to protect concentrated populations, such as spawners. The existing commercial fishing season on Lake of the Woods does not include such periods. Areas are closed instead to avoid conflicts between sport and commercial interests, especially in the walleye fishery. Data are lacking to measure the effect of this regulation on the catch of walleye by commercial and sport interests, but it is believed they are minimal. Marked walleye moved from area to area throughout the Big Traverse of the lake. With relatively few concentrating physical features in the lake morphometry, walleye would be continuously arriving at and leaving a particular area throughout most of the open-water season. This behavior pattern would tend to minimize the potential capability that the commercial or sport fisherman might have to fish out an area. This result is clearly seen in Muskeg Bay on the west side of the lake. This bay supports more commercial fishing effort than any other and yet continues to provide excellent sport fishing.

Size Limits

It is well documented in the literature that the use of size limits can regulate the catch of any species by allowing for maximum production through growth and by insuring survival of the younger age groups to maturity. In Lake of the Woods, however, size limits are relatively inefficient. The major harvesting gear for walleye is the gill net. The size of the fish taken by this gear is determined by the mesh size of the net. A stretch measure net of 4 inches takes relatively few walleye smaller than 15 inches fork length. In addition, undersize walleye which are caught are usually too weak to be returned to the lake successfully.

In contrast, the size limit regulation is very effective in determining the size of walleye taken by pound and trap nets. Here mesh sizes smaller than 4 inches stretch are allowed, and consequently a large share of the walleye catch is composed of undersize fish. These undersize walleye can, for the most part, be culled out and returned unharmed to the lake. Because the percentage of the total walleye catch taken by pound nets is small, the impact of this culling on the walleye population and harvest is minimal.

Size limits for all other species are somewhat meaningless also. Although the sauger population is relatively underexploited, the species is protected by a size limit. The same can be said for northern pike, and so few whitefish are caught

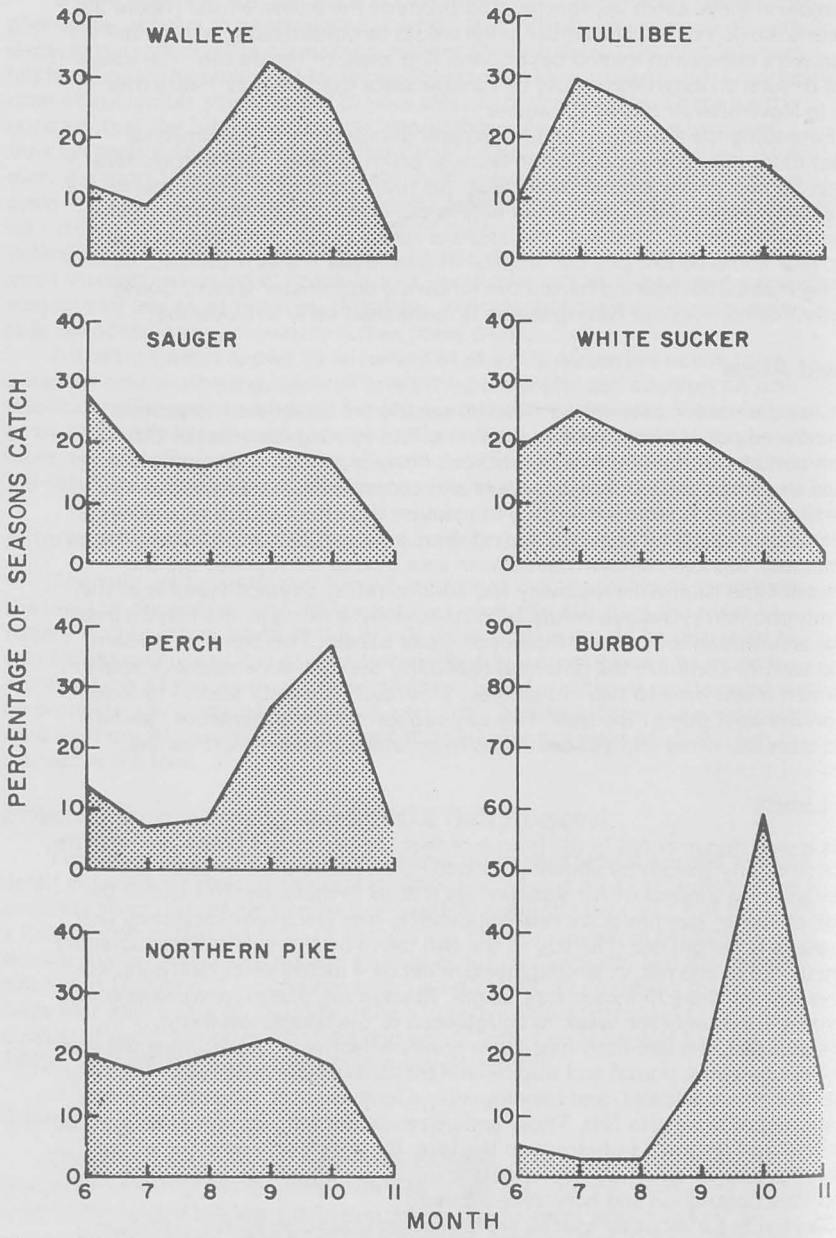


Figure 33. Seasonal catch of commercial fish species, expressed as the percentage contribution of each month to the season's total.

that a size restriction for this species is totally meaningless. Eliminating all size restrictions, except for the walleye in the commercial fishery, would have little or no adverse effect on the harvested fish populations.

Appropriate size limits, however, could improve the status and potential yield of the populations. Carlander (1942) discussed the benefits of increasing the commercial minimum size of walleye. However, the restrictions would have to apply to the sport fishery also and would drastically reduce the sport catch. If an efficient method of harvesting saugers is developed, size limits could be used to increase their yield. If an excessive number of trawls were allowed on the lake, the tullibee population might require the protection of minimum size limits.

Relationship between Minnesota and Canadian Fishery Operations

Very little cooperative work has been attempted to illucidate the influence of Minnesota or Canadian fishing practices on each other. Catch records of the Canadian commercial fishery indicate that about 50 percent of the total Ontario walleye catch (300,000 pounds) from Lake of the Woods is taken from waters of the lake contiguous with Minnesota waters. When the catch of the Canadian sport fishery is added, the total Ontario walleye harvest from the southern part of the lake would approximate the total Minnesota catch.

Although the walleye stocks of Sabaskong Bay, Ontario, appear to be distinct, tagging studies have shown fish from other areas of the southern half of the lake to migrate both directions across the international boundary with a general dispersal of stocks evident within each jurisdictional area of the lake (Carlander, 1942, V. Macins, personal communication, present study). Because fish do not recognize artificial boundaries, fishing practices on one side of the border may influence the fishing success on the other. Currently the Canadian commercial fishing industry is undergoing a gear transformation from the historic use of gill nets with greater than 4 inches stretch mesh to submerged trap nets with less than 4 inches stretch mesh. This change could place additional fishing pressure on the walleye population in Lake of the Woods which could, in turn, influence the success of the walleye fishery in Minnesota waters. This entire question of the lake-wide management of the walleye resource should receive additional attention.

RECOMMENDATIONS FOR OPTIMUM UTILIZATION OF THE FISHERY RESOURCE

With the interest of sport fishermen directed so completely toward walleye, the continued existence of a commercial fishery is mandatory if the optimum utilization of the entire resource in Lake of the Woods is to be made. Although competition between the sport and commercial fisheries for walleye is sometimes intense, data compiled during the current study indicate that the combined fishing intensity has not adversely affected the population. However, the large harvest of immature individuals suggests that the population should be closely monitored in the future as changes occur in the fishing intensity.

Changes in regulations for the harvest of walleye could increase the maximum sustained yield in weight that could be expected from the population. To be most effective, these changes should be applied first to the sport fishery in the form of larger size limits and then to the commercial fishery. This management approach would result in a large reduction in the number of walleye harvested and consequently would not be popular with the sportsman's interests.

Reducing the commercial fishing pressure for walleye but not for other species can be accomplished only by reducing the number of commercial fishermen or by changing the type of commercial fishing gear allowed. The majority of the commercial fishermen use gill nets, and because this gear is injurious to entangled fish, the walleyes caught cannot be returned to the lake alive and healthy.

Trawl nets increase the utilization of commercial species but do not increase the fishing intensity for walleye when substituted on a 1:1 basis for existing licensed commercial gear. There is no evidence that the use of trawls at water depths greater than 20 feet is injurious to aquatic plants, fish food, spawning grounds, undersize fish, or the water quality of the lake. Trawls can be extremely efficient in harvesting tullibee. Because this species forms the greatest portion of their total catch, however, the number of trawls allowed to operate on the lake must be carefully controlled.

All species except walleye could be exploited more fully by either the sport or commercial fishery if the means for increasing their harvest would not increase the fishing pressure on walleye. Substantial increases in the value of the commercial catch also could be anticipated but mainly through changes in market potential. The largest of these potentials is for tullibee. If the Federal Pure Food and Drug Administration raised the tolerance limits for incidence of the *Trianophorus sp.* parasite, the availability of the tullibee on the human market could triple the value of the tullibee catch. Likewise, the value of burbot and sucker also could be increased through the development of human instead of animal food markets. The yellow perch, already sold to the human market, could add significantly to the value of the commercial harvest through increased catches. In addition, the freshwater crayfish populations in the lake could provide an additional source of income if a market and suitable catch methods were developed. This industry is well developed in the southeastern United States, and the capture and marketing of these crustaceans locally could increase the value of the commercial industry. This potential should be studied more thoroughly.

Finally, any proposed changes in the management of the combined sport and commercial fisheries on Lake of the Woods must be considered in terms of international implications. Because interchange of fish populations occurs across the international boundary, harvest practices may have a broad rather than localized effect. This area of inquiry has received little attention in the past, but will become more important as competition for desired species, especially walleye, increases.

LITERATURE CITED

Burrows, C.R. 1951. Status of the Lake of the Woods Fisheries, 1938 through 1949, with special reference to the walleye. Minnesota Dept. Conservation, Fish. Res. Invest. Rep. No. 106, 20 pp.

_____, and E.G. Heyerdahl. 1969. Supplemental report on Lake of the Woods fisheries studies, 1968. State of Minnesota, Lake of the Woods-Rainy Lake Commission, 13 pp.

Carlander, K.D. 1942. An investigation of Lake of the Woods, Minnesota, with particular reference to the commercial fisheries. Minnesota Dept. Conservation, Fish. Res. Invest. Rep. No. 42, 384 pp.

_____. 1945. Age, growth, sexual maturity, and population fluctuations of the yellow pikeperch, *Stizostedion vitreum vitreum* (Mitchill), with reference to the commercial fisheries, Lake of the Woods, Minnesota. Trans. Am. Fish. Soc. 73: 90-107.

_____, and L.L. Smith, Jr. 1944. Some uses of nomographs in fish growth studies. Copeia 1944(3): 157-162.

Fridriksson, A. 1934. On the calculation of age distribution within a stock of cod by means of relatively few age determinations as a key to measurements on a large scale. Cons. Perm. Internat. Explor. Mer, Rapp. et Proc.-Verb., No. 86, 5 pp.

Hile, Ralph. 1962. Collection and analysis of commercial fishery statistics in the Great Lakes. Great Lakes Fish. Comm., Tech. Rept. 5, 31 pp.

Kennedy, W.A. 1949. Relationship of length, weight, and sexual maturity to age in three species in Lake Manitoba fish. Bull. Fish. Res. Bd. Canada 81: 1-5.

Ketchen, K.S. 1950. Stratified subsampling for determining age distributions. Trans. Am. Fish. Soc. 79: 205-212.

Miller, R.B. 1949. Observations on mortality rates in fishes and unfished cisco populations. Trans. Am. Fish. Soc. 79: 180-186.

Olson, D.E. 1957. Statistics of a walleye sport fishery in a Minnesota lake. Trans. Am. Fish. Soc. 87: 52-72.

Regier, H.A., V.C. Applegate, and R.A. Ryder. 1969. The ecology and management of the walleye in Western Lake Erie. Great Lakes Fishery Commission, Tech. Rep. No. 15, 101 pp.

Ricker, W.E. 1947. Mortality rates in some little-exploited populations of freshwater fishes. Trans. Am. Fish. Soc. 77: 114-128.

_____. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada, Bull. No. 119, 300 pp.

Scidmore, W.J. 1963. Experimental commercial trawl fishing Lake of the Woods, Minnesota. Minnesota Dept. Conservation, Fish. Res. Invest. Rep. No. 266, 24 pp.

Smith, L.L., Jr., and R.L. Pycha. 1961. Factors related to commercial production of the walleye in Red Lakes, Minnesota. Trans. Am. Fish. Soc. 90: 190-217.

Stam, J.M. 1972. An economic analysis of the Lake of the Woods-Rainy Lake Region of Minnesota. (Unpublished manuscript).

Whitney, J.K., J. Leirfallom, and S.O. Berg. 1971. Lake of the Woods and Rainy Lake Commission Report to the Legislature. State of Minnesota, Lake of the Woods-Rainy Lake Commission, pp. 7-9.

Appendix Table 1. Total commercial catch, all species, and catch in various types of gear - American waters of Lake of the Woods, 1940-1970

Year	Gill Nets Catch	Pound Nets Catch	Trap Nets Catch	Fyke Nets Catch	Sub-Trap Nets Catch	Trawls Catch	Total[2]
1940	1,582,893	390,303	--	195,151			2,168,347
1941	970,492	439,754	--	106,147			1,516,393
1942	894,339	307,412	--	252,525			1,454,276
1943	860,978	223,775	--	238,092			1,322,845
1944	890,158	404,618	--	53,949			1,348,725
1945	651,596	306,052	--	29,618			987,266
1946	759,066	460,417	--	24,887			1,244,370
1947	854,992	475,489	--	34,280			1,364,761
1948	1,256,188	606,821	--	62,184			1,925,193
1949	881,680	721,582	327,022	49,444			1,979,728
1950	891,296	482,080	295,743	33,938			1,703,057
1951	613,528	299,841	280,507	115,345			1,309,221
1952	1,069,977	360,393	327,272	117,655	16,406		1,891,703
1953	956,131	273,111	158,134	141,601			1,528,977
1954	601,833	218,376	225,990	131,302			1,177,501
1955	823,982	318,589	117,917	44,299	7,612		1,312,399
1956	999,319	98,929	251,297	53,806	7,537		1,410,888
1957	749,895	170,361	357,142	12,805			1,290,203
1958	1,536,714	374,966	543,555	7,259			2,462,494
1959	1,434,585	142,327	405,464	7,861			1,990,237
1960	2,009,694	158,500	492,072	15,370			2,675,636
1961	1,924,628	108,925	636,743	12,366		625,476[1]	3,308,138
1962	1,699,930	94,570	677,867	52,099		1,109,545[1]	3,634,011
1963	1,464,041	--	500,101	57,323		852,222	2,873,687
1964	1,547,010	4,018	478,628	222		968,611	2,998,489
1965	1,032,482	167,629	286,510	44,781			1,531,402
1966	1,243,561	19,438	307,258	38,973			1,609,230
1967	1,119,052	1,178	338,818	47,943			1,506,991
1968	1,126,029	125,970	283,065	7,480		150,679[1]	1,693,223
1969	1,035,118	471,549	--	--		112,273[1]	1,618,940
1970	801,502	318,123	--	1,314		80,893[1]	1,201,832

[1] Trawl net fished under an experimental permit. Catches included in totals.

[2] Does not include burbot catches from winter fishing.

Appendix Table 2. Total catch of walleye in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	303,598		63,772	27.7	45,893	19.9
1950	217,618	28.3	83,576	40.0	46,890	19.1
1951	191,150	22.8	30,908	15.0	25,108	10.3
1952	326,203	39.0	13,865	12.6	19,805	8.4
1953	399,523	45.0	25,244	19.8	43,455	16.2
1954	259,002	29.8	22,372	22.0	30,552	15.5
1955	200,806	24.2	19,731	13.4	7,909	4.7
1956	183,594	20.6	16,232	64.4	35,792	18.9
1957	149,270	28.0	10,944	51.7	40,525	33.1
1958	134,316	20.2	11,082	12.7	23,188	9.3
1959	186,319	26.2	9,770	25.1	22,318	13.3
1960	354,135	43.0	10,510	26.6	63,409	34.6
1961	242,976	31.5	8,975	36.2	65,651	30.5
1962	120,199	19.7	--	--	35,136	16.5
1963	187,922	25.6	--	--	27,716	15.5
1964	181,747	33.1	890	55.4	28,759	19.7
1965	91,161	16.4	10,465	13.2	32,468	22.2
1966	258,282	44.3	1,801	11.7	40,150	19.9
1967	112,411	18.8	202	8.8	21,630	8.9
1968	82,113	16.4	3,715	18.8	18,262	11.5
1969	63,275-1/2	16.0	15,811	13.4	--	--
1970	83,958	17.9	16,743	15.7	--	--

Appendix Table 2. (Continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls[1]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	5,891						419,154
1950	5,587	7.2					353,671
1951	10,515	4.2					257,681
1952	5,859	3.2	755	12.8			366,487
1953	12,613	5.8					480,835
1954	14,381	7.7					326,307
1955	4,843	5.5	350	17.5			233,639
1956	8,352	12.0	1,502	21.5			245,472
1957	3,792	15.7					204,531
1958	1,692	2.9					170,278
1959	1,938	14.5					220,345
1960	1,748	7.9					429,802
1961	664	1.6			6,549	11.2	318,266
1962	387	2.0			10,135	7.8	155,722
1963	3,183	3.0			6,111	4.7	224,932
1964	68	5.5			5,566	3.8	217,030
1965	6,794	6.2					140,888
1966	4,985	4.1					305,218
1967	3,937	5.4					138,180
1968	1,332	2.6			1,922	8.8	105,422
1969	--	--			2,458	16.0	79,086
1970	84	3.4			1,971	14.4	100,785

[1] Catch by trawl in 1961, 1962 and 1968, 1969, and 1970 by permit not included in total.

Appendix Table 3. Total catch of sauger in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	85,562	10.3	13,981	5.8	14,778	6.9
1950	56,594	7.4	26,000	12.4	24,583	10.0
1951	29,950	3.6	18,407	9.0	21,053	8.7
1952	29,656	3.5	1,826	1.6	6,771	2.9
1953	40,441	4.6	4,251	3.4	15,390	5.8
1954	42,499	4.9	5,472	5.4	11,973	6.0
1955	48,629	5.9	12,969	8.8	6,285	3.7
1956	70,568	7.9	3,517	14.0	33,359	17.6
1957	34,519	6.4	4,810	21.9	23,540	19.2
1958	22,025	3.3	4,374	5.0	11,264	4.5
1959	27,226	3.8	715	1.8	8,469	5.1
1960	41,674	5.2	890	2.2	17,297	8.6
1961	41,800	5.4	5,511	22.2	47,726	22.2
1962	49,288	8.0	--	--	37,813	17.7
1963	37,357	5.1	--	--	14,818	8.3
1964	26,692	4.5	191	11.2	15,033	10.2
1965	22,468	4.0	5,482	6.9	12,080	8.3
1966	14,569	2.5	442	2.9	10,523	5.2
1967	16,495	2.8	54	2.4	7,921	3.2
1968	10,041	2.0	370	1.9	5,062	3.2
1969	8,493	2.2	3,909	3.3	--	--
1970	12,994	2.8	3,959	3.7	--	--

Appendix Table 3. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls[1]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	2,559	1.3					116,880
1950	548	.7					107,725
1951	4,502	1.8					73,912
1952	2,453	.9	1,544	26.2			42,250
1953	6,253	2.8					66,335
1954	3,650	1.8					63,594
1955	1,047	1.2	249	12.5			69,179
1956	495	.7	1,640	23.4			109,579
1957	729	3.0					63,598
1958	252	.4					37,915
1959	157	1.2					36,567
1960	68	.3					59,929
1961	79	.2			22,728	38.9	95,116
1962	294	1.5			57,376	44.1	87,395
1963	2,231	2.0			29,950	22.8	84,356
1964	41	3.5			26,515	18.1	68,472
1965	2,796	2.5					42,826
1966	1,752	1.4					27,286
1967	1,175	1.6					25,645
1968	364	.7			1,010	4.8	15,837
1969	--	--			652	4.3	12,402
1970	3	.1			465	3.4	16,956

[1] Catch by trawl in 1961, 1962 and 1968, 1969, and 1970 by permit not included in total.

Appendix Table 4. Total catch of northern pike in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	59,403	7.1	14,104	6.2	6,823	3.0
1950	50,110	6.2	13,736	6.6	4,449	1.8
1951	61,307	7.4	6,278	3.1	2,854	1.2
1952	53,258	6.2	6,574	6.0	7.278	3.1
1953	71,121	8.0	7,969	5.4	13,164	4.9
1954	64,710	7.4	23,747	23.4	5,148	2.6
1955	41,833	5.1	2,158	1.4	1,442	.9
1956	41,954	4.7	719	2.9	5,640	3.0
1957	70,465	13.2	2,007	7.7	7,388	6.0
1958	46,524	7.0	5,929	6.8	6,080	2.4
1959	36,375	5.1	3,669	9.4	6,665	4.0
1960	36,029	3.5	2,996	7.5	9,519	3.0
1961	33,533	4.3	1,491	6.0	20,281	9.5
1962	48,641	8.0	--	--	10,259	4.8
1963	59,677	8.1	--	--	11,299	6.3
1964	61,713	11.6	1,870	110.0	12,444	8.5
1965	42,361	7.1	3,657	4.6	10,129	6.9
1966	37,740	6.5	10,240	66.5	9,049	4.5
1967	25,299	4.2	475	26.5	6,464	2.6
1968	37,130	7.4	2,157	11.0	9,710	6.1
1969	51,349	13.0	15,480	13.1	--	--
1970	47,024	10.0	10,358	9.7	--	--

Appendix Table 4. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls[1]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	6,417	5.5					86,747
1950	5,190	6.7					73,485
1951	10,141	4.1					80,580
1952	8,242	4.3	1,567	26.6			76,919
1953	11,784	5.5					104,038
1954	11,033	6.4					104,638
1955	6,758	7.7	778	38.5			52,969
1956	5,506	7.9	949	13.6			54,768
1957	1,691	7.0					81,551
1958	1,121	1.9					59,654
1959	596	4.4					47,305
1960	546	3.2					49,090
1961	2,779	6.7			292	.5	58,084
1962	1,006	5.2			348	.3	59,906
1963	3,323	3.0			0	--	74,299
1964	39	3.0			0	--	76,066
1965	3,779	3.4					59,926
1966	6,999	5.7					64,028
1967	1,608	2.2					33,846
1968	2,238	4.4			245	1.1	51,235
1969	--	--			103	0.7	66,829
1970	310	12.4			124	0.9	57,692

[1] Catch by trawl in 1961, 1962 and 1968, 1969, and 1970 by permit not included in total.

Appendix Table 5. Total catch of tullibee in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	321,779	38.9	266,561	92.2	183,264	42.5
1950	441,252	59.3	185,392	88.7	136,670	55.6
1951	185,581	20.5	61,031	29.7	141,244	58.1
1952	384,090	45.3	141,606	128.4	186,970	79.7
1953	300,627	33.9	104,102	85.5	33,551	12.5
1954	113,834	12.9	27,847	27.5	172,784	87.7
1955	411,195	49.4	95,211	64.8	84,789	50.5
1956	589,013	66.0	94	--	55,012	29.1
1957	417,322	78.8	69,550	174.9	177,481	144.9
1958	1,133,201	170.7	249,942	286.0	384,252	153.8
1959	1,070,509	150.3	37,618	96.5	144,733	86.5
1960	1,420,153	190.0	23,990	60.3	204,888	105.0
1961	1,373,280	178.5	17,800	71.7	221,007	103.0
1962	1,279,680	210.3	16,575	182.1	446,294	209.2
1963	917,020	125.2	--	--	375,455	210.3
1964	1,030,418		39	2.3	309,579	201.4
1965	574,350	103.5	110,797	139.0	158,380	108.4
1966	717,185	123.1	256	1.7	204,016	101.2
1967	699,495	116.9	190	8.3	162,622	66.7
1968	838,500	168.0	87,970	444.3	161,833	102.2
1969	798,740	202.4	240,294	204.0	--	--
1970	514,921	109.6	172,519	162.0	--	--

Appendix Table 5. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls[1]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	--	--					771,604
1950	--	--					763,314
1951	10	--					387,866
1952	--	--					712,666
1953	5	--					438,285
1954	9	--					314,474
1955	15	--	306	15.3			591,516
1956	--	--	46	.7			644,165
1957	--	--					664,353
1958	--	--					1,767,395
1959	101	.8					1,252,961
1960	--	--					1,649,031
1961	2	--			548,171	939.3	1,612,089
1962	16	--			918,104	704.9	1,742,565
1963	180	.2			737,130	561.7	2,029,785
1964	--	--			863,465	588.1	2,203,501
1965	157	--					843,684
1966	370	.3					921,827
1967	503	1.6					862,810
1968	437	.9			135,594	621.8	1,088,740
1969	--	--			100,673	655.4	1,039,034
1970	1	--			70,859	520.0	687,441

[1] Catch by trawl in 1961, 1962 and 1968, 1969, and 1970 by permit not included in total.

Appendix Table 6. Total catch of perch in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	16,593	1.6	695	.3	2,035	.9
1950	10,961	1.4	692	.3	2,729	1.1
1951	6,667	.8	562	.3	2,362	1.0
1952	12,020	1.4	279	.2	3,476	1.5
1953	12,908	1.4	993	.8	2,273	.8
1954	6,975	.8	229	.2	1,468	.1
1955	15,707	1.8	1,795	1.2	1,007	.6
1956	15,811	1.8	21	.1	2,227	1.2
1957	9,788	1.8	34	.2	1,757	1.4
1958	16,791	2.5	1,038	1.2	3,274	1.3
1959	18,159	2.5	257	.7	2,411	1.4
1960	11,582	1.6	259	.6	5,161	2.6
1961	10,298	1.3	638	2.6	7,738	3.6
1962	11,513	1.9	--	--	3,559	1.7
1963	6,485	.9	--	--	1,944	1.1
1964	3,146	.6	81	4.8	3,182	2.2
1965	4,852	.9	766	1.0	1,515	1.0
1966	10,932	1.9	105	.7	7,513	3.7
1967	22,307	3.7	4	--	3,699	1.5
1968	28,940	5.8	580	2.4	4,906	3.1
1969	16,879	4.3	4,319	3.7	--	--
1970	8,599	1.8	3,491	3.3	--	--

Appendix Table 6. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls[1/]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	2,397	2.1					21,720
1950	388	.5					14,770
1951	2,004	.8					11,595
1952	2,802	1.2	3,047	51.6			21,624
1953	9,974	4.6					26,148
1954	4,120	2.2					12,792
1955	1,263	1.4	283	14.2			20,055
1956	1,621	2.3	95	1.4			19,775
1957	775	3.2					12,354
1958	314	.5					21,417
1959	44	.3					20,871
1960	190	1.0					17,192
1961	1,258	3.0			5,682	9.7	19,932
1962	341	1.8			12,858	9.9	15,413
1963	2,644	2.4			8,432	6.4	19,505
1964	11	1.0			5,134	3.5	11,554
1965	1,281	1.2					8,414
1966	4,212	3.4					22,762
1967	2,063	2.8					28,073
1968	931	1.8			696	3.2	35,357
1969	--	--			145	0.9	21,198
1970	53	2.1			560	4.1	12,143

1/ Catch by trawl in 1961, 1962 and 1968, 1969, and 1970 by permit not included in total.

Appendix Table 7. Total catch of burbot in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970 2/

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	48,946	5.9	345,636	134.5	63,476	8.8
1950	58,130	7.1	151,051	72.2	68,665	28.0
1951	86,388	10.2	172,503	83.9	80,216	33.0
1952	213,311	25.8	190,956	173.1	89,588	38.2
1953	54,991	6.2	126,019	103.5	43,134	16.1
1954	65,591	7.6	134,974	133.5	--	--
1955	63,354	7.4	172,960	117.8	13,200	7.8
1956	73,200	8.2	77,343	306.9	111,910	59.1
1957	38,517	7.3	82,355	233.0	101,809	83.1
1958	96,032	14.5	80,518	92.1	103,943	41.6
1959	40,189	5.6	89,030	228.3	214,320	128.1
1960	81,159	7.7	119,005	296.0	181,722	98.0
1961	46,733	6.1	72,939	295.0	242,631	113.0
1962	36,531	6.0	77,995	857.1	134,641	63.1
1963	21,614	2.9	--	--	62,532	35.0
1964	22,690	4.3	294	17.4	107,965	66.7
1965	21,337	3.9	34,215	43.0	68,005	46.6
1966	23,094	4.0	2,925	19.0	30,984	15.4
1967	63,264	10.5	--	--	132,757	80.4
1968	32,944	8.0	31,043	156.8	75,891	82.1
1969	33,913	8.6	188,938	160.4	--	--
1970	37,093	7.9	97,210	91.3	--	--

Appendix Table 7. (continued)

Year	Fyke Nets		Sub-trap Nets		Trawl[1/]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	771	.7					458,829
1950	6,860	8.9					284,706
1951	18,676	7.5					357,783
1952	42,295	26.4	4,603	78.0			540,753
1953	34,222	15.9					258,366
1954	68,889	36.9					269,454
1955	17,127	195.0	5,516	275.8			272,157
1956	27,648	39.7	3,219	45.9			293,320
1957	1,009	7.6					223,690
1958	--	--					280,493
1959	652	4.9					344,191
1960	29	.2					381,915
1961	131	.3			35,080	60.1	362,434
1962	48,547	250.2			102,031	78.3	297,714
1963	33,433	31.0			62,225	47.4	179,804
1964	--	--			57,688	39.3	188,637
1965	25,962	23.6					149,519
1966	5,471	4.5					62,474
1967	34,353	62.9					230,374
1968	392	1.6			9,755	44.7	140,270
1969	--	--			7,805	50.8	222,851
1970	718	28.7			6,181	45.4	135,021

1/ Catch by trawl in 1961, 1962 and 1968,1969 and 1969 by permit not included in total.

2/ Winter fishery catch not included.

Appendix Table 8. Total catch of white sucker in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	43,295	4.4	14,855	6.2	7,819	3.6
1950	54,083	7.2	19,540	9.3	8,582	3.5
1951	51,187	6.1	8,756	4.3	5,218	2.1
1952	50,220	6.0	4,987	4.5	5,770	2.5
1953	72,812	8.2	4,345	3.5	5,845	2.2
1954	48,687	5.6	3,504	3.4	3,652	1.8
1955	41,997	4.5	13,494	9.2	2,662	1.5
1956	24,998	2.8	947	3.8	6,866	3.6
1957	27,826	5.2	364	1.5	3,164	2.6
1958	87,189	13.1	21,463	24.6	9,000	3.6
1959	53,083	7.5	1,056	2.7	4,325	2.6
1960	61,832	8.3	750	1.9	5,980	2.2
1961	169,419	22.0	1,137	4.6	22,035	10.2
1962	152,707	25.1	--	--	5,939	2.8
1963	232,621	32.0	--	--	5,463	3.0
1964	218,566	38.6	364	21.4	1,331	.9
1965	274,817	49.5	2,184	2.7	3,046	2.1
1966	181,251	31.1	2,490	16.2	4,610	2.3
1967	179,413	30.0	242	10.5	3,534	1.4
1968	96,076	21.9	80	--	7,287	4.6
1969	62,181	15.8	2,587	2.2	--	--
1970	96,675	20.6	13,762	12.9	--	--

Appendix Table 8. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls[1]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	5,414	4.7					71,383
1950	2,504	3.3					84,709
1951	8,286	3.3					73,447
1952	14,196	7.4	887	15.0			76,060
1953	12,580	5.8					95,582
1954	10,933	5.8					66,776
1955	5,378	6.1	130	6.5			63,661
1956	5,255	7.5	86	1.2			38,152
1957	1,944	8.1					33,298
1958	--	--					117,652
1959	104	.8					58,568
1960	1,225	7.1					69,787
1961	577	1.4			6,843	11.7	193,168
1962	669	3.4			8,400	6.4	159,315
1963	1,410	1.3			8,319	6.3	247,813
1964	4	.4			10,214	7.0	230,479
1965	2,380	2.2					282,427
1966	7,463	6.1					195,814
1967	2,461	3.3					185,650
1968	1,491	2.9			1,398	6.4	104,934
1969	--	--			427	2.8	64,768
1970	70	2.8			731	5.4	110,507

[1] Catch by trawl in 1961, 1962 and 1968, 1969, and 1970 by permit not included in total.

Appendix Table 9. Total catch of bullhead in various types of gear - catch per unit of gear and total catch from American waters of Lake of the Woods, 1949-1970

Year	Gill Nets		Pound Nets		Trap Nets	
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit
1949	1,669	.2	287	.1	962	.3
1950	1,706	--	138	.1	2,251	.9
1951	903	.1	1,155	.6	2,392	1.0
1952	790	--	112	.1	7,541	3.2
1953	3,399	.4	38	--	1,252	.5
1954	54	--	8	--	239	.1
1955	2	--	63	--	601	.4
1956	7	--			448	.2
1957	107	--	297	1.3	1,396	1.1
1958	385	.1	539	.6	2,450	1.0
1959	1,107	.2	208	.5	1,188	.7
1960	1,158	--	93	.2	1,233	.4
1961	6,195	.8	434	1.7	939	.4
1962	1,297	.2	--	--	897	.4
1963	1,038	--	--	--	467	.3
1964	1,397	.2	--	--	252	--
1965	503	--	35	--	140	--
1966	441	--	4	--	337	--
1967	291	--	3	--	179	--
1968	219	--	42	--	108	--
1969	166	.04	59	.05	--	--
1970	200	.04	77	.07	--	--

Appendix Table 9. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawl[1/]		Total
	Catch	Catch/Unit	Catch	Catch/Unit	Catch	Catch/Unit	
1949	25,995	22.4					28,913
1950	12,857	16.7					16,952
1951	59,210	23.8					63,660
1952	41,568	24.5	4,003	67.8			54,014
1953	54,170	25.2					58,859
1954	18,120	9.9					18,421
1955	7,606	8.7					8,272
1956	4,929	7.1					5,384
1957	2,865	6.2					4,665
1958	3,880	6.7					7,254
1959	4,269	31.9					6,772
1960	10,447	47.6					12,931
1961	6,868	16.6			--	--	14,436
1962	839	4.3			--	--	3,033
1963	10,854	10.8			25	--	12,384
1964	59	5.0			6	--	1,714
1965	1,624	1.5					2,302
1966	3,875	3.2					4,657
1967	1,843	2.5					2,316
1968	286	.6			2	--	655
1969	--	--			--	--	225
1970	75	3.0			--	--	352

[1/] Catch by trawl in 1968 by permit not included in total.

Appendix Table 10. Total commercial harvest from Lake of the Woods and total from state and provinces, 1930-1970, summer and winter harvests combined

Year	Total			
	Minnesota	Ontario	Manitoba	Total
1930	2,221,876	1,538,516	--	3,760,392
1931	2,034,749	1,566,818	44,400	3,645,967
1932	2,478,121	1,763,486	11,900	4,253,507
1933	1,798,600	1,742,912	3,000	3,544,512
1934	2,001,000	1,808,105	7,100	3,816,205
1935	2,227,280	1,929,282	12,000	4,168,562
1936	2,184,649	1,705,207	6,800	3,896,656
1937	1,976,865	1,477,557	20,300	3,474,722
1938	1,779,800	1,603,823	80,400	3,464,023
1939	1,771,386	1,469,934	40,600	3,281,920
1940	2,168,347	1,716,559	92,800	3,977,706
1941	1,516,393	1,540,589	95,700	3,152,682
1942	1,454,276	1,559,481	143,100	3,156,857
1943	1,322,845	1,432,761	84,500	2,840,106
1944	1,348,725	1,358,529	113,900	2,821,154
1945	997,048	1,284,591	71,100	2,352,739
1946	1,244,370	1,411,922	87,100	2,743,392
1947	1,364,761	1,433,857	74,200	2,872,818
1948	2,165,178	1,251,997	224,800	3,641,975
1949	2,099,666	1,643,578	79,100	3,822,344
1950	1,855,342	1,445,929	134,400	3,435,671
1951	1,377,191	1,361,253	78,000	2,816,444
1952	1,891,703	1,560,715	150,800	3,603,218
1953	1,566,904	1,951,374	99,100	3,617,378
1954	1,360,737	1,632,259	66,000	3,058,996
1955	1,489,953	1,778,753	63,300	3,332,006
1956	1,613,910	1,779,074	65,600	3,458,584
1957	1,630,747	1,581,463	-- 2/	3,212,210
1958	2,538,025	2,091,910	--	4,629,935
1959	2,296,138	1,782,643	--	4,078,781
1960	3,048,827	2,209,842	--	5,258,669
1961	3,793,185	2,451,894	--	6,245,079
1962	4,002,096	2,379,420	--	6,381,516
1963	3,265,558	2,371,394	--	5,636,952
1964	3,404,434	2,479,301	--	5,883,735
1965	1,733,261	1,950,162	--	3,683,423
1966	1,832,286	1,916,366	--	3,748,652
1967	1,743,905	2,040,937	--	3,784,842
1968	1,908,823	2,137,110 1/	--	4,045,933
1969	1,641,800	NA	--	--
1970	1,201,832	NA	--	--

1/ Preliminary
2/ Commercial Fishing Season Closed
NA -- Not Presently Available

Appendix Table 11. Commercial harvest of walleye and sauger from Lake of the Woods by state and province, 1930-1970

Year	Walleye				Sauger			
	Minnesota	Ontario	Manitoba	Total	Minnesota	Ontario	Manitoba	Total
1930	768,225	541,900	NA	1,310,125	73,602	NA	NA	73,602
1931	954,818	630,637	NA	1,585,455	218,657	NA	NA	218,657
1932	625,536	686,958	9,500	1,321,994	215,898	NA	NA	215,898
1933	670,600	759,847	500	1,430,947	242,500	2,200	NA	244,700
1934	891,600	841,723	1,700	1,735,023	282,500	3,700	NA	286,200
1935	1,020,700	860,375	6,500	1,887,575	346,500	6,000	NA	352,500
1936	846,600	747,643	3,000	1,597,243	391,400	25,200	NA	416,600
1937	636,400	604,667	8,500	1,249,567	415,000	16,800	NA	431,800
1938	362,600	643,358	6,700	1,012,658	87,900	43,900	NA	131,800
1939	332,225	624,525	11,500	968,250	68,987	NA	NA	68,987
1940	520,790	785,452	18,500	1,324,742	82,072	NA	32,200	114,272
1941	643,209	671,891	34,500	1,349,600	69,625	NA	18,000	87,625
1942	420,547	617,705	41,800	1,080,052	55,761	NA	10,900	66,661
1943	343,828	549,128	7,300	900,256	56,850	NA	8,200	65,050
1944	346,183	587,734	31,000	964,917	33,458	NA	2,000	35,458
1945	367,538	569,927	3,700	941,165	37,965	NA	1,800	39,765
1946	345,714	563,415	50,100	959,229	44,798	NA	2,700	47,498
1947	299,855	608,355	49,900	958,110	77,988	NA	2,100	80,088
1948	303,090	592,176	69,800	965,066	63,165	NA	10,700	73,865
1949	419,154	705,569	46,200	1,170,923	116,880	NA	4,200	121,080
1950	353,671	571,388	53,800	978,859	107,725	NA	14,000	121,725
1951	257,681	463,658	38,300	759,639	73,912	NA	6,500	80,412
1952	366,487	508,240	57,800	932,527	42,250	NA	2,700	44,950
1953	480,835	718,469	71,800	1,271,104	66,335	NA	3,000	69,335
1954	326,307	502,561	30,700	859,568	63,594	NA	4,200	67,794
1955	233,639	535,565	21,100	790,304	69,179	NA	4,700	73,879
1956	245,472	368,487	19,500 2/	633,459	109,579	NA	2,900 2/	112,479
1957	204,531	479,067	-- 2/	683,598	63,598	NA	-- 2/	63,598
1958	170,278	641,637	--	811,915	37,915	NA	--	37,915
1959	220,345	681,457	--	901,802	36,567	NA	--	36,567
1960	429,802	777,411	--	1,207,213	59,929	NA	--	59,929
1961	324,038	1,062,182	--	1,386,220	117,844	NA	--	117,844
1962	165,857	875,138	--	1,040,995	144,771	NA	--	144,771

Appendix Table 11. (continued)

Year	Walleye				Sauger			
	Minnesota	Ontario	Manitoba	Total	Minnesota	Ontario	Manitoba	Total
1963	224,932	635,540	--	860,472	84,356	NA	--	84,356
1964	217,030	578,263	--	795,293	68,472	NA	--	68,472
1965	140,888	401,997	--	542,885	42,826	NA	--	42,826
1966	305,218	517,036	--	822,254	27,286	NA	--	27,286
1967	138,180	667,053	--	805,233	25,645	NA	--	25,645
1968	107,344	628,355[1/]	--	735,699	16,847	24,131[1/]	--	40,978
1969	81,554	NA	--	81,554	13,054	NA	--	13,054
1970	102,756	NA	--	102,756	17,421	NA	--	17,421

1/ Preliminary
2/ Commercial Fishing Season Closed
NA -- Not Presently Available

Appendix Table 12. Commercial harvest of northern pike and tullibee from Lake of the Woods by state and province, 1930-1970

Year	Northern Pike				Tullibee			
	Minnesota	Ontario	Manitoba	Total	Minnesota	Ontario	Manitoba	Total
1930	227,628	406,870	--	634,498	903,023	102,110	NA	1,005,133
1931	168,352	375,787	--	544,139	435,225	20,358	NA	455,583
1932	150,564	480,420	800	631,784	1,296,467	--	NA	1,296,467
1933	260,200	431,775	--	691,975	293,300	27,200	NA	320,500
1934	349,500	453,991	3,600	807,091	155,500	81,300	NA	236,800
1935	246,500	479,135	2,000	727,635	131,600	82,200	NA	213,800
1936	197,300	454,539	1,500	653,339	103,100	65,000	NA	168,100
1937	163,400	420,119	7,900	591,419	223,300	96,200	NA	319,500
1938	137,900	396,220	--	534,120	878,120	112,200	NA	990,600
1939	146,900	345,162	11,500	503,562	910,508	NA	NA	910,508
1940	168,435	419,690	3,300	591,425	1,184,851	NA	19,600	1,204,451
1941	126,417	333,605	6,000	466,022	471,513	NA	22,400	493,913
1942	86,150	375,037	5,100	466,287	533,920	NA	59,000	592,920
1943	105,319	317,092	15,200	437,611	549,592	NA	36,900	586,492
1944	104,921	300,909	10,700	416,530	689,175	NA	60,600	749,775
1945	91,229	325,102	9,900	426,231	238,212	NA	12,400	250,612
1946	84,802	308,190	13,000	405,992	419,600	NA	1,100	420,700
1947	66,040	351,964	7,400	425,404	519,480	NA	7,400	526,880
1948	73,899	306,782	13,200	393,881	1,062,913	NA	111,500	1,174,413
1949	86,747	374,200	13,100	474,047	771,604	NA	600	772,204
1950	73,485	280,464	6,400	360,349	763,314	NA	46,200	809,514
1951	80,580	347,886	7,200	435,666	387,866	NA	9,300	397,166
1952	76,919	372,190	23,100	472,209	712,666	NA	54,000	766,666
1953	104,038	367,959	15,600	487,597	438,285	NA	--	438,285
1954	104,638	417,906	7,700	530,244	314,474	NA	4,200	318,674
1955	52,969	385,497	6,700	445,166	591,516	NA	11,000	602,516
1956	54,768	319,318	5,000 2/	379,086	644,165	NA	15,700 2/	659,865
1957	81,551	369,944	-- 2/	451,495	664,353	NA	-- 2/	664,353
1958	59,654	435,236	--	494,890	1,767,496	NA	--	1,767,496
1959	47,305	260,602	--	307,907	1,252,860	NA	--	1,252,860
1960	49,090	288,672	--	337,762	1,649,031	NA	--	1,649,031
1961	58,376	290,393	--	348,769	2,160,260	NA	--	2,160,260
1962	60,254	308,361	--	368,615	2,660,669	NA	--	2,660,669
1963	74,299	444,451	--	518,750	2,029,785	NA	--	2,029,785

Appendix Table 12. (continued)

Year	Northern Pike				Tullibee			
	Minnesota	Ontario	Manitoba	Total	Minnesota	Ontario	Manitoba	Total
1964	76,066	529,228	--	605,294	2,203,501	NA	--	2,203,501
1965	59,926	378,703	--	438,629	843,684	NA	--	843,684
1966	64,028	381,809	--	445,837	921,827	NA	--	921,827
1967	33,846	425,230	--	459,076	862,810	NA	--	862,810
1968	51,480	312,433[1/]	--	363,913	1,224,334	226,773[1/]	--	1,451,107
1969	66,932	NA	--	66,932	1,139,707	NA	--	1,139,707
1970	57,816	NA	--	57,816	758,300	NA	--	758,300

1/ Preliminary
2/ Commercial Fishing Season Closed
NA -- Not Presently Available

Appendix Table 13. Commercial harvest of burbot and sucker from Lake of the Woods by state and province, 1930-1970

Year	Burbot				Sucker			
	Minnesota	Manitoba	Minnesota (winter)	Total	Minnesota	Ontario	Manitoba	Total
1930	NA	NA	--	--	125,102	NA	NA	125,102
1931	NA	NA	--	--	126,000	NA	NA	126,000
1932	45	NA	--	45	117,718	NA	NA	117,718
1933	63,974	NA	--	63,974	168,300	NA	NA	168,300
1934	91,344	NA	--	91,344	120,000	NA	NA	120,000
1935	175,480	NA	--	175,480	183,300	NA	NA	183,300
1936	178,649	NA	--	178,649	230,600	NA	NA	230,600
1937	70,965	NA	--	70,965	183,600	NA	NA	183,600
1938	20,602	NA	--	20,602	180,300	NA	NA	180,300
1939	46,746	NA	--	46,746	161,666	NA	NA	161,666
1940	42,037	NA	--	42,037	100,297	NA	NA	100,297
1941	49,082	NA	--	49,082	98,138	NA	8,600	106,738
1942	74,293	NA	--	74,293	118,814	NA	15,200	134,014
1943	51,154	NA	--	51,154	151,566	NA	12,000	163,566
1944	39,634	NA	--	39,634	106,033	NA	9,000	115,033
1945	113,057	NA	9,782	122,839	109,715	NA	6,900	116,615
1946	203,484	NA	NA	203,484	83,687	NA	6,400	90,087
1947	247,807	NA	NA	247,807	100,000	NA	4,800	104,800
1948	300,000	NA	239,985	539,985	68,800	NA	7,100	75,900
1949	458,829	NA	119,938	578,767	71,383	NA	9,300	80,683
1950	284,706	NA	152,285	436,991	84,709	NA	7,200	91,909
1951	357,783	NA	67,970	425,753	73,447	NA	11,600	85,047
1952	540,753	NA	NA	540,753	76,060	NA	9,700	85,760
1953	258,366	NA	37,927	296,293	95,582	NA	6,700	102,282
1954	269,454	14,500	183,236	467,190	66,776	NA	3,800	70,576
1955	272,157	11,000	177,554	460,711	63,661	NA	4,500	68,161
1956	293,320	15,700	203,022	512,042	38,152	NA	4,100	42,252
1957	223,690	-- 2/	340,544	564,234	33,298	NA	-- 2/	33,298
1958	280,493	--	75,531	356,024	117,652	NA	--	117,652
1959	344,191	--	305,901	650,092	58,568	NA	--	58,568
1960	381,915	--	373,191	755,106	69,787	NA	--	69,787
1961	397,514	--	485,047	882,561	200,011	NA	--	200,011
1962	399,745	--	368,085	767,830	167,715	NA	--	167,715

Appendix Table 13. (continued)

Year	Burbot				Sucker			
	Minnesota	Manitoba	Minnesota (winter)	Total	Minnesota	Ontario	Manitoba	Total
1963	179,804	--	391,871	571,675	247,813	NA	--	247,813
1964	188,637	--	405,945	594,582	230,479	NA	--	230,479
1965	149,519	--	201,378	351,859	282,427	NA	--	282,427
1966	62,474	--	223,056	285,530	195,814	NA	--	195,814
1967	230,374	--	236,914	467,288	185,650	NA	--	185,650
1968	150,025	--	215,600	365,625	106,332	NA	--	106,332
1969	230,656	--	22,860	253,516	65,195	NA	--	65,195
1970	141,202	--	NA	141,202	111,238	NA	--	111,238

2/ Commercial Fishing Season Closed
NA -- Not Presently Available

Appendix Table 14. Commercial harvest of perch and whitefish from Lake of the Woods by state and province, 1930-1970

Year	Perch				Whitefish			
	Minnesota	Ontario	Manitoba	Total	Minnesota	Ontario	Manitoba	Total
1930	54,721	NA	--	54,721	16,662	259,187	--	275,849
1931	55,883	NA	--	55,883	17,310	407,250	--	424,560
1932	36,698	NA	1,000	37,698	13,300	478,448	1,000	492,748
1933	40,000	NA	NA	40,000	7,100	410,232	NA	417,332
1934	43,700	NA	NA	43,700	9,800	336,782	1,800	348,382
1935	77,800	NA	2,000	79,800	6,400	338,251	1,000	345,651
1936	156,000	NA	1,000	157,000	3,800	266,963	1,000	271,763
1937	218,700	NA	NA	218,700	3,700	149,350	3,900	156,950
1938	53,600	NA	30,400	84,000	3,700	192,226	43,300	239,226
1939	50,179	NA	NA	50,179	3,789	255,808	4,800	264,397
1940	41,259	NA	19,200	60,459	3,532	220,745	5,800	230,077
1941	16,688	NA	5,000	21,688	3,218	270,011	--	273,229
1942	11,965	NA	11,100	23,065	1,625	323,339	300	325,264
1943	12,552	NA	4,800	17,352	3,109	222,858	300	226,267
1944	8,703	NA	NA	8,703	1,465	139,333	300	141,098
1945	6,456	NA	3,000	9,456	867	89,740	2,400	93,007
1946	17,508	NA	8,600	26,108	2,587	195,329	900	198,816
1947	27,517	NA	2,100	29,617	5,391	124,392	500	130,283
1948	24,498	NA	12,200	36,698	5,140	120,503	300	125,943
1949	21,720	NA	5,600	27,320	2,404	218,670	100	221,174
1950	14,770	NA	6,600	21,370	1,829	258,578	200	260,607
1951	11,595	NA	5,100	16,695	379	188,499	--	188,878
1952	21,624	NA	3,400	25,024	633	202,686	100	203,419
1953	26,148	NA	1,900	28,048	507	220,708	100	221,315
1954	12,792	NA	900	13,692	752	154,157	--	154,909
1955	20,055	NA	4,200	24,255	951	224,257	100	225,308
1956	19,775	NA	2,700 2/	22,475	220	239,649	--	239,869
1957	12,354	NA	-- 2/	12,354	1,935	196,474	-- 2/	198,409
1958	21,417	NA	--	21,417	326	146,057	--	146,383
1959	20,871	NA	--	20,871	576	88,101	--	88,677
1960	17,192	NA	--	17,192	117	149,778	--	149,895
1961	25,614	NA	--	25,614	17	62,937	--	62,954
1962	28,271	NA	--	28,271	93	82,266	--	82,359
1963	19,505	NA	--	19,505	11	74,480	--	74,491

Appendix Table 14. (continued)

Year	Perch				Whitefish			
	Minnesota	Ontario	Manitoba	Total	Minnesota	Ontario	Manitoba	Total
1964	11,554	NA	--	11,554	77	108,927	--	109,004
1965	8,414	NA	--	8,414	529	150,436	--	150,965
1966	22,762	NA	--	22,762	93	79,865	--	79,958
1967	28,069	NA	--	28,069	31	80,207	--	80,238
1968	36,053	NA	--	36,053	11	80,117 1/	--	80,128
1969	21,343	NA	--	21,343	37	NA	--	37
1970	12,703	NA	--	12,703	39	NA	--	39

1/ Preliminary
2/ Commercial Fishing Season Closed
NA -- Not Presently Available

Appendix Table 15. Commercial harvest of bullhead from Lake of the Woods by state and province, 1930-1970

Year	Bullhead			
	Minnesota	Ontario	Manitoba	Total
1930	23,956	NA	--	23,956
1931	12,299	NA	--	12,299
1932	9,412	NA	NA	9,412
1933	32,200	NA	NA	32,200
1934	46,000	NA	NA	46,000
1935	27,900	NA	NA	27,900
1936	60,700	NA	NA	60,700
1937	44,200	NA	NA	44,200
1938	41,300	NA	NA	41,300
1939	39,228	NA	NA	39,228
1940	20,843	NA	NA	20,843
1941	26,470	NA	1,200	27,670
1942	29,189	NA	NA	29,189
1943	40,176	NA	NA	40,176
1944	7,573	NA	500	8,073
1945	15,193	NA	NA	15,193
1946	34,704	NA	4,300	39,004
1947	13,801	NA	NA	13,801
1948	22,283	NA	NA	22,283
1949	28,913	NA	NA	28,913
1950	16,952	NA	NA	16,952
1951	63,660	NA	NA	63,660
1952	54,014	NA	NA	54,014
1953	58,859	NA	NA	58,859
1954	18,421	NA	NA	18,421
1955	8,272	NA	NA	8,272
1956	5,384	NA	NA	5,384
1957	4,665	NA	--[2/]	4,665
1958	7,254	NA	--	7,254
1959	6,772	NA	--	6,772
1960	12,931	NA	--	12,931
1961	14,436	NA	--	14,436
1962	3,033	NA	--	3,033
1963	12,384	NA	--	12,384
1964	1,714	NA	--	1,714
1965	2,302	NA	--	2,302
1966	4,657	NA	--	4,657
1967	2,316	NA	--	2.316
1968	655	NA	--	32,655
1969	225	NA	--	225
1970	352	NA	--	352

2/ Commercial Fishing Season Closed
NA - Not Presently Available

Appendix Table 16. Average catch of various species by 5-year periods from Ontario waters of Lake of the Woods, 1895-1967 - expressed in thousands of pounds and as percentage of total catch

Year	All Species	Lake Sturgeon	Lake Whitefish	Northern Pike	Walleye	Lake Trout	Other
1895-99	1,240.9	466.6	397.1	48.3	212.0	29.1	88.3
1900-04	500.6	44.2	138.1	42.6	108.0	18.6	149.0
1905-09	647.5	63.4	283.5	92.9	144.8	13.4	49.4
1910-14	1,618.7	87.3	580.4	302.6	404.3	19.5	224.7
1915-19	1,742.4	19.1	295.3	459.8	501.1	62.7	404.4
1920-24	1,125.6	.9	261.8	233.8	445.1	10.6	173.4
1925-29	1,656.5	.8	206.7	460.9	593.3	18.6	380.2
1930-34	1,684.0	.4	378.4	429.8	692.2	22.2	160.9
1935-39	1,637.2	.1	240.5	419.0	696.1	13.8	267.6
1940-44	1,561.6	0	235.3	349.3	642.4	11.6	323.7
1945-49	1,405.2	tr	149.7	333.2	607.9	1.6	308.6
1950-54	1,566.2	.1	204.9	357.3	552.9	6.6	444.5
1955-59	1,802.8	tr	178.9	354.1	541.2	3.8	688.2
1960-64	2,378.4	.2	95.7	372.2	785.7	3.3	1,106.4
1965-67	2,042.5	.5	103.5	395.2	528.7	3.9	1,010.7
1895-99	100.0	37.6	32.0	3.9	17.1	2.3	7.1
1900-04	100.0	8.8	27.6	8.5	21.6	3.7	29.8
1905-09	100.0	9.8	43.8	14.3	22.4	2.1	7.6
1910-14	100.0	5.4	35.8	18.7	25.0	1.2	13.9
1915-19	100.0	1.1	16.9	26.4	28.8	3.6	23.2
1920-24	100.0	.1	23.3	20.8	39.5	.9	15.4
1925-29	100.0	tr	12.4	27.8	35.8	1.1	22.9
1930-34	100.0	tr	22.5	25.5	41.1	1.3	9.6
1935-39	100.0	tr	14.7	25.6	42.5	.8	16.4
1940-44	100.0	0	15.1	22.4	41.1	.7	20.7
1945-49	100.0	tr	10.7	23.8	43.3	.2	22.0
1950-54	100.0	tr	13.1	22.8	35.3	.4	28.4
1955-59	97.9	tr	9.9	19.6	30.0	.2	38.2
1960-64	99.2	tr	4.0	15.6	33.0	.1	46.5
1965-67	100.0	tr	5.1	19.3	25.9	.2	49.5

Appendix Table 17. Average catch of various species by 5-year periods from Minnesota waters of Lake of the Woods, 1888-1969 - expressed in thousands of pounds and as percentage of total catch

Year	All Species 2/	lake Sturgeon 2/	Lake Whitefish 2/	Northern Pike 2/	Walleye 2/	Yellow Perch 2/
1888-89	180	76	40	20	50	--
1890-94	1,461	830	257	136	285	--
1895-99	1,101	682	169	70	226	--
1900-04	393	93	101	48	155	--
1905-09	548	63	150	122	210	--
1910-14	1,315	370	102	312	440	1
1915-19	1,516	12	72	329	425	5
1920-24	1,148	3	33	277	502	8
1925-29	1,678	1	21	209	589	16
1930-34	2,107	1	13	231	782	46
1935-39	1,988	--	4	178	640	111
1940-44	1,538	--	3	118	455	18
1945-49	1,500	1/	3	81	347	20
1950-54	1,601	"	.8	88	357	17
1955-59	1,914	"	.8	59	215	19
1960-64	3,501	"	.1	64	272	20
1965-69	1,772	"	.1	55	155	23
1888-89	100.0	40.9	21.5	10.7	26.9	--
1890-94	100.0	55.0	17.1	9.0	18.9	--
1895-99	100.0	59.5	14.7	6.1	19.7	--
1900-04	100.0	23.4	25.4	12.1	39.1	--
1905-09	100.0	11.5	27.4	22.3	38.3	--
1910-14	100.0	28.1	7.8	23.7	33.5	.1
1915-19	100.0	.8	4.8	21.7	28.0	.3
1920-24	100.0	.3	2.9	24.1	43.7	.7
1925-29	100.0	.1	1.2	12.5	35.1	1.0
1930-34	100.0	tr	.6	11.0	37.1	2.2
1935-39	100.0	--	.2	8.9	32.2	5.6
1940-44	100.0	--	.2	7.7	29.6	1.2
1945-49	100.0	--	.2	5.4	23.1	1.4
1950-54	100.0	--	.1	5.5	22.3	1.1
1955-59	100.0	--	tr	3.1	11.2	1.0
1960-64	100.0	--	tr	1.8	7.8	.6
1965-69	100.0	--	tr	3.1	8.8	1.3

1/ Commercial harvest prohibited.

Appendix Table 17. (continued)

Year	Sauger[2/]	Tullibee	Burbot	White Sucker	Other	Bullhead
1888-89	--	--	--	--	(-6)	--
1890-94	--	--	--	--	(-47)	--
1895-99	--	--	--	--	(-46)	--
1900-04	--	--	--	--	(-4)	--
1905-09	--	--	--	--	3	--
1910-14	--	--	--	--	90	--
1915-19	--	--	--	--	673	--
1920-24	--	--	--	--	325	--
1925-29	46	541	--	112	143	--
1930-34[1/]	207	617	31	131	23	25
1935-39	262	449	98	188	15	43
1940-44	60	686	51	115	5	27
1945-49	68	602	265	87	4	23
1950-54	71	523	386	79	37	42
1955-59	63	984	503	62	1	7
1960-64	94	2,141	714	180	7	9
1965-69	25	998	345	167	2	2
1888-89	--	--	--	--	--	--
1890-94	--	--	--	--	--	--
1895-99	--	--	--	--	--	--
1900-04	--	--	--	--	--	--
1905-09	--	---	--	--	.5	--
1910-14	--	--	--	--	6.8	--
1915-19	--	--	--	--	44.4	--
1920-24	--	--	--	--	28.3	--
1925-29	2.7	32.2	--	6.7	8.5	--
1930-34	9.8	29.3	1.5	6.2	1.1	1.2
1935-39	13.2	22.6	4.9	9.5	.7	2.2
1940-44	3.9	44.6	3.3	7.5	.3	1.7
1945-49	4.5	40.1	17.7	5.8	.3	1.5
1950-54	4.4	32.7	24.1	4.9	2.3	2.6
1955-59	3.3	51.4	26.3	3.2	.1	.4
1960-64	2.7	61.2	20.4	5.1	.2	.2
1965-69	1.4	56.3	19.5	9.4	.1	.1

1/ Commercial harvest prohibited.
2/ Data for 1888-1934 from Carlander (1942).

Appendix Table 18. Total fish gear and fishing effort in American waters of Lake of the Woods, 1932-1970

Year	Number of Fishermen	Gill Nets		Pound Nets		Trap Nets	
		Ft. Licensed	Ft. Lifted	Nets Licensed	Nets Lifted	Nets Licensed	Nets Lifted
1932	NA	88,000	NA	60	NA	NA	NA
1933	NA	90,000	NA	60	NA	NA	NA
1934	NA	87,000	NA	60	NA	NA	NA
1935	NA	89,000	NA	60	NA	NA	NA
1936	NA	85,500	NA	60	NA	NA	NA
1937	NA	88,500	NA	60	NA	NA	NA
1938	NA	90,000	NA	60	NA	NA	NA
1939	NA	85,000	NA	60	NA	NA	NA
1940	NA	89,000	NA	56	NA	NA	NA
1941	NA	88,000	NA	59	NA	NA	NA
1942	44	80,500	NA	50	NA	NA	NA
1943	--	90,000	NA	40	NA	NA	NA
1944	40	86,500	NA	63	NA	NA	NA
1945	38	86,000	NA	50	NA	NA	NA
1946	42	86,000	NA	61	NA	NA	NA
1947	41	80,500	NA	63	NA	NA	NA
1948	39	77,500	NA	30	NA	20	NA
1949	41	80,500	8,268,000	32	2,215	20	2,010
1950	43	74,500	7.272,500	36	2,090	20	2,459
1951	37	65,500	8,055,500	24	2,056	20	2,432
1952	37	70,000	8,168,400	17	1,103	20	2,346
1953	38	70,000	8,875,000	18	1,218	20	2,678
1954	37	70,000	8,560,400	21	1,071	20	1,970
1955	35	67,500	7,913,000	18	1,468	20	1,677
1956	33	67,500	8,924,000	12	252	20	1,897
1957	30	67,500	5,279,000	6	198	20	1,225
1958	31	68,500	6,637,000	12	874	23	2,498
1959	30	66,000	7,123,000	12	390	23	1,673
1960	30	69,000	7,700,000	12	398	23	1,938
1961	31	69,000	7,701,000	6	248	38	2,153
1962	28	66,000	6,086,000	6	91	28	2,133
1963	28	60,000	7,325,000	-	--	23	1,785
1964	27	57,000	5,407,000	3	17	20	1,469

Appendix Table 18. (continued)

Year	Number of Fishermen	Gill Nets		Pound Nets		Trap Nets	
		Ft. Licensed	Ft. Lifted	Nets Licensed	Nets Lifted	Nets Licensed	Nets Lifted
1965	29	63,000	5,550,000	3	796	38	1,460
1966	29	64,000	5,825,000	5	154	38	2,017
1967	28	60,000	5,985,000	4	23	38	2,436
1968	24	54,000	4,992,000	6	198	29	1,584
1969	22	51,000	3,946,500	20	1,178	0	--
1970	19	45,000	4,698,500	12	1,065	-	--

Appendix Table 18. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls	
	Nets Licensed	Nets Lifted	Nets Licensed	Nets Lifted	Trawls Licensed	Hrs. Trawled
1932	89	NA				
1933	95	NA				
1934	90	NA				
1935	89	NA				
1936	83	NA				
1937	96	NA				
1938	90	NA				
1939	89	NA				
1940	90	NA				
1941	89	NA				
1942	66	NA				
1943	70	NA				
1944	54	NA				
1945	20	NA				
1946	18	NA				
1947	24	NA				
1948	32	NA				
1949	45	1,159				
1950	53	769				
1951	60	2,484				
1952	60	1,604	2	59		
1953	59	2,143				
1954	60	1,793				
1955	60	878	3	20		
1956	43	696	3	70		
1957	23	241	3			
1958	16	579	1			
1959	15	134				
1960	10	207				
1961	18	414			Permit-2	583.6
1962	13	194			Permit-2	1,302.4
1963	25	1,077			2	1,312.4
1964	23	12			2	1,468.0

Appendix Table 18. (continued)

Year	Fyke Nets		Sub-Trap Nets		Trawls	
	Nets Licensed	Nets Lifted	Nets Licensed	Nets Lifted	Trawls Licensed	Hrs. Trawled
1965	30	1,101				
1966	33	1,228				
1967	23	736				
1968	20	508			Permit-1	218.1
1969	10	--			Permit-1	153.6
1970	20	25			Permit-1	136.3

NA -- Not Presently Available

Appendix Table 19. Monthly catch of walleye from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	109,896	43,009	100,103	99,055	47,786	19,305	--	419,154
1950	126,831	56,757	56,630	55,465	47,618	10,370	--	353,671
1951	55,003	43,162	52,608	61,160	43,842	1,906	--	257,681
1952	46,089	40,725	94,435	116,743	56,710	11,361	424	366,487
1953	107,481	82,572	93,246	93,711	91,948	11,877	--	480,835
1954	80,085	54,453	80,489	65,113	40,556	5,611	--	326,307
1955	32,963	33,674	68,037	56,688	36,749	5,378	150	233,639
1956	44,776	22,758	59,442	61,990	51,750	4,756	--	245,472
1957	31,465	24,431	36,630	66,092	40,164	5,444	305	204,531
1958	25,593	16,639	40,328	51,708	30,108	5,902	--	170,278
1959	32,291	23,381	44,151	66,099	52,576	1,657	190	220,345
1960	62,388	26,280	59,502	147,633	124,793	8,992	214	429,802
1961	56,244	39,851	65,182	100,246	55,471	1,272	--	318,266
1962	34,236	15,784	31,543	38,486	32,156	3,500	17	155,722
1963	11,422	15,932	29,920	73,503	66,735	27,418	2	224,932
1964	10,691	15,513	48,868	64,715	64,319	12,924	--	217,030
1965	15,768	13,306	24,471	53,972	28,921	4,450	--	140,888
1966	18,162	20,485	61,481	117,624	83,887	3,402	177	305,218
1967	20,701	20,317	29,129	42,064	25,969	--	--	138,180
1968	13,075	7,271	20,992	30,818	33,266	--	--	105,422
1969	9,354	6,516	16,207	23,800	21,512	1,697	--	79,086
1970	18,617	11,590	19,685	25,184	23,038	2,671	--	100,785

1/ Catch by trawl in 1961, 1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 20. Monthly catch of sauger from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	21,118	20,492	36,187	15,366	14,697	9,020	--	116,880
1950	35,111	25,039	14,079	15,842	11,232	6,422	--	107,725
1951	36,058	13,498	10,428	6,221	7,327	380	--	73,912
1952	9,698	6,919	8,337	9,058	6,912	1,326	--	42,250
1953	27,049	11,819	10,940	9,129	5,583	1,815	--	66,335
1954	17,012	13,439	11,140	9,120	10,986	1,897	--	63,594
1955	18,034	12,715	11,177	13,375	11,098	2,753	27	69,179
1956	42,020	15,178	22,332	16,427	11,172	2,450	--	109,579
1957	20,342	10,096	9,624	11,096	10,169	2,258	13	63,598
1958	13,400	5,894	6,293	5,849	5,433	1,046	--	37,915
1959	12,060	5,566	5,167	6,854	6,555	295	70	36,567
1960	19,124	8,264	10,940	13,252	7,319	1,021	9	59,929
1961	34,291	11,240	11,195	21,757	15,005	1,628	--	95,116
1962	30,980	15,356	13,947	12,819	11,244	2,984	65	87,395
1963	16,072	16,123	15,879	15,244	13,624	7,410	4	84,356
1964	8,844	12,228	12,134	13,006	18,438	3,842	--	68,492
1965	7,777	6,876	7,061	8,868	10,327	1,917	--	42,826
1966	11,957	4,760	3,900	3,212	2,815	532	110	27,286
1967	5,799	4,365	4,431	5,497	5,553	--	--	25,645
1968	5,707	3,510	2,763	1,998	1,859	--	--	15,837
1969	2,937	2,495	2,718	2,330	1,765	157	--	12,402
1970	4.165	3,735	4,235	2,749	1,777	295	--	16,956

1/ Catch by trawl in 1961, 1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 21. Monthly catch of northern pike from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	18,966	18,187	5,458	17,971	17,690	8,475	--	86,747
1950	9,679	5,618	6,379	21,849	23,016	6,944	--	73,485
1951	21,174	7,647	8,641	17,851	23,172	2,095	--	80,580
1952	10,505	6,649	8,768	18,666	27,142	4,598	591	76,919
1953	27,748	9,488	12,773	21,567	25,435	7,027	--	104,038
1954	20,529	29,606	8,434	22,387	19,175	4,307	--	104,438
1955	7,777	3,351	3,932	13,081	19,735	4,910	183	52,969
1956	9,336	2,894	5,486	15,305	19,472	2,275	--	54,768
1957	11,683	5,965	4,293	34,925	20,203	3,850	632	81,551
1958	14,128	5,783	6,424	10,671	14,358	8,290	--	59,654
1959	9,828	2,915	2,835	11,014	18,773	1,862	78	47,305
1960	6,346	1,843	1,271	14,513	21,657	3,253	207	49,090
1961	9,211	6,807	4,698	19,970	16,133	1,265	--	58,084
1962	8,879	4,419	4,959	16,034	21,901	3,707	7	59,906
1963	7,274	2,725	4,702	17,668	25,089	16,800	41	74,299
1964	10,088	5,559	7,308	14,801	29,244	9,066	--	76,066
1965	6,891	4,362	4,795	21,482	18,711	3,685	--	59,926
1966	9,349	4,335	7,207	15,910	23,857	2,412	958	64,028
1967	5,032	3,365	3,822	9,234	12,393	--	--	33,846
1968	7,850	3,425	7,059	11,331	21,570	--	--	51,235
1969	6,116	4,505	2,790	13,331	35,086	5,001	--	66,829
1970	8,746	4,399	2,342	14,503	22,474	5,228	--	57,692

1/ Catch by trawl in 1961, 1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 22. Monthly catch of tullibee from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	62,947	281,517	164,558	29,008	22,177	211,397	--	771,604
1950	29,397	191,943	238,433	76,965	46,203	180,373	--	763,314
1951	30,604	167,721	121,075	30,815	20,787	16,864	--	387,866
1952	14,803	280,296	153,447	61,320	138,131	64,669	--	712,666
1953	25,823	101,958	87,372	73,002	43,006	107,124	--	438,285
1954	8,247	82,845	65,368	21,090	48,537	88,387	--	314,474
1955	90,443	251,201	76,248	47,935	61,894	62,321	1,474	591,516
1956	67,088	237,311	142,189	54,184	55,208	88,185	--	644,165
1957	36,473	109,970	102,061	132,087	156,244	127,518	--	664,353
1958	199,251	331,347	275,271	255,835	369,379	336,312	--	1,767,395
1959	105,821	371,175	232,968	218,537	286,235	38,180	45	1,252,961
1960	159,283	480,543	431,943	296,108	183,808	97,265	81	1,649,031
1961	133,954	470,875	533,098	259,526	171,355	43,281	--	1,612,089
1962	163,322	460,719	450,288	289,740	195,300	182,571	625	1,742,565
1963	104,970	683,366	559,222	332,277	238,579	111,371	--	2,029,785
1964	139,533	692,045	436,465	257,185	358,125	320,148	--	2,203,501
1965	61,064	161,656	122,175	122,723	210,128	165,938	--	843,684
1966	125,017	270,727	219,099	148,818	143,828	13,988	350	921,827
1967	80,122	299,959	160,673	168,746	153,310	--	--	862,810
1968	179,132	305,245	215,168	100,494	288,701	--	--	1,088,740
1969	110,813	320,078	203,418	183,947	120,765	100,013	--	1,039,034
1970	64,251	240,422	181,788	84,170	67,005	49,805	--	687,441

1/ Catch by trawl in 1961, 1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 23. Monthly catch of perch from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	4,325	5,519	4,867	4,754	1,511	744	--	21,720
1950	5,705	2,941	2,125	2,188	1,445	366	--	14,770
1951	2,748	3,064	1,670	2,192	1,812	101	8	11,595
1952	4,140	4,321	4,941	5,765	2,125	266	66	21,624
1953	7,059	4,430	6,587	4,750	2,785	537	--	26,148
1954	3,479	2,896	2,017	2,601	1,608	191	--	12,792
1955	4,163	2,679	4,250	5,905	2,645	412	1	20,055
1956	4,455	2,932	5,165	4,289	2,722	222	--	19,775
1957	2,581	3,570	2,198	3,015	863	60	67	12,354
1958	5,860	4,884	5,332	3,750	1,308	283	--	21,417
1959	3,611	2,775	5,113	5,357	3,969	34	12	20,871
1960	4,227	3,143	2,837	4,477	2,382	122	4	17,192
1961	7,258	2,858	2,447	4,873	2,357	139	--	19,932
1962	3,469	2,533	3,070	3,499	2,483	356	3	15,413
1963	1,880	2,053	2,758	5,301	5,621	1,867	25	19,505
1964	1,458	1,993	1,177	2,660	3,520	746	--	11,554
1965	949	1,376	1,229	2,123	2,187	550	--	8,414
1966	6,034	3,994	4,082	4,692	3,512	327	121	22,762
1967	3,628	5,506	6,613	6,470	5,856	--	--	28,073
1968	8,125	7,209	9,938	5,804	4,281	--	--	35,357
1969	3,947	5,737	3,678	4,676	2,902	258	--	21,198
1970	3,435	1,901	588	2,282	2,865	1,072	--	12,143

1/ Catch by trawl in 1961,1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 24. Monthly catch of burbot from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	4,631	3,636	1,831	49,554	210,400	188,777	--	458,829
1950	11,808	13,233	6,870	24,385	176,009	52,401	--	284,706
1951	35,821	16,891	16,518	66,084	213,791	8,493	185	357,783
1952	12,157	9,489	13,032	54,556	382,964	51,555	17,000	540,753
1953	19,385	9,511	6,903	36,521	66,136	119,910	--	258,366
1954	17,339	12,337	18,368	40,762	167,773	12,875	--	269,454
1955	16,975	10,640	5,472	12,809	174,627	47,839	3,795	272,157
1956	22,320	7,617	9,426	26,532	154,717	72,708	--	293,320
1957	5,713	2,625	7,139	23,288	109,054	75,871	--	223,690
1958	15,573	11,231	16,627	80,589	126,556	29,917	--	280,493
1959	9,436	5,394	5,869	112,288	185,178	25,942	84	344,191
1960	10,813	4,897	5,431	64,214	213,998	77,335	5,227	381,915
1961	19,038	5,742	7,936	72,131	231,574	26,013	--	362,434
1962	8,886	7,406	6,321	30,770	157,230	86,948	153	297,714
1963	16,673	12,292	14,640	15,824	60,915	58,570	890	179,804
1964	12,219	15,505	11,968	25,207	104,619	19,119	--	188,637
1965	2,807	1,761	1,015	35,104	90,654	18,178	--	149,519
1966	6,692	3,476	3,986	1,259	38,821	7,353	887	62,474
1967	14,237	6,613	4,120	22,331	183,073	--	--	230,374
1968	9,096	3,621	5,944	13,531	108,078	--	--	140,270
1969	6,316	4,417	1,691	9,167	161,147	40,113	--	222,851
1970	10,948	5,182	1,881	23,336	73,529	20,145	--	135,021

1/ Catch by trawl in 1961, 1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 25. Monthly catch of white sucker from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	18,858	11,073	11,816	21,772	6,159	1,705	--	71,383
1950	27,136	13,578	17,748	18,613	6,810	824	--	84,709
1951	19,182	14,919	15,816	14,740	8,214	576	--	73,447
1952	22,979	14,469	17,000	13,278	7,431	903	--	76,060
1953	28,356	17,792	18,618	17,741	10,397	2,678	--	95,582
1954	14,313	17,716	11,699	13,619	7,957	1,472	--	66,776
1955	14,569	8,140	7,203	15,191	8,841	9,638	79	63,661
1956	12,606	5,905	6,267	8,002	4,891	481	--	38,152
1957	7,687	4,443	7,810	8,633	4,225	469	31	33,298
1958	28,149	19,754	24,676	24,210	18,570	2,293	--	117,652
1959	12,087	13,486	14,744	11,570	6,097	554	30	58,568
1960	16,913	11,306	12,312	19,210	9,400	646	--	69,787
1961	33,126	108,504	26,577	18,084	6,459	418	--	193,168
1962	22,196	37,719	40,299	37,398	19,304	2,318	81	159,315
1963	51,680	50,185	47,870	55,678	35,942	6,434	24	247,813
1964	31,625	43,826	47,525	47,532	43,441	16,530	--	230,479
1965	60,796	60,772	33,802	66,009	50,573	10,475	--	282,427
1966	27,378	39,976	48,437	39,729	39,373	841	80	195,814
1967	39,515	41,964	48,574	33,532	22,065	--	--	185,650
1968	24,769	19,243	26,088	21,514	13,320	--	--	104,934
1969	11,701	12,363	16,108	14,782	8,744	1,070	--	64,768
1970	23,125	20,511	13,815	26,120	22,884	4,052	--	110,507

1/ Catch by trawl in 1961,1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 26. Monthly catch of bullhead from Minnesota waters of Lake of the Woods, 1949-1970 1/

Year	June	July	August	September	October	November	December	Total
1949	3,808	4,913	4,708	12,710	2,769	5	--	28,913
1950	390	1,322	6,280	5,906	2,985	69	--	16,952
1951	10,293	11,045	17,399	14,824	9,930	0	169	63,660
1952	12,022	9,854	10,710	14,830	6,596	2	--	54,014
1953	10,563	10,960	8,351	15,322	13,337	326	--	58,859
1954	4,188	3,075	4,009	4,096	3,050	3	--	18,421
1955	1,644	2,309	2,066	1,890	334	29	--	8,272
1956	476	390	1,993	1,721	804	0	--	5,384
1957	418	348	303	1,481	2,031	84	--	4,665
1958	1,828	1,662	946	2,390	426	2	--	7,254
1959	1,071	308	274	3,299	1,780	0	--	6,732
1960	2,664	938	142	5,241	3,925	21	--	12,931
1961	2,929	844	5,354	4,003	1,300	6	--	14,436
1962	509	39	268	1,455	735	27	--	3,033
1963	2,558	218	957	4,148	2,135	158	2,210	12,384
1964	243	64	686	252	450	19	--	1,714
1965	613	230	271	567	582	39	--	2,302
1966	480	413	542	983	2,234	5	--	4,657
1967	375	15	77	1,233	616	--	--	2,316
1968	136	27	85	266	141	--	--	655
1969	99	3	3	74	45	1	--	225
1970	174	3	3	130	42	0	--	352

1/ Catch by trawl in 1961, 1962, 1968, 1969, and 1970 by permit not included.

Appendix Table 27. Average value by 5-year periods of commercial catch from Minnesota waters of Lake of the Woods, 1898-1969 - expressed as dollars and percentage of total

Year	All Species	Lake Sturgeon	Lake Whitefish	Northern Pike	Walleye	Yellow Perch
1888-89	4,500	1,462	400	200	500	NA
1890-94	37,442	26,611	3,994	1,362	3,955	NA
1895-99	44,155	35,565	3,377	701	4,512	NA
1900-04	16,414	8,131	2,523	713	3,875	NA
1905-09	26,157	6,230	5,384	2,437	7,441	NA
1910-14	NA	NA	NA	NA	NA	NA
1915-19	NA	NA	NA	NA	NA	NA
1920-24	NA	NA	NA	NA	NA	NA
1925-29	140,764	352	2,484	11,122	85,870	1,628
1930-34	111,467	201	1,060	8,493	75,090	2,638
1935-39	106,498	59	396	7,018	55,179	6,020
1940-44	136,375	26 1/	383	6,348	62,042	1,809
1945-49	155,691	-- 1/	626	6,832	74,954	3,123
1950-54	137,971	--	445	7,120	70,210	2,006
1955-59	90,797	--	240	4,642	40,838	1,678
1960-64	157,900	--	12	3,853	54,538	1,673
1965-69	102,726	--	NA	3,263	47,815	1,870
1888-89	100.00	32.49	8.89	4.44	11.11	NA
1890-94	100.00	71.07	10.67	3.64	10.56	NA
1895-99	100.00	80.54	7.65	1.59	10.22	NA
1900-04	100.00	49.54	15.37	4.34	23.61	NA
1905-09	100.00	23.82	20.58	9.32	28.45	NA
1910-14	NA	NA	NA	NA	NA	NA
1915-19	NA	NA	NA	NA	NA	NA
1920-24	NA	NA	NA	NA	NA	NA
1925-29	99.99	.25	1.76	7.90	61.00	1.16
1930-34	99.99	.18	.95	7.62	67.36	2.37
1935-39	100.00	.06	.37	6.59	51.81	5.65
1940-44	99.99	.02 1/	.28	4.65	45.49	1.33
1945-49	99.98	-- 1/	.40	4.39	48.14	2.00
1950-54	100.00	--	.32	5.16	50.89	1.45
1955-59	99.99	--	.26	5.11	44.98	1.85
1960-64	100.00	--	.01	2.44	34.54	1.06
1965-69	100.00	--	tr	3.18	46.55	1.82

Year	Sauger	Tullibee	Burbot	White Sucker	Other	Bullhead
1888-89	NA	NA	NA	NA	1,938	NA
1890-94	NA	NA	NA	NA	1,520	NA
1895-99	NA	NA	NA	NA	--	NA
1900-04	NA	NA	NA	NA	1,172	NA
1905-09	NA	NA	NA	NA	4,665	NA
1910-14	NA	NA	NA	NA	NA	NA
1915-19	NA	NA	NA	NA	NA	NA
1920-24	NA	NA	NA	NA	NA	NA
1925-29	3,452	31,151	NA	NA	4,705	NA
1930-34	8,999	7,039	NA	NA	7,947	NA
1935-39	11,606	14,834	NA	NA	11,386	NA
1940-44	4,505	52,919	626	3,145	1,242	3,330
1945-49	8,948	48,384	4,988	3,417	520	3,899
1950-54	7,258	32,260	9,850	1,649	30	7,143
1955-59	5,668	23,612	12,319	1,094	8	698
1960-64	9,671	63,513	20,364	3,540	43	693
1965-69	3,521	32,314	10,481	3,332	4	126
1888-89	NA	NA	NA	NA	43.07	NA
1890-94	NA	NA	NA	NA	4.06	NA
1895-99	NA	NA	NA	NA		NA
1900-04	NA	NA	NA	NA	7.14	NA
1905-09	NA	NA	NA	NA	17.83	NA
1910-14	NA	NA	NA	NA	NA	NA
1915-19	NA	NA	NA	NA	NA	NA
1920-24	NA	NA	NA	NA	NA	NA
1925-29	2.45	22.13	NA	NA	3.34	NA
1930-34	8.07	6.31	NA	NA	7.13	NA
1935-39	10.90	13.93	NA	NA	10.69	NA
1940-44	3.30	38.80	.46	2.31	.91	2.44
1945-49	5.75	31.08	3.20	2.19	.33	2.50
1950-54	5.26	23.38	7.14	1.20	.02	5.18
1955-59	6.24	26.00	13.57	1.20	.01	.77
1960-64	6.12	40.22	12.90	2.24	.03	.44
1965-69	3.43	31.46	10.20	3.24	tr	.12

1/ Commercial Fishing Season Closed
NA -- Not Presently Available

Appendix Table 28. Value (dollars) of catch by species of commercial fisheries in Minnesota waters of Lake of the Woods, 1888-1969

Year	All Species	Lake Sturgeon	Lake Whitefish	Northern Pike	Walleye	Yellow Perch
1888	2,375	860	200	100	250	NA
1889	6,625	2,063	600	300	750	NA
1890	7,050	4,130	1,000	500	1,200	NA
1891	19,200	8,825	1,750	850	2,000	NA
1892	37,481	27,300	3,750	1,150	4,500	NA
1893	61,750	51,330	5,250	2,000	6,000	NA
1894	58,898	41,468	8,220	2,311	6,076	NA
1895	59,437	53,319	5,611	1,258	9,475	NA
1896	46,600	47,666	4,000	800	6,000	NA
1897	25,136	32,482	1,438	482	2,749	NA
1898	23,777	27,776	2,252	566	1,843	NA
1899	21,771	16,583	3,584	399	2,494	NA
1900	14,465	9,416	2,115	600	2,500	NA
1901	16,825	9,416	2,875	750	3,250	NA
1902	19,700	11,015	3,250	900	3,750	NA
1903	15,969	4,037	2,751	644	5,627	NA
1904	14,945	6,773	1,625	670	4,250	NA
1905	14,553	5,366	1,639	658	4,336	NA
1906	11,696	2,688	1,951	1,331	3,230	NA
1907	32,017	8,817	9,048	1,922	6,757	NA
1908	44,467	9,620	7,251	4,939	14,113	NA
1909	28,051	4,661	7,031	3,333	8,771	NA
1910-1924	NA	NA	NA	NA	NA	NA
1925	NA	NA	NA	NA	NA	NA
1926	165,415	613	3,282	8,493	82,842	1,679
1927	149,869	382	2,096	12,254	88,383	969
1928	109,081	145	2,748	10,803	81,382	1,319
1929	137,502	269	1,810	12,937	90,871	2,547
1930	128,843	269	1,017	12,902	75,718	2,736
1931	136,086	345	1,681	5,909	101,739	4,470
1932	110,209	NA	NA	NA	50,043	

Appendix Table 28. (continued)

Year	All Species	Lake Sturgeon	Lake Whitefish	Northern Pike	Walleye	Yellow Perch
1933	79,989	160	970	7,643	52,795	1,600
1934	100,949	232	574	7,518	70,106	1,748
1935	125,788	175	105	7,469	88,334	3,112
1936	120,378	91	719	6,925	69,961	9,360
1937	104,288	--	432	5,882	51,763	13,122
1938	108,861	--	368	10,411	35,336	2,680
1939	73,177	28	355	4,403	30,500	1,826
1940	116,340	130	351	5,074	45,463	2,870
1941	150,545	--[1/]	400	7,264	82,380	1,913
1942	123,763	--	263	4,189	59,683	1,123
1943	163,134	--	616	8,392	68,377	2,147
1944	128,095	--	284	6,822	54,308	991
1945	159,251	--	285	9,169	98,676	1,233
1946	133,851	--	568	7,245	74,089	2,759
1947	125,559	--	984	4,963	58,521	4,742
1948	204,564	--	932	6,711	63,844	4,062
1949	155,230	--	360	6,070	79,640	2,820
1950	148,040	--	415	6,730	69,030	2,080
1951	151,088	--	95	7,250	64,420	2,200
1952	147,006	--	1,300	5,400	73,300	2,200
1953	128,942	--	115	6,800	79,000	2,500
1954	114,781	--	300	9,420	65,300	1,050
1955	90,843	--	200	3,900	37,400	1,500
1956	94,453	--	30	5,000	36,800	1,500
1957	84,422	--	800	6,200	35,300	900
1958	74,971	--	50	4,800	39,600	2,400
1959	109,297	--	120	3,310	55,090	2,090
1960	182,646	--	20	3,450	94,500	1,200
1961	176,342	--	--	4,600	57,287	2,561
1962	156,120	--	20	3,615	33,503	2,205
1963	132,928	--	1	4,600	44,000	1,500

Appendix Table 28. (continued)

Year	All Species	Lake Sturgeon	Lake Whitefish	Northern Pike	Yellow Walleye	Yellow Perch
1964	141,463		20	3,000	43,400	900
1965	100,495			2,900	42,300	1,100
1966	161,300			4,800	109,800	2,500
1967	80,745			2,000	31,800	2,200
1968	85,490			2,612	26,881	1,836
1969	85,598			4,003	28,295	1,712

Appendix Table 28. (continued)

Year	Sauger	Tullibee	Burbot	White Sucker	Other	Bullhead
1888	NA	NA	NA	NA	965	NA
1889	NA	NA	NA	NA	2,912	NA
1890	NA	NA	NA	NA	220	NA
1891	NA	NA	NA	NA	5,775	NA
1892	NA	NA	NA	NA	781	NA
1893	NA	NA	NA	NA	NA	NA
1894	NA	NA	NA	NA	823	NA
1895	NA	NA	NA	NA	NA	NA
1896	NA	NA	NA	NA	NA	NA
1897	NA	NA	NA	NA	NA	NA
1898	NA	NA	NA	NA	NA	NA
1899	NA	NA	NA	NA	NA	NA
1900	NA	NA	NA	NA	NA	NA
1901	NA	NA	NA	NA	534	NA
1902	NA	NA	NA	NA	785	NA
1903	NA	NA	NA	NA	2,910	NA
1904	NA	NA	NA	NA	1,627	NA
1905	NA	NA	NA	NA	2,554	NA
1906	NA	NA	NA	NA	2,496	NA
1907	NA	NA	NA	NA	5,473	NA
1908	NA	NA	NA	NA	8,544	NA
1909	NA	NA	NA	NA	4,255	NA
1910-1924	NA	NA	NA	NA	NA	NA
1925	NA	NA	NA	NA	NA	NA
1926	3,713	54,183	NA	NA	10,610	NA
1927	4,151	NA	NA	NA	NA	NA
1928	2,675	11,197	NA	NA	NA	NA
1929	3,271	23,200	NA	NA	2,597	NA
1930	4,060	22,605	NA	NA	9,536	NA
1931	10,933	4,352	NA	NA	6,657	NA
1932	NA	NA	NA	NA	NA	NA

Appendix Table 28. (continued)

Year	Sauger	Tullibee	Burbot	White Sucker	Other	Bullhead
1933	9,703	810	NA	NA	6,308	NA
1934	11,299	389	NA	NA	9,083	NA
1935	14,260	701	NA	NA	11,632	NA
1936	18,496	1,920	NA	NA	12,906	NA
1937	16,207	4,671	NA	NA	12,211	NA
1938	6,290	43,915	NA	NA	9,861	NA
1939	2,778	22,965	493	2,049	5,512	2,268
1940	4,020	51,603	631	1,304	3,347	1,547
1941	5,576	44,798	738	3,323	1,233	2,920
1942	3,904	49,245	355	1,892	350	2,759
1943	6,408	62,087	1,408	6,415	496	6,788
1944	2,618	56,861	--	2,789	788	2,634
1945	6,418	31,010	2,393	6,731	472	2,864
1946	6,610	30,305	3,492	2,384	1,008	5,391
1947	12,054	31,774	5,324	4,308	377	2,512
1948	10,308	102,529	9,143	2,232	704	4,099
1949	9,350	46,300	4,590	1,430	40	4,630
1950	10,920	50,910	2,785	1,695	40	3,435
1951	12,570	38,790	10,733	2,200	100	12,730
1952	2,600	35,700	16,300	1,500	6	8,700
1953	3,800	17,000	10,377	1,500	--	7,850
1954	6,400	18,900	9,055	1,350	6	3,000
1955	5,200	29,600	11,243	1,600	--	200
1956	8,800	25,800	14,751	800	--	972
1957	4,800	19,900	15,122	700	--	700
1958	4,200	17,700	4,421	1,200	--	600
1959	5,340	25,060	16,057	1,170	40	1,020
1960	8,400	49,500	22,696	1,400	190	1,290
1961	11,126	64,808	30,860	4,000	--	1,100
1962	13,029	77,159	21,190	5,199	--	200
1963	10,000	60,000	9,525	2,500	2	800

Appendix Table 28. (Continued)

Year	Sauger	Tullibee	Burbot	White Sucker	Other	Bullhead
1964	5,800	66,100	17,547	4,600	20	76
1965	7,300	25,300	15,855	5,600	10	130
1966	5,400	27,600	7,000	3,900	--	300
1967	2,600	25,900	12,322	3,723	--	200
1968	1,172	42,846	8,015	2,128	--	--
1969	1,133	39,924	9,212	1,309	10	--

1/ Protected from commercial fishing.
NA -- Not Presently Available