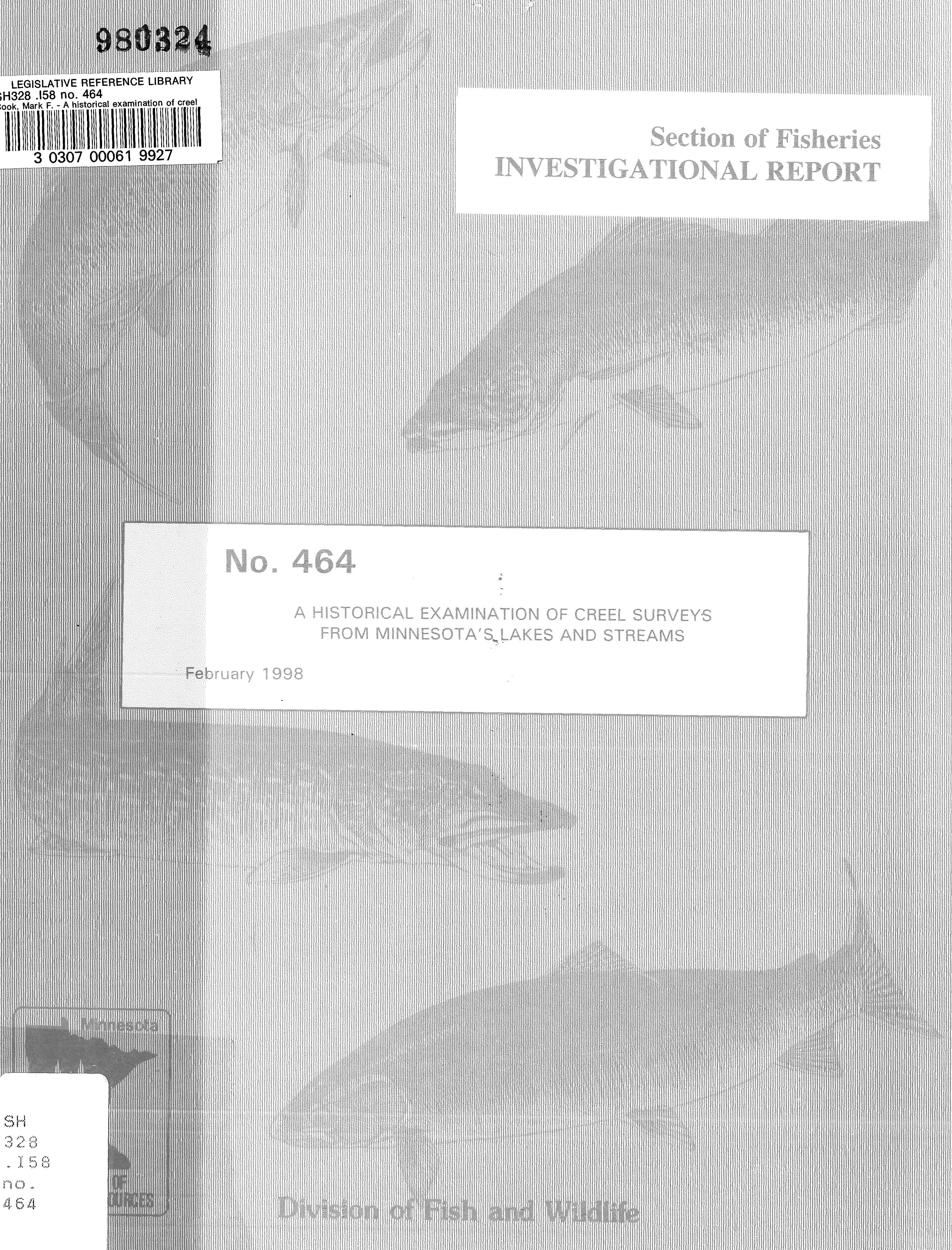

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A HISTORICAL EXAMINATION OF CREEL SURVEYS FROM MINNESOTA'S LAKES AND STREAMS

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Division of Fish and Wildlife

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Investigational Report 464

A Historical Examination of Creel Surveys from Minnesota's Lakes and Streams[1]

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Abstract.-- Creel surveys have been the primary tool used to measure the recreational fisheries in Minnesota since the 1930s. A long-term data set from Lake Winnibigoshish and analysis of creel surveys by lake class both showed that fishing pressure had increased on Minnesota's waters. Distance from population centers, ease of access, month of the year, and lake size were all found to affect fishing pressure. The highest fishing pressure was found on small lakes managed primarily as put-and-take fisheries and on lakes nearest the seven metro counties. The recent popularity of winter fishing has also contributed to the increase in fishing pressure on Minnesota lakes. Numbers and weight of harvested fish were both positively correlated with fishing pressure, while angler harvest rates were negatively correlated with fishing pressure. Lake size, percent littoral area, MEI, and TSI were all positively correlated with harvest (both numbers and weight). Minnesota's natural walleye lakes were more resilient to fishing pressure related changes than other lakes managed for walleye. Natural walleye lakes had higher average harvest rates than walleye lakes managed by stocking. Anglers targeting a specific species had median harvest rates up to 24 times higher than the species harvest rate computed for all anglers.

Harvested fish mean size was negatively correlated with fishing pressure. Minnesota anglers have been releasing mostly small fish except for largemouth bass. Release rates of larger walleye have increased, suggesting that catch-and-release may be increasing for walleye. The percentage of the catch released tended to be positively correlated with catch rates. Generally, panfish species had the highest release rates. Winter anglers tended to keep smaller fish and a higher percentage of their catch than summer anglers. Currently, anglers are harvesting younger and smaller bluegill and walleye than during the early years of creel survey. Anglers fishing put-grow-and-take stream trout lakes harvested a large portion of their catch. Winter darkhouse spearers harvested northern pike at rates similar to anglers targeting northern pike. Spearers harvested larger northern pike and at a faster rate than all summer and all winter anglers. Summer anglers harvested the largest numbers and weight of northern pike.

Walleye is the most preferred game fish in Minnesota, although the majority of fish harvested were panfish. Very few anglers take the maximum bag limit of any species. Little creel survey information exists for rivers and streams. However, summarized information suggests that fishing pressure on rivers and streams may be very high when compared with lakes on a per acre basis.

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Introduction

The Minnesota Department of Natural Resources (MNDNR) has conducted creel surveys as the primary means to estimate the recreational harvest since the 1930s. Creel surveys have been conducted on over 1,000 water bodies, resulting in more than 750 publications that discuss various aspects of the recreational catch (Cook et al. 1997). Consequently, a very large database was available for trend analysis. More than 4,000 lakes are managed for recreational fisheries in Minnesota, but few have had multiple creel surveys for which long-term changes in recreational fishing can be documented. The Lake Winnibigoshish fishery is the classic example of fishing pressure-related changes in a Minnesota lake (Osborn and Schupp 1985). Fishing pressure increased 700% from 1939 to 1977 in Lake Winnibigoshish, and walleye harvest rates and mean size declined. Since the establishment of the MNDNR large lake program in 1983, similar, but condensed, trend data is now available for all of Minnesota's large natural walleye lakes.

The most comprehensive examination of long-term changes in Minnesota fisheries was conducted using fishing contest records (Olson and Cunningham 1989). They found declining trends in numbers of large-sized entries for 8 of 10 species in northwestern Minnesota. Only rainbow and brown trout differed from this trend, both of which are more intensely managed in the few waters where they are found in this area. The authors concluded that increasing exploitation (more fishing pressure) is responsible for changing the size structure of Minnesota's fish stocks. A 1987 survey of Minnesota resident anglers also found that most perceived a decline in fish sizes over the last 10 years (Leitch and Baltezore 1987).

Analyzing creel data by similar lake types is an option when long-term records for individual lakes are lacking. The earliest attempts at quantifying angling information involved selecting lakes representative of "typical" fishing waters (Hiner 1943; Moyle and Franklin 1952, 1955; Scidmore 1961). The first study to describe recreational fishing use on lakes with similar fish assemblages occurred in the 1970s (Hawkinson and Krosch 1972; Peterson 1978). Currently, MNDNR is implementing a lake classification system that uses limnological variables to identify distinct lake types (Schupp 1992). Most of the 43 lake classes are also characterized by different fish communities and have diverse geographic centers (Figure 1). Fishery managers already use this lake classification system to evaluate lake survey results and management techniques by comparing lakes of the same classification. A Wisconsin study that grouped walleye lakes by acreage is the only other study we are aware of that analyzed a large volume of creel survey estimates across a broad geographic scale (Staggs 1989).

Recreational fishing is among the most popular outdoor activities in Minnesota. More than two million anglers annually fish Minnesota waters (Minnesota Department of Administration 1988) and spend over $1.9 billion (U.S. Department of the Interior and U.S. Department of Commerce 1997). The popularity of fishing in Minnesota is due to the variety and abundance of fishing opportunities available. Anglers may choose from kid's fishing ponds, warm and cold water stream fisheries, salmonid fishing in Lake Superior, world class walleye fisheries, and trophy muskellunge fisheries, just to name a few. Angling pressure on all these fisheries is expected to increase in the future. As fishing pressure increases, it is expected that average size and catch (or harvest) rate will continue to decline for the most preferred fish species, or at best remain stable under current statewide regulations.

This study had three objectives, the first of which was to collect and computerize all available creel survey information about Minnesota's recreational fisheries. Second, we described long-term creel survey statistics (means and quartiles) by lake class for Minnesota's fisheries to be used in place of regional or statewide values currently being used. Finally, we examined changes in the recreational fisheries through time and describe relationships between commonly collected limnological variables and recreational fishing.

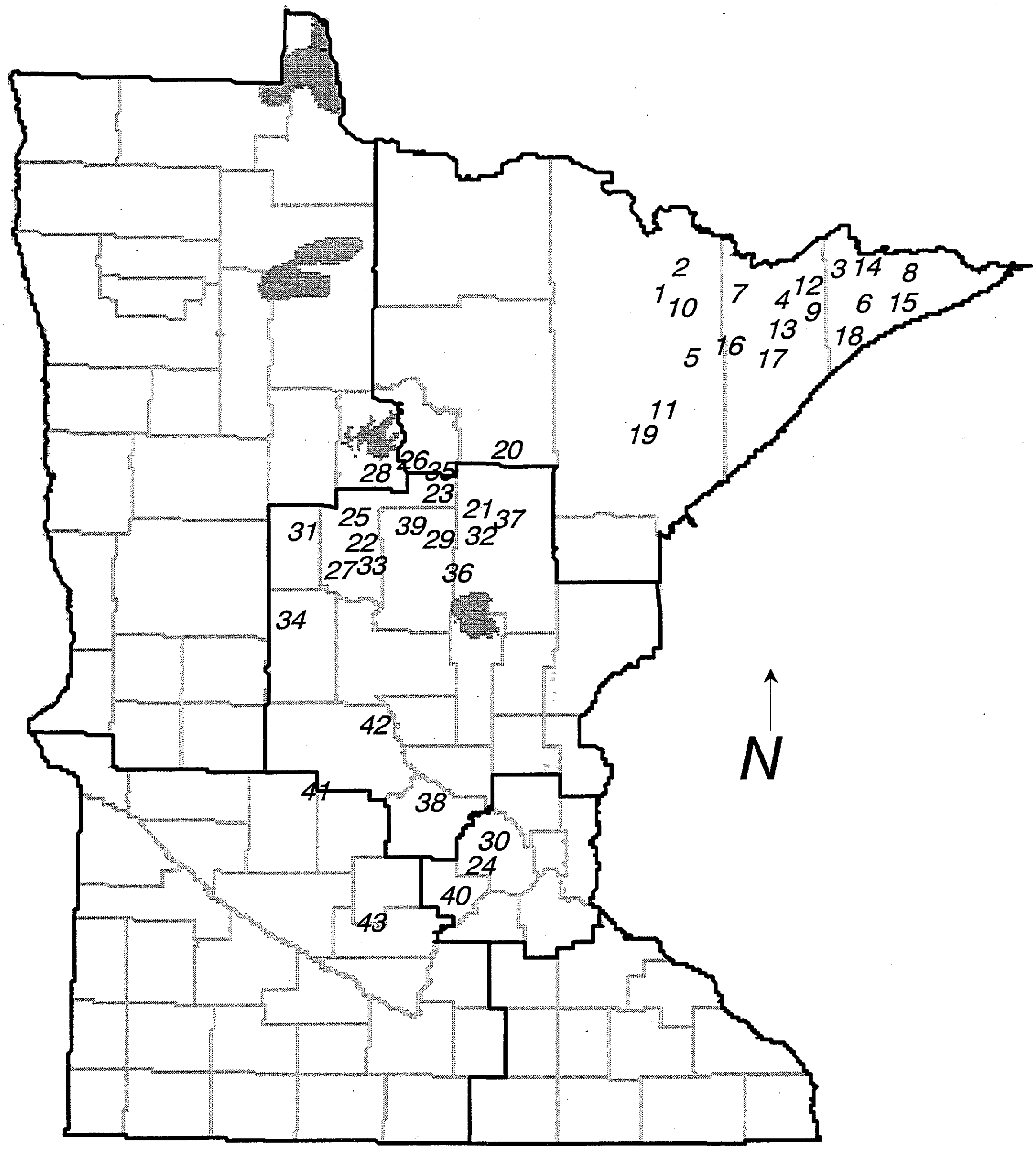


Figure 1. Geographic centers of 43 Minnesota lake classes (adapted from Schupp 1992). Lake Classes 1-19 lie mainly in the three northeastern counties and most are soft-water lakes. The remaining lakes (Lake Classes 20-43) which lie southwest of the arrowhead region of Minnesota, form two clusters of hard-water lakes.

The majority of this report discusses the second and third objectives.

Methods

Assumptions and Creel Survey History

The MNDNR has conducted creel surveys for years, primarily to answer specific management questions on a particular water body. No comprehensive design was used for choosing which lakes to sample, and consequently, large-scale geographic or long-term trends on individual water bodies could not be described. Because a comprehensive sampling design was lacking, we made several assumptions in the analysis of the creel survey database. To obtain a larger sample size, we grouped creel surveyed lakes by lake class (Schupp 1992) and described the recreational fishing within a class. However, in many cases within a lake class, creel surveys were not equally distributed either between lakes or years, thus limiting our analyses. We treated multiple creel surveys from a lake as random and independent observations for the following reason: fishing success and species composition of the harvest can change dramatically from year to year in the north-central Great Lakes region (Kempinger et al. 1975; Bruesewitz 1996; Albert 1996). Many reasons for the variation in harvest have been given, including: varying weather conditions (O'Bara 1991), year-class strength (Bruesewitz 1996), partial winter kills (Bandow et al. 1993), and forage composition and availability (Lux and Smith 1960; Kempinger et al. 1975). Because of the variety of factors affecting fishing success on any particular lake, we felt that using each season of creel survey as an independent observation would give the best measure of variability from within a lake class (as opposed to averaging all creels from a given lake).

Creel surveys in Minnesota have been conducted by a variety of sampling designs (Cook et al. 1997). For example, the opening day of walleye and northern pike fishing season is not constant from year to year. Most summer creel surveys were started on opening day, thus survey start dates varied. The ending date of summer creel surveys has been less consistent, ranging from just after Labor Day to late November. The text of many creel reports, however, declared that the survey ended after most anglers had quit fishing for the season, or when fishing pressure dropped to an insignificant level. Rather than trying to adjust all the survey estimates to a standard time frame, we assumed that the reported creel estimates accounted for most of the recreational fishing during that season, and any angler activity not sampled was insignificant. Similar assumptions were made for other strata (month, day period, etc.).

Terminology contained in Minnesota creel surveys has been inconsistently used (Cook et al. 1997). In this document, "creel survey" will refer to estimates of the recreational fishery based on samples of anglers in that fishery. "Harvest" will describe those fish removed from the water, while "released" will describe those fish returned to the water. "Catch" shall mean all fish caught, those harvested and those released.

All fish lengths contained in this report are total lengths. Length data about harvested fish were collected by creel clerks during angler interviews. Evaluation of released fish size is based on anglers' recollections and estimations of released fish lengths.

Data Base Design

dBASE IV® was used to construct a creel survey database. Creel survey estimates were grouped into the following major data groups (dBASE® files): descriptive variables about the survey, fishing pressure, catch, mean size of the catch, length frequency of the catch, age of the harvest, methodology used by anglers, and species sought. Two complete suites of files were constructed, one for lakes and the other for rivers. Creel survey estimates were entered into the database by assigning several categorical variables to each creel estimate, such as: creel season, stratum within the creel season, day period, species, and angler group. Creel season was a general description of the period encompassed by the creel survey (spring, summer, winter, fall). Only two seasons are presented in this report, summer (opening of fishing to ice-cover) and winter (ice-cover to the close of fishing season). Insufficient numbers of bona fide spring or fall creel surveys were available for analysis. Season strata were usually designated by calendar month, or one-half month periods. Day period was the hours in a fishing day sampled. This was approximately 0600 to slightly past sunset for most creel surveys. Angler groups were separated by where the anglers were fishing: bank, boat, fish house, etc.

Statistical Analysis

Creel survey estimates from 924 lakes and 189 stream reaches were available for analysis. The sample size of a given statistic may be presented three ways in this report: 1) by the number of lakes within a lake class that were surveyed, 2) by the number of creel surveys (some lakes may have multiple surveys), and 3) by the number of fish or anglers observed in the creel surveys. Creel survey estimates expressed on a per acre basis were normalized by adding one to the variable and using base 10 logarithms. Long-term descriptive values (means, medians and quartiles) were calculated for fishing pressure and catch (by species) for each of the 43 lake classes. Because of small sample sizes at times, extreme values could greatly influence means, therefore, medians were considered to be more representative of values within a lake class. Medians were used for most statistical analyses presented in this report. All interrelationships among variables and time trends were explored by regression and correlation analysis, or comparisons utilizing Student's τ (for unequal variances), Wilcoxon rank-sum, or Kolmogorov-Smirnov tests (Steel and Torrie 1980). For most statistical procedures, the actual probability level is presented, but any claim to statistical significance within this report was based on exceeding the 0.1 level. Number Cruncher Statistical Systems© was used in performing all statistical calculations (Hintze 1995).

Species catch estimates of zero were often not included in creel reports. This presented an analysis problem, since it was unknown how many reports left out these values. Therefore, we excluded all zero values from the catch analyses. The catch estimates in this report represent catches greater than zero, or when fish were indeed reported caught. True means and quartiles for catch estimates would be lower than values presented here. Conversely, values of zero were included in fishing pressure analysis, since zero fishing pressure has normally been reported in Minnesota creel reports.

Lake Classes 26 and 27 had the best data sets (more lakes sampled over a longer time span) and were chosen to illustrate trends that we believe to be happening, or have the potential to happen on the other 41 lake classes. Lake Class 26 is commonly called the "large lakes" and consists of the seven largest natural walleye lakes in Minnesota. These lakes are known for the world-class percid fisheries, specifically walleye, and secondarily for large northern pike. Many creel surveys have been conducted on these lakes because of their popularity and political sensitivity. Lake Class 27 represents the "hard water walleye lakes," which are smaller than the large lakes. Lake Class 27 has a good distribution of creel surveys both within the lake class and throughout time. Management of fisheries within this class has also been concentrated on walleye. Many creel surveys conducted in the remaining lake classes were also used to evaluate walleye fisheries. This has created a preponderance of information on walleye harvest, and many walleye-specific examples are included in this document.

The majority of Minnesota anglers fish as a group or party of anglers. Therefore, individual angler bag limit data were obtained by dividing the total fish harvest (by species) by the number of anglers in the party. Six species commonly harvested by Minnesota anglers were analyzed: walleye, northern pike, largemouth bass, yellow perch, sunfish, and crappie. Bag limits during this study were as follows: 6 walleye; 3 northern pike; 6 largemouth bass; 100 yellow perch; 30 sunfish (all species combined); and 15 crappie (black and white crappie combined). Gini coefficients

(Smith 1990) were calculated, and Lorenz curves (Lorenz 1905) were drawn for each species.

Historically, MNDNR has given little attention to rivers and streams, and creel surveys on rivers were no exception. Four categories were used to summarize creel survey estimates from rivers and streams: large rivers (Minnesota, Mississippi, Rainy, Red, and St. Croix), warm water streams, southeast Minnesota cold water trout streams, and northeast Minnesota cold water trout streams. Quartiles of fishing pressure and catch were prepared for each category.

The genus level is used throughout much of this report for discussing conclusions about several species (bullhead, crappie, and sunfish), because creel estimates for these species were occasionally combined in creel survey reports.

Results and Discussion

Distribution of Creel Surveys and Angler Demographics

Estimates of the recreational fishery have been made for lakes representing all 43 Minnesota lake classes (Table 1). Analysis of long-term changes in recreational fishing were possible for only a few lake classes, because most creel surveys have been conducted since the mid-1970s. In addition, not all lake classes have been sampled equally. More attention has been given to lake trout lakes (Lake Class 1), larger walleye lakes (Lake Classes 2, 22, and 26), and hard water walleye lakes (Lake Class 27). The summer fishing season has been surveyed most often, followed by winter fishing season (Table 2). Relatively few lakes have multi-season repetitive creel surveys (Table 3).

Angler demographics routinely collected in creel surveys revealed two items of interest. First, fishing in Minnesota has been an outdoor activity predominated by males, both during the summer (80.3%) and winter (92.2%) seasons. This ratio of males to females fishing Minnesota waters appears to have remained constant during the last 50 years. Hiner (1943, 1947) reported that women comprised about one-fifth of summer anglers and less than 5% of winter anglers. Second, angler use of "high-tech" fishing equipment is increasing. Creel surveys show that the use of depth finders has increased from 19.7% in the 1970s, to 60.6% in the 1980s, and up to 69.1% in the 1990s. The use of small trolling motors (either gas or electric) has also increased from 41.9% during the 1980s, to 46.5% in the 1990s. Boat registrations show that anglers are using better boats as well. The ratio of boats less than 16 feet to those 16 feet and longer has been decreasing (Cook et al. 1997). This strongly suggests that many anglers are switching from small open-bowed boats 12 and 14 feet long, to 16-20 feet long boats that are faster, more comfortable, and loaded with features specifically designed for fishing. No quantitative information is available on fishing tackle, however, today's anglers have access to better rods, reels, and tackle than anglers interviewed during the early years of creel survey.

Fishing Pressure

Recreational fishing pressure on Minnesota waters is highly variable and ranges from only a few hours to more than 1,000 hours per surface acre. Lake class medians show that most Minnesota lakes still receive less than 100 angler-hours per acre annually (Table 4). In general, fishing pressure per acre is low on very large and on remote lakes (Lake Classes 1, 2, 10, 16, and 26). Conversely, fishing pressure is high on smaller lakes and those near metropolitan areas (Lake Classes 24, 30, and 38). The highest fishing pressure was found on small trout lakes or kid's fishing ponds, managed as primarily put-and-take fisheries (Lake Classes 20, 21, and 33). Fishing pressure within a lake class can also vary greatly between summer and winter seasons depending on location and accessability (Table 4). No dramatic change in the relative distribution of fishing pressure in Minnesota has occurred since Scidmore (1961) presented fishing pressure based on six lake groupings. Clarke et al. (1991) demonstrated that fishing

Table 1. A tally of Minnesota lakes that were creel surveyed 1935 - 1994, presented by Schupp's (1992) lake classification system. A lake was considered creel surveyed if any aspect of the recreational fishery was measured, including recreational surface use surveys that measured fishing pressure.

Lake class	Number of lakes	Number of lakes surveyed	Percent of class surveyed	Total number of creels	Recreational surface use surveys
1	35	33	94	217	0
2	13	10	77	81	0
3	72	34	47	86	0
4	45	22	49	42	0
5	60	21	35	46	0
6	47	8	17	16	0
7	39	14	36	40	0
8	62	18	29	42	0
9	51	13	25	30	0
10	75	23	31	29	0
11	47	11	23	11	0
12	90	10	11	21	0
13	83	22	27	37	0
14	108	11	10	17	0
15	58	2	3	2	0
16	39	13	33	24	0
17	112	10	9	11	0
18	101	1	1	4	0
19	66	11	17	11	0
20	80	7	9	35	0
21	83	9	11	23	0
22	72	52	72	204	14
23	115	29	25	49	15
24	131	98	75	132	108
25	110	37	34	102	9
26	7	7	100	149	0
27	103	52	50	233	16
28	125	5	4	8	4
29	125	12	10	47	5
30	120	57	48	26	60
31	141	35	25	59	13
32	80	13	16	35	9
33	109	6	6	11	4
34	107	21	20	40	13
35	48	12	25	18	5
36	107	10	9	8	8
37	112	1	1	0	1
38	71	26	37	36	23
39	115	8	7	10	5
40	81	17	21	11	22
41	62	12	19	22	9
42	75	12	16	5	14
43	148	23	16	7	23
Lake Superior	1	1	100	33	0
Unclassified	-	69	-	97	14
Totals:	3,531	918	26	2,167	394

Table 2. Tally of seasons in which Minnesota waters were creel surveyed, 1935 - 1994.

Season	Number of surveys	Percent
Spring	33	1.5
Summer	1,302	60.6
Winter	787	36.6
Fall	28	1.3
Total	2,167	

Table 3. Repetitiveness of creel surveys conducted on individual Minnesota lakes, 1935 -1994.

Survey frequency	Number of lakes	Percent of lakes
Single summer	267	40.5
Single winter	70	10.6
Multi - summer	80	12.1
Multi - winter	49	7.4
Annual estimates	61	9.2
Scattered seasons	133	20.2
Total	660	

pressure is related to anglers' expectations of catch, but how and to what degree this influences fishing pressure distribution in Minnesota is unknown.

The number of anglers fishing Minnesota lakes has continued to increase since the inception of fishing licenses (Cook et al. 1997), and this has translated into an increase in fishing pressure as well. Concern about how fish populations would be affected by increasing fishing pressure is as old as creel surveys in Minnesota (USDA Forest Service 1935, 1938; Stoudt 1939; Hiner 1947; Cook et al. 1997). Creel surveys conducted at Lake Winnibigoshish span the greatest number of years. Between the first creel survey in 1938 and the latest in 1995, fishing pressure has increased more than ninefold (Albert 1996). Much of the recent increase in fishing pressure has been due to the popularity of yellow perch fishing during winter. While fishing pressure on Lake Winnibigoshish has increased ninefold, license sales during this time increased only by a factor of 2.1 (Cook et al. 1997), and the average length of a fishing trip has remained constant. Thus, two conclusions can be drawn as to why fishing pressure on Lake Winnibigoshish has increased at a faster rate than license sales. First, a disproportionate number of anglers may be choosing to fish Lake Winnibigoshish, or second, anglers are making more fishing trips to Lake Winnibigoshish each season. Recreational fishery studies spanning decades are rare in the fisheries literature. In an annual creel survey on Lake Powell, Utah, fishing pressure increased over twentyfold during a 21-year period (Scott and Gustaveson 1986). However, at least part of this increase was due to a developing reservoir fishery at Lake Powell.

Lacking other long-term data sets from Minnesota lakes, temporal trends in fishing pressure were examined by lake class. A scatter plot of summer fishing pressure by survey year reveals an upward trend for Lake Class 26, which includes Lake Winnibigoshish (Figure 2). Lake Class 27 exhibited a similar trend of increasing fishing pressure, but variability among lakes was much larger than for Lake Class 26 (Figure 2). Changes in fishing pressure, by season, were inconsistent when lakes within a class were combined by decade (Table 5). Summer fishing pressure has both increased and decreased, but the only statistically significant change was the increase in Lake Class 27. The largest increases in fishing pressure were during the winter season (Table 5). An increase in Minnesota fish house license sales also indicates that winter fishing is increasing in popularity (Cook et al. 1997).

Most lakes receive more fishing pressure during the summer than during winter (Table 4). Summer fishing pressure normally peaks during the months of May or June and then decreases until freeze-up in October or November (Figure 3). Not surprisingly, the highest summer fishing pressure estimates occur during the most popular vacationing months. The peak in June fishing pressure also corresponds to higher catch rates of many

Table 4. Summer, winter, and annual long-term medians of fishing pressure (angler-hours per acre) for 43 Minnesota lake classes as determined by creel survey, 1935 - 1994.

Lake class	Summer fishing pressure: Number of lakes	Number of seasons	Median	Winter fishing pressure: Number of lakes	Number of seasons	Median	Minimum annual fishing pressure
1	15	63	6.1	31	125	1.2	7.3
2	7	54	4.8	5	11	1.1	5.9
3	13	18	9.2	27	67	3.0	12.2
4	14	15	18.3	16	23	2.4	20.7
5	9	16	12.3	3	13	0.0	12.3
6	3	6	9.2	4	8	0.5	9.7
7	11	19	11.5	1	1	8.4	19.9
8	8	12	18.9	15	26	1.8	20.7
9	9	12	40.8	9	15	4.4	45.2
10	14	14	3.0	4	9	1.3	4.3
11	11	11	6.8	-	-	-	6.8
12	8	11	11.3	1	2	1.3	12.6
13	12	15	8.8	10	18	7.6	16.4
14	7	9	8.7	4	6	4.5	13.2
15	3	3	15.0	-	-	-	15.0
16	5	7	8.7	5	5	0.6	9.3
17	6	6	0.3	-	-	-	0.3
18	-	-	-	1	4	0.9	0.9
19	11	11	5.5	-	-	-	5.5
20	5	20	112.2	3	15	1.8	114.0
21	6	15	146.1	2	7	3.3	149.4
22	29	69	15.2	22	48	1.8	17.0
23	18	42	19.6	4	11	2.3	21.9
24	95	137	46.2	19	37	17.8	64.0
25	16	26	29.8	9	16	5.6	35.4
26	6	51	5.9	5	45	1.2	7.1
27	35	88	26.3	30	61	3.7	30.0
28	5	10	51.2	-	-	-	51.2
29	10	25	32.3	5	20	5.8	38.1
30	56	68	39.9	2	5	28.6	68.5
31	21	23	26.0	7	7	5.7	31.7
32	10	17	28.1	2	6	2.8	30.9
33	5	10	231.1	-	-	-	231.1
34	15	21	45.3	2	10	5.9	51.2
35	9	10	17.0	2	2	0.5	17.5
36	8	8	29.5	1	3	0.9	30.4
37	1	1	37.1	-	-	-	37.1
38	25	33	51.3	3	8	16.6	67.9
39	6	10	23.3	2	2	3.1	26.4
40	16	24	73.6	-	-	-	73.6
41	12	16	16.1	6	9	7.0	23.1
42	12	14	12.4	1	1	-	12.4
43	23	24	17.5	2	2	0.5	18.0

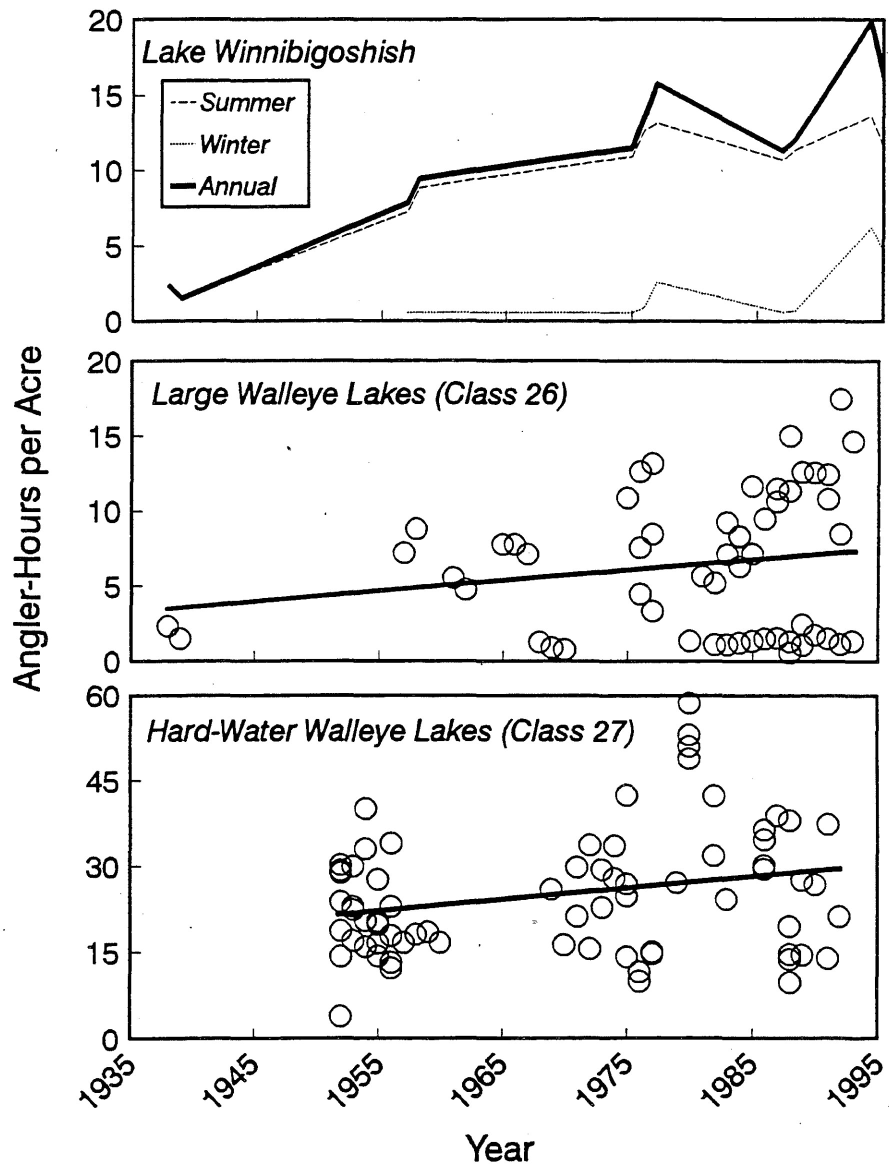


Figure 2. Historical changes in fishing pressure for Lake Winnibigoshish, Lake Class 26 (large walleye lakes) and Lake Class 27 (hard-water walleye lakes) as determined by creel survey.

Table 5. Historical changes in fishing pressure (angler-hours per acre) for selected Minnesota lake classes as determined by creel survey.

	Decades								Probability value	
	1950 - 1960				1970 - 1990					
Lake Class	Number of seasons	Angler-hours per acre Median	Mean	SE	Number of seasons	Angler-hours per acre Median	Mean	SE	Wilcoxon rank-sum	Kolmogorov-Smirnov
					Summer					
1	31	6.4	6.3	0.5	32	6.0	9.8	2.1	0.747	0.213
22	13	15.8	15.5	2.2	56	15.1	17.8	1.3	0.684	0.739
24	21	68.8	56.5	10.9	116	44.6	47.3	2.9	0.344	0.015
26	9	5.5	5.0	0.9	42	6.7	6.4	0.7	0.393	0.098
27	28	20.0	21.5	1.5	60	29.2	30.8	1.8	0.006	0.005
30	4	52.8	45.4	12.0	64	38.0	93.5	19.5	0.927	0.573
					Winter					
1	39	0.8	3.9	0.9	86	1.5	3.5	0.6	0.262	0.083
3	13	0.0	0.8	0.4	54	4.3	5.0	0.6	0.000	0.000
22	18	0.9	1.0	0.2	30	2.9	4.7	1.1	0.001	0.005
24	23	17.8	14.0	2.6	14	16.2	17.2	3.5	0.491	0.564
26	8	0.4	1.7	1.0	37	1.2	6.0	1.1	0.004	0.002
27	32	1.5	2.9	0.7	29	6.3	8.8	1.8	0.000	0.001

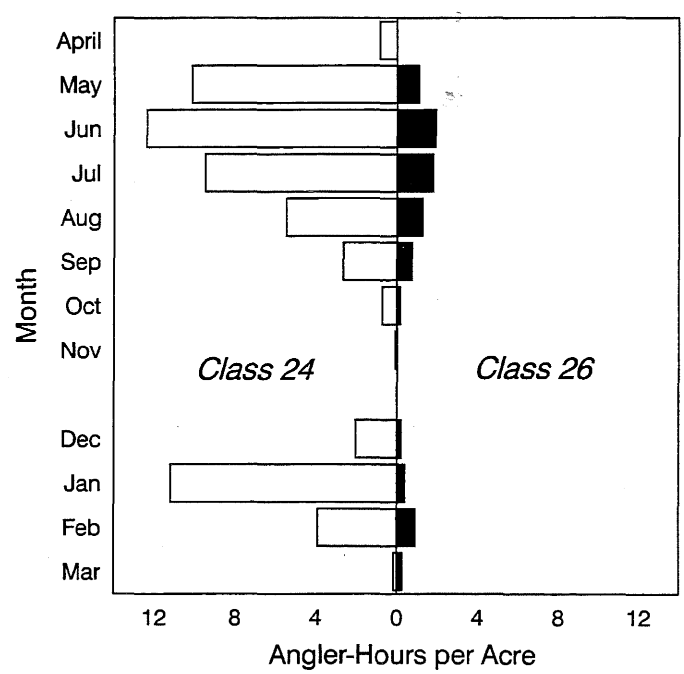


Figure 3. Within season distribution of fishing pressure for Lake Class 26 (large walleye lakes) and Lake Class 24 as determined by creel survey. Lake Class 26 is comprised of 7 lakes with a mean size of 109,308 acres. Lake Class 24 includes 131 lakes with a mean size of 429 acres.

species during this time. During winter, fishing pressure on most lake classes peaks during January and trails off toward spring thaw (Figure 3). In Minnesota, the ice fishing season is usually well under way by mid-December, but as ice thickens enough to support vehicles in January, many more anglers participate in the winter fishing season.

Lake Classes 26 and 24 clearly demonstrate the tempering effect of lake size on fishing pressure (Figure 3). While Lake Class 24 received 9 times the fishing pressure per acre when compared with Lake Class 26 (64 angler-hours compared with 7 angler-hours per acre), 45 times more total angler-hours were spent fishing on Lake Class 26 when compared with Lake Class 24 lakes (1,278,000 angler-hours compared with 28,000 angler-hours). Similarly, mean lake size was negatively correlated with observed angler-hours per acre across all lake classes (Figure 4). Separating Lake Classes 1-19 (northeastern Minnesota) from the remainder of the lake classes improved the coefficients of determination. Because of their remoteness from large population centers (Figure 1) and more restricted access (Voyageurs National Park and Boundary Waters Canoe Area Wilderness), Lake Classes 1-19 generally do not receive the high fishing pressures observed in other lake classes. When separated by location, lake size accounted for over 40% of the variation in fishing pressure on a per acre basis. In a nationwide study of relationships between environmental variables and reservoir sport fisheries, Jenkins and Morais (1971) also found fishing pressure to be inversely correlated with reservoir size.

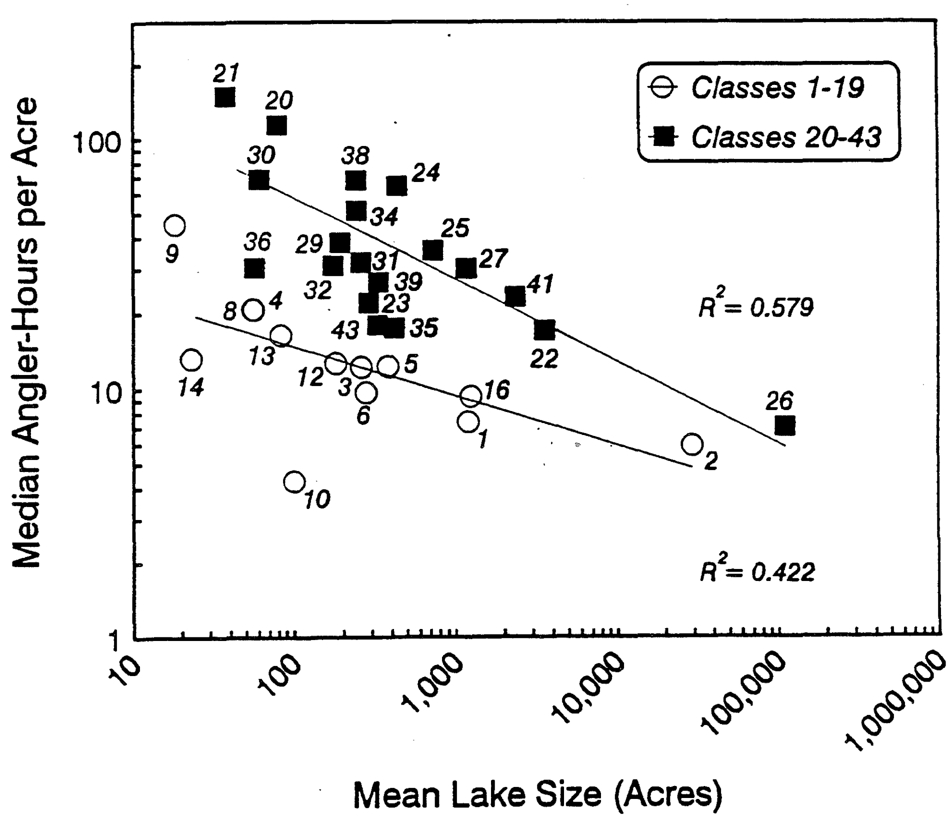


Figure 4. Regressions of median fishing pressure per acre by lake class regressed against mean size of lake class. Two regressions are shown, one for Lake Classes 1-19 (soft-water lakes of northeastern Minnesota) and Lake Classes 20-43 (lakes southwest of the arrowhead region). Lake class is indicated next to the data points on the figure. Not all lake classes had enough creel survey data to be included in the regressions.

Catch and Harvest

Peaks in fishing pressure during the months of June and January coincide with the seasonal harvest peaks for most fish species in Minnesota (Table 6). The only notable exception to this pattern was northern pike. During December, more northern pike are harvested than in the later winter months. Much of the December harvest can be attributed to early season darkhouse spearing when the ice is still thin.

Increasing fishing pressure on Minnesota lakes has affected the typical angler's catch, but not all species in the catch have been affected equally. On Lake Winnibigoshish, numbers and weight of harvested yellow perch have continued to increase with fishing pressure (Figure 5). Conversely, yield of walleye and northern pike have remained flat or declined since their highest harvest levels. During the 1990s, Lake Winnibigoshish yielded more pounds of fish than ever before, but these high biomass yields can be attributed solely to increased yellow perch harvest. Lake survey test nets indicate that yellow perch numbers were not excessively high during this period of record perch harvest. However, there is evidence that more anglers were seeking yellow perch during both the summer and winter seasons (Albert 1996). The increase in yellow perch harvest appears to be caused by record high levels of fishing pressure coupled with more anglers targeting yellow perch. Concurrent with a ninefold increase in fishing pressure, total fish harvest from Lake Winnibigoshish has also increased but not as rapidly as fishing pressure.

Table 6. Monthly distribution of the harvest by species (percent) for summer and winter seasons as determined by creel survey. Percentages within a season total to 100%.

	Summer							Winter		
	May	June	July	August	September	October	November	December	January	February
All fish species										
Number	28	31	21	12	7	1	0	24	45	31
Weight	29	30	21	12	7	1	0	26	44	30
Bullhead species										
Number	28	41	16	8	6	0	0	-	-	-
Weight	13	29	18	20	20	0	0	-	-	-
Crappie species										
Number	21	27	22	17	10	3	0	11	70	20
Weight	19	29	22	16	11	3	0	10	70	20
Largemouth bass										
Number	18	37	18	16	10	2	0	-	-	-
Weight	20	38	17	15	8	1	0	-	-	-
Northern pike										
Number	24	23	19	22	11	1	0	58	25	17
Weight	22	18	16	25	16	3	0	60	23	17
Sauger										
Number	9	38	26	15	11	0	0	23	43	33
Weight	9	35	27	18	12	0	0	24	45	31
Smallmouth bass										
Number	4	13	33	34	15	0	0	-	-	-
Weight	4	17	29	33	17	0	0	-	-	-
Sunfish species										
Number	12	28	30	21	8	1	0	19	70	11
Weight	17	30	25	21	6	1	0	-	-	-
Walleye										
Number	34	34	17	9	5	1	0	36	36	28
Weight	33	34	18	9	5	1	0	32	37	31
Yellow perch										
Number	19	26	17	19	18	1	0	19	48	33
Weight	20	28	18	18	15	1	0	15	46	38

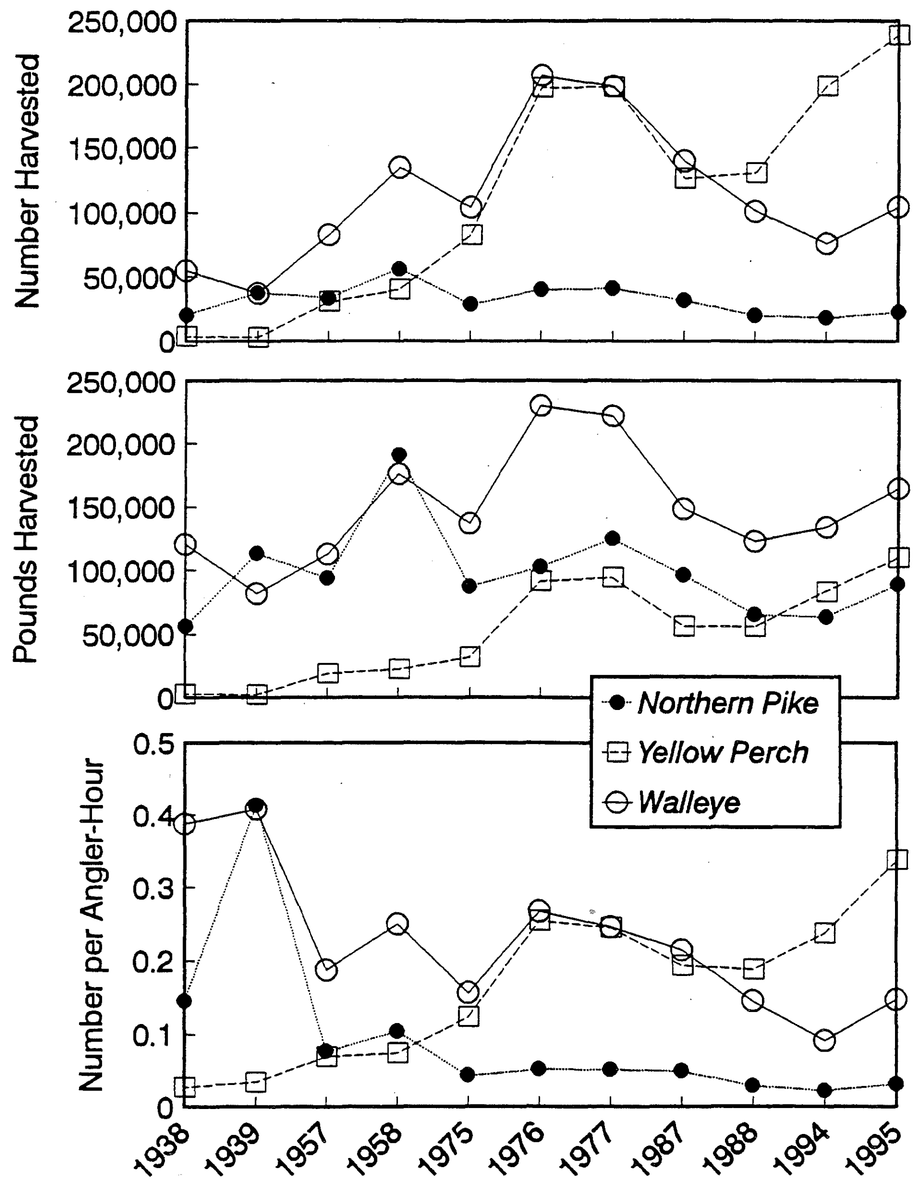


Figure 5. Historical changes in the fish harvest (numbers and weight) and harvest rates (number per angler-hour) from Lake Winnibigoshish as determined by creel survey, 1938-1995.

Harvest per angler-hour has also fluctuated throughout the years at Lake Winnibigoshish (Albert 1996). In general, walleye and northern pike harvest rates have decreased while yellow perch have increased. Walleye harvest rates have decreased from a high of 0.4 fish per hour during the 1930s to a low of 0.1 fish per hour in the 1990s (Figure 5), while fishing pressure has continually increased over the same time. Northern pike have shown a similar trend, declining from a high of 0.3 fish per hour in the 1930s to a low of 0.03 fish per hour during the 1990s. Only yellow perch had an increasing harvest rate per angler-hour, which is due to anglers' willingness to harvest yellow perch (Albert 1996). We believe that if similar long-term data were available for more of Minnesota's lakes, similar trends would be observed. Yields would be more or less stable, while the individual angler harvest rate for the most desired species would be decreasing.

Most other long-term data sets in the literature have reported similar findings. A decline in catch rates, average size, and yield of walleye was also seen in Big Moose Lake, Minnesota during a 20 year period (Holmbeck and Johnson 1978a). In contrast, virtually no change was observed in walleye catch rates, average size, or yield in Big Splithand Lake, Minnesota over the same 20 year period (Holmbeck and Johnson 1978b). The number of anglers fishing Atlantic salmon increased in the River Severn, United Kingdom, while the catch per angler was decreasing from 1940-1989 (Churchward and Hickley 1991). Likewise, increasing fishing pressure and decreasing harvest rates for lake trout and smallmouth bass at Lake Opeongo, Ontario were documented over a 47 year period (Shuter et al. 1987). They also reported that variations in angler catch rates may be related to changes in angler skill levels.

The harvest of three species (walleye, northern pike, and yellow perch) was examined for relationships with increasing fishing pressure in Lake Classes 26 and 27. In both lake classes, the walleye harvest (numbers and weight) has remained stable, while the harvest rate has declined in Lake Class 27 and significantly declined in Lake Class 26 (Table 7 and Figure 6). Northern pike showed a similar response in Lake Class 27, but in Lake Class 26, the numbers and weight of northern pike harvested also declined (Table 7 and Figure 7). Yellow perch harvest appears to have been unaffected by increased fishing pressure in these two lake classes as indicated by the near zero slopes of the regression lines (Table 7 and Figure 8).

The total fish harvest trends differed slightly for Lake Classes 26 and 27 (Figure 9). In Lake Class 27, the slopes for all three components of the total fish harvest (numbers, weights, and rates) did not differ from zero. Regression lines for the number and weight of

Table 7. Trends of the historical angler harvest as determined by least-square regressions for Minnesota Lake Classes 26 (large walleye lakes) and 27 (hard water walleye lakes).

	Number per acre		Pounds per acre		Harvest rate (fish per hour)	
	Trend	*P*-value	Trend	*P*-value	Trend	*P*-value
			Lake Class 26			
Northern pike	Negative	0.000	Negative	0.000	Negative	0.000
Walleye	Positive	0.720	Negative	0.955	Negative	0.079
Yellow perch	Positive	0.704	Negative	0.944	Negative	0.732
Total fish harvest	Positive	0.987	Negative	0.196	Negative	0.001
			Lake Class 27			
Northern pike	Positive	0.684	Positive	0.775	Negative	0.176
Walleye	Negative	0.803	Negative	0.549	Negative	0.196
Yellow perch	Positive	0.790	Positive	0.362	Positive	0.769
Total fish harvest	Positive	0.272	Positive	0.370	Negative	0.573

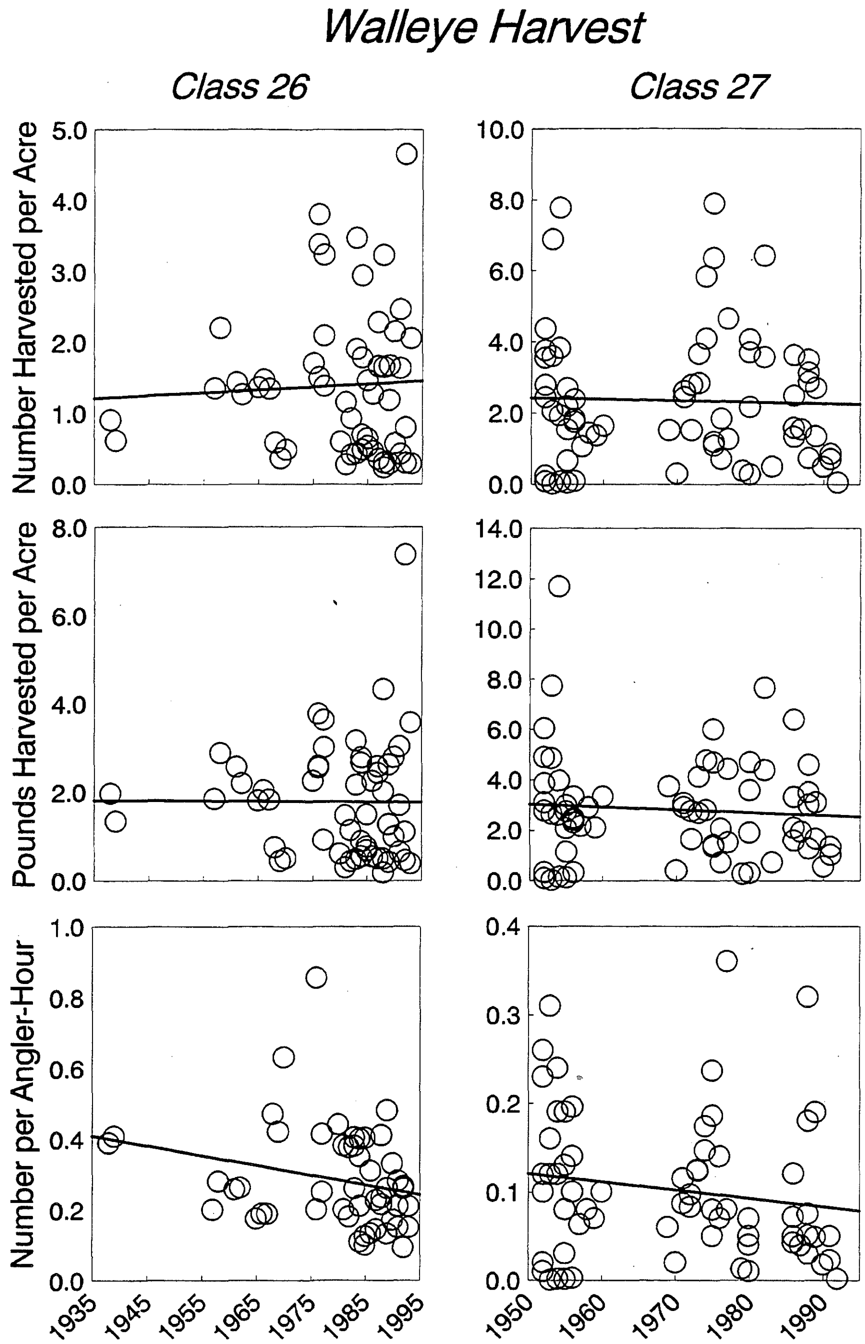


Figure 6. Relationships between the walleye harvest (number and weight) and harvest rates (number per angler-hour) with fishing pressure for Lake Classes 26 (large walleye lakes) and 27 (hard-water walleye lakes) as determined by creel survey.

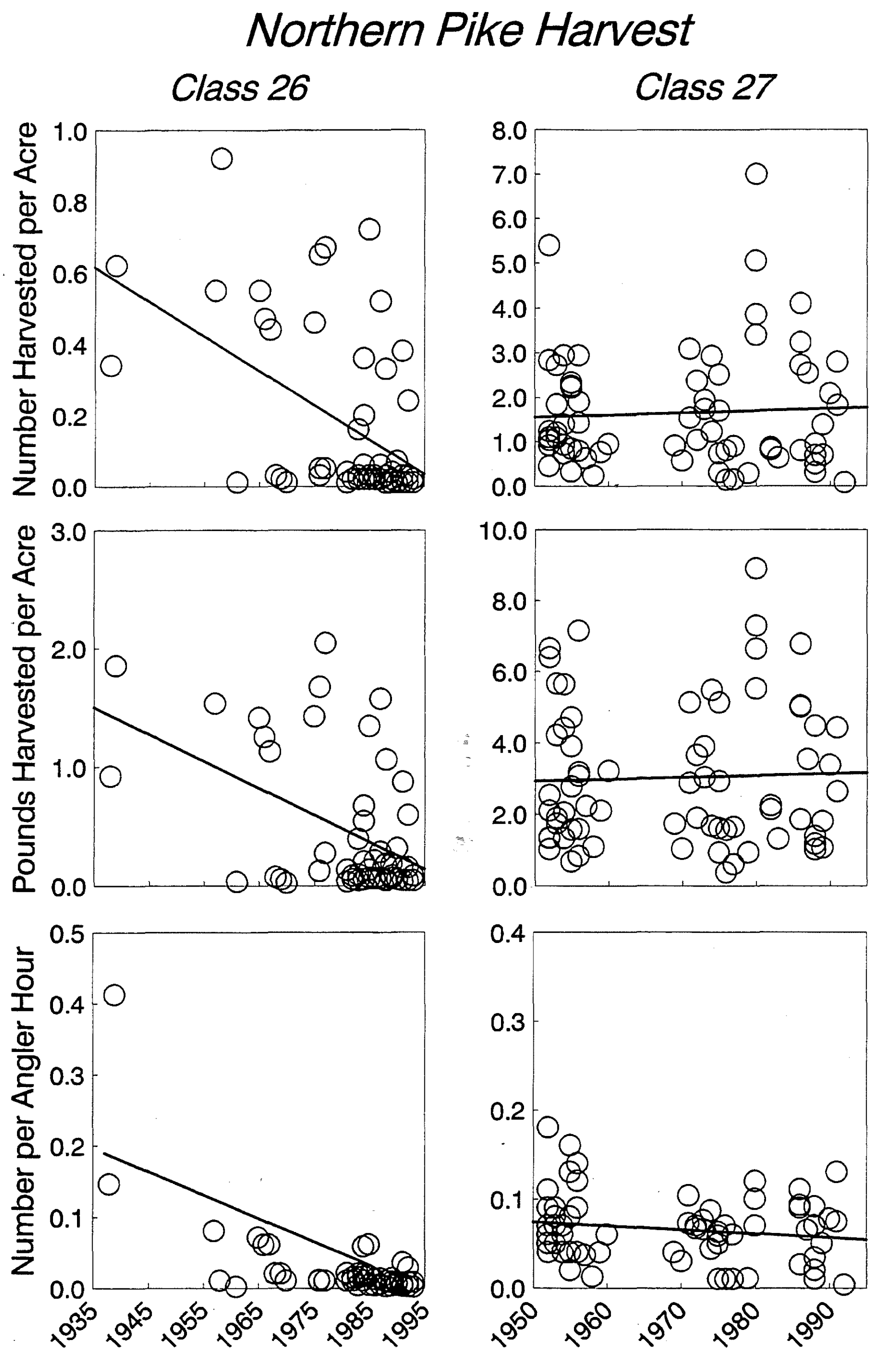


Figure 7. Relationships between the northern pike harvest (number and weight) and harvest rates (number per angler-hour) with fishing pressure for Lake Classes 26 (large walleye lakes) and 27 (hard-water walleye lakes) as determined by creel survey.

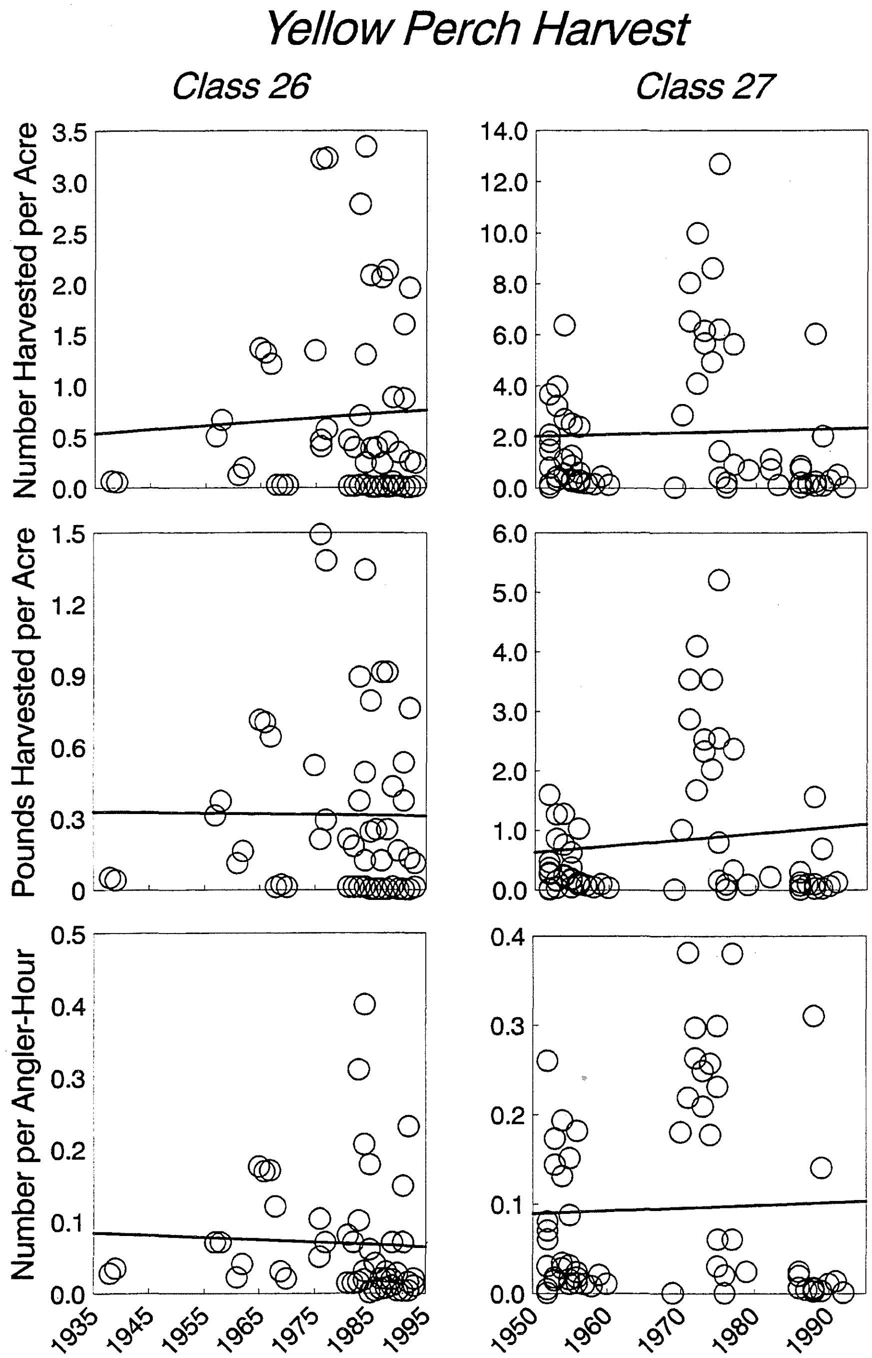


Figure 8. Relationships between the yellow perch harvest (number and weight) and harvest rates (number per angler-hour) with fishing pressure for Lake Classes 26 (large walleye lakes) and 27 (hard-water walleye lakes) as determined by creel survey.

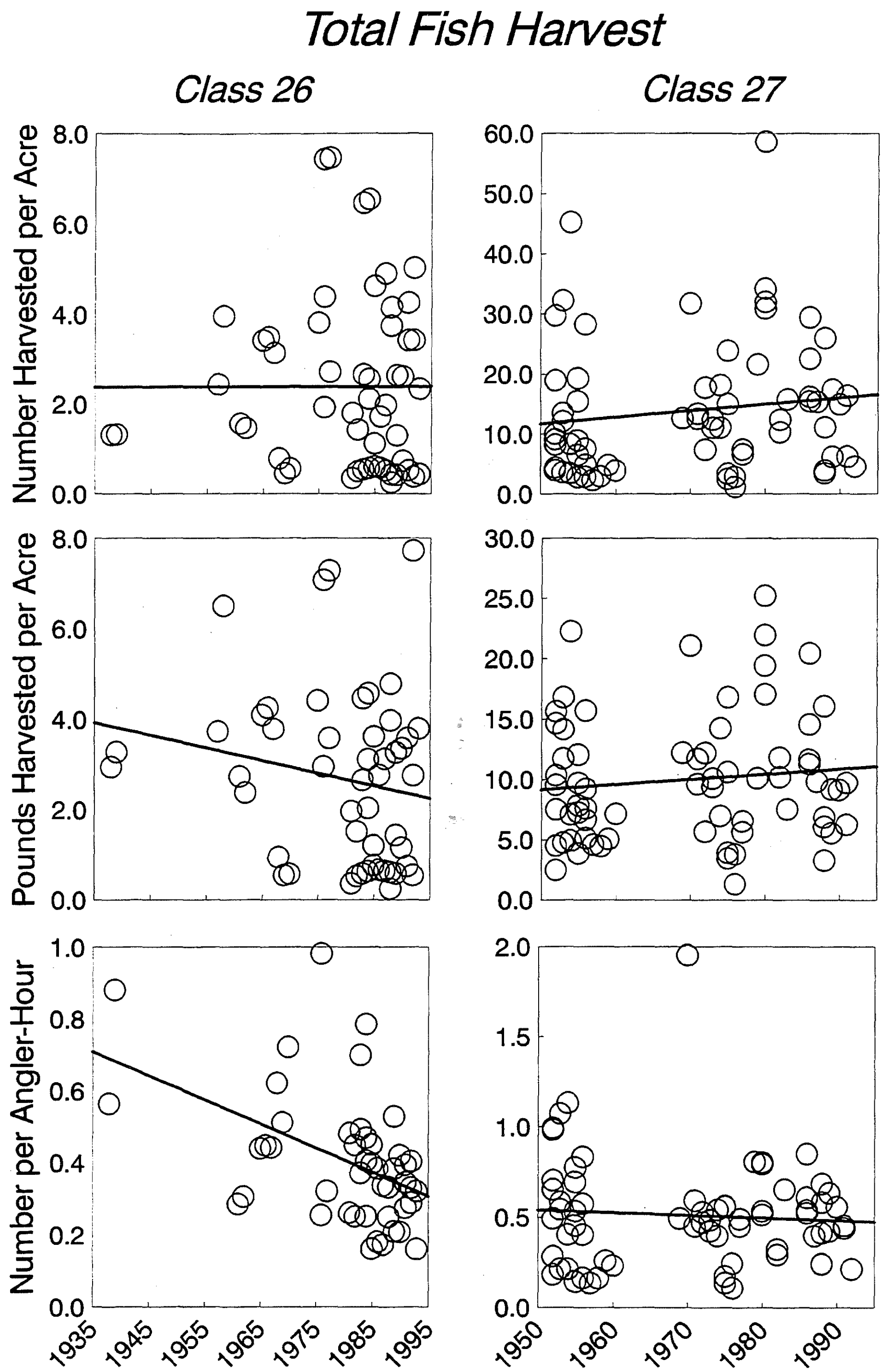


Figure 9. Relationships between the total fish harvest (number and weight) and harvest rates (number per angler-hour) with fishing pressure for Lake Classes 26 (large walleye lakes) and 27 (hard-water walleye lakes) as determined by creel survey.

total fish harvested from Lake Class 26 were also flat, while the total fish harvest rate declined. One-half of the total fish harvest from Lake Class 26 is walleye, and the combination of walleye and yellow perch accounts for over 90% by numbers (82% by weight) of the total fish yield from these lakes. Any change in either of these two species harvest rates will exert considerable influence on the total fish yield from these lakes. Conversely, walleye yield is only 17% (by number) and 27% (by weight) of the total yield from Lake Class 27. A greater proportion of other fish species such as sunfish, crappie, and largemouth bass contribute to the harvest in Lake Class 27. This may have a dampening effect on increasing fishing pressure, as harvest rates from one fish species fall, it appears anglers may switch to fishing other species and thus prolong or reduce the effect of increasing fishing pressure. Fishing for alternative species is less common in Lake Class 26 because of the percid dominated fish communities in these lakes.

Harvest rates for most species were negatively related to fishing pressure. Generally, high harvest rates were only observed at low levels of fishing pressure, and as fishing pressure increased, harvest rates declined rapidly. The scatter plot of walleye harvest rates and angler-hours per acre clearly illustrates this relationship (Figure 10). The plot presented here is remarkably similar to the one presented for Ontario and upper midwest waters by Baccante and Colby (1991). Both plots have many observations clustered in the lower left graph corners, suggesting that the walleye per acre available for harvest in these lakes was variable. Explanations for unequal numbers of walleye per acre include: 1) creel surveys were conducted after fishing effort had affected the population; 2) many creel surveys were conducted in response to complaints about poor fishing; and 3) lakes surveyed had marginal walleye habitats (Baccante and Colby 1991). Two curves were fitted to illustrate this relationship better, one for Minnesota's classic

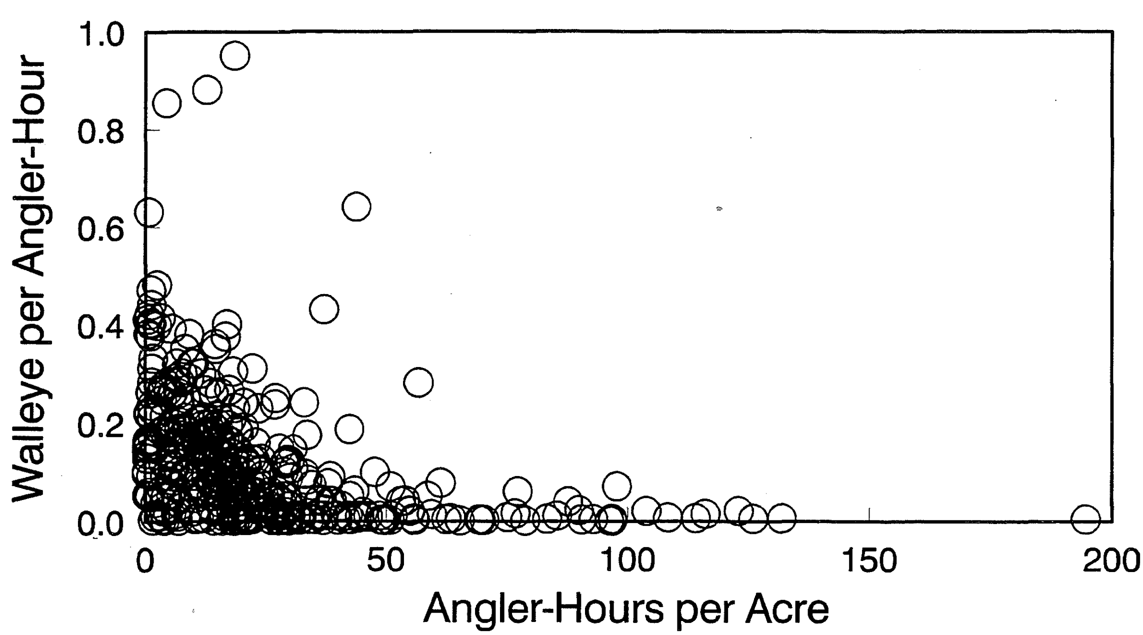


Figure 10. Number of walleye harvested per angler-hour plotted with fishing pressure per acre for Minnesota lakes as determined by creel survey.

walleye lakes (Lake Classes 2, 7, 12, 16, 22, 26, and 41) and one for all other lakes classes (Figure 11). These curves indicate Minnesota's classic walleye lakes clearly produce more walleye per angler-hour than the non-classic walleye lakes. Fishing pressure in non-classic walleye lakes will reduce the harvest per angler-hour approximately two to three times as fast as it will in classic walleye lakes. In other words, classic walleye lakes are more resistant to changes induced by fishing pressure, but not immune to fishing pressure. Total fish harvest rates were more resistant to increased fishing pressure than any individual species (Figure 11). For example, the total fish harvest rate curve did not decline as rapidly as the curves presented for walleye (Figure 11). Nonetheless, even for total fish harvest, rates will eventually decline with increases in fishing pressure.

Bennett (1962) found a similar trend of decreasing bass-bluegill harvest rates in Illinois and Missouri with increasing fishing pressure. Bennett's (1962) relationship between harvest rates and fishing pressure was exceptionally clear; the relationships for Minnesota lakes were not as apparent for most species. He showed that harvest rates declined most rapidly after several hundred angler-hours per acre, which was higher than our curves indicated. Data from Minnesota showed that the total fish harvest rate declines most rapidly before 76 angler-hours per acre and walleye harvest rates declined before 37 angler-hours per acre (Figure 11). As expected, the more fertile and productive ponds Bennett (1962) studied should be able to accommodate more fishing pressure than Minnesota lakes. Minnesota fishery managers are constantly receiving requests to increase catch rates for walleye. We believe as did Bennett (1962), that curves such as these could be useful in estimating the levels of fishing pressure to maintain a desired harvest rate. One way to accomplish this may be to use limited-entry fishing to reduce fishing pressure below 37 hours per acre. However, we suspect that this would be an unpopular option with most anglers.

Usually, MNDNR creel surveys report catch estimates for all anglers, regardless of which species anglers were seeking. However, when most anglers go fishing they are "targeting" a specific species. Catch estimates from anglers targeting a specific species have been reported in relatively few creel surveys and generally have been limited to harvest rate estimates. Harvest rates computed from anglers targeting specific species are very different from harvest rates computed from all anglers. In paired comparisons, median seasonal harvest rates for targeting anglers were 2 to 24 times higher than harvest rates for all anglers (Table 8). Furthermore, harvest rates for the two groups of anglers were always positively correlated (Table 8). Harvest rate differences between all anglers and targeting anglers was greatest for panfish species. Anglers seeking panfish species such as crappie and yellow perch have greater harvest rates than all anglers, in part due to the location and different fishing techniques used to fish panfish. Walleye and northern pike are targeted by most Minnesota anglers; therefore, when comparing harvest rates from targeting anglers with those from all anglers, the difference between groups is small but correlation coefficients are high (Table 8). The difference between the harvest rates of all anglers and targeting anglers was similar for walleye in Wisconsin (Staggs 1989). Minnesota anglers targeting largemouth bass release a larger percentage of their catch than do all anglers, and thus, the correlation coefficient between these harvest rates is the lowest observed.

Traditionally, anglers in Minnesota have harvested most of their catch that was large enough to be of an acceptable (eatable) size. Fish with high release rates have historically suffered from a bad reputation, such as the poor flavor of largemouth bass, the repulsive looks of the burbot, the grubby yellow perch, or the bony meat and slime of the northern pike. Catch-and-release fishing was rarely practiced before the 1980s. There were a few exceptions; catch-and-release was more widely practiced by clubs targeting specific species such as muskellunge, trout, and largemouth bass. Most MNDNR creel surveys did not estimate the release component of the catch until the 1980s. Even today, the majority of

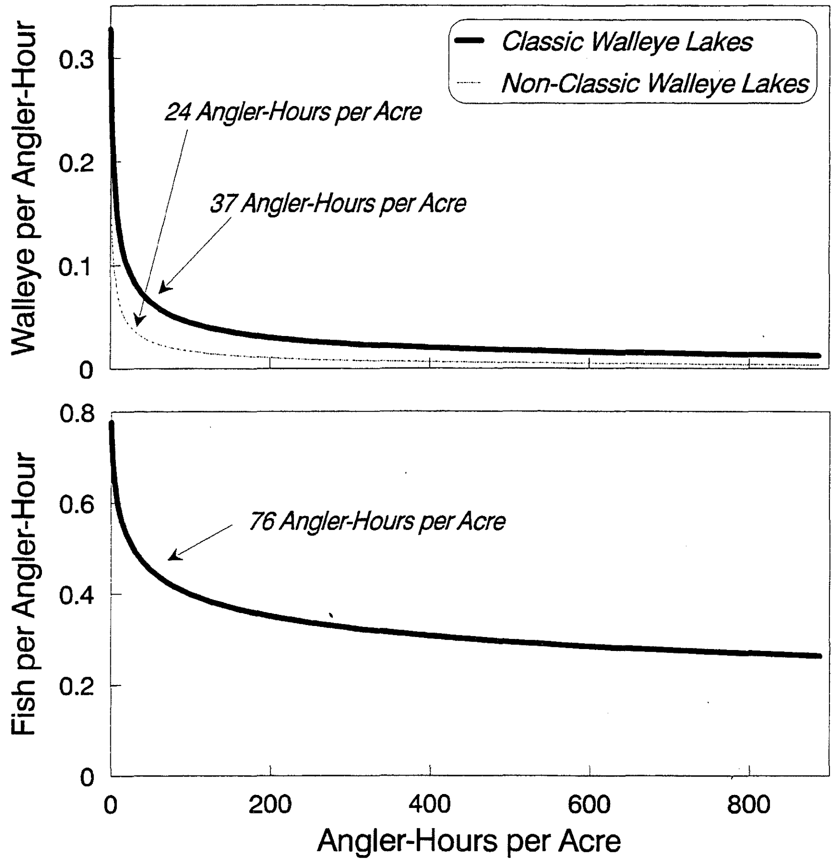


Figure 11. Relationship between number of walleye harvested per angler-hour and fishing pressure per acre for Minnesota lakes as determined by creel survey (top). The relationship between the total fish harvest rate and fishing pressure is also shown (bottom).

Table 8. Paired comparisons of harvest rates (fish per angler-hour) from all anglers with anglers targeting specific species in Minnesota Lakes. Harvest rates were determined during creel surveys.

Species	*N*	Median harvest rate: Targeting anglers	Median harvest rate: All anglers	Ratio of targeting anglers to all anglers	*P*-Value Wilcoxon signed-rank test	Pearson correlation coefficient
Bullhead	7	0.250	0.043	6 : 1	0.035	0.971
Crappie species	66	0.432	0.030	15 : 1	0.000	0.586
Lake trout	7	0.082	0.034	2 : 1	0.108	0.732
Largemouth bass	61	0.160	0.025	7 : 1	0.000	0.309
Northern pike	111	0.097	0.025	4 : 1	0.000	0.703
Smallmouth bass	43	0.108	0.021	5 : 1	0.000	0.684
Sunfish species	49	1.340	0.307	4 : 1	0.000	0.657
Walleye	122	0.152	0.079	2 : 1	0.000	0.761
Yellow perch	20	1.532	0.065	24 : 1	0.000	0.457

anglers fishing Minnesota waters harvest a large portion of their catch. Therefore, we believe the release values summarized in this report are reflecting angler harvest preferences, rather than a measure of true catch-and-release fishing. Nevertheless, these values will serve as baseline information to evaluate changes in angler behavior as catch-and-release fishing continues to increase in popularity.

The percentage of fish released varies from as little as 10% for lake trout to as much as 88% for yellow perch (Table 9). Generally, Minnesota anglers release panfish species at higher rates than predator fish species. Two factors influence the higher release of panfish, 1) many panfish caught are smaller than angler size preferences, 2) panfish are caught at higher rates than predator fish, so anglers are less likely to harvest all the fish they catch, simply because they are catching more fish. Correlations for percent of fish released and catch rates are generally positive, although few were statistically significant (Table 10). Northern pike had the highest percentage of released fish for a predator species. The combination of an abundance of small fish in many waters and the perception by many that northern pike are not edible is likely the cause for this high release rate. Minnesota anglers released a higher percentage of walleye than the reported 30% released by Wisconsin anglers (Staggs 1989). Grambsch and Fisher (1991) reported that the percentage of bass and trout anglers practicing catch-and-release fishing was correlated with angling success. Our results agree with theirs for black bass anglers, but differ for rainbow trout. Minnesota anglers pursuing rainbow trout will not necessarily release more rainbow trout as catch rates increase. However, the trout lakes examined in this study were primarily managed for put-grow-and-take fisheries.

Generally, winter anglers release significantly less (harvest more) of their catch than summer anglers. Two reasons explain why winter anglers harvest more of their catch. First, snow and lake ice conditions during winter prevent anglers from being as mobile as summer anglers, which may be why catch rates are often lower during the winter. As catch

Table 9. Percent of the catch released by all and targeting anglers fishing Minnesota lakes. Estimates of the percent of catch released were collected from parties of anglers interviewed during creel surveys.

		Season									
	Estimates from targeting anglers only	Summer				Winter				Probability level	
Fish species		Number of seasons	Median	Mean	SE	Number of seasons	Median	Mean	SE	Wilcoxon rank-sum	Kolmogorov -Smirnov
All fish species	No	140	60	56	1.7	51	31	35	3.5	0.000	0.000
Black crappie	No	79	31	36	2.9	29	13	16	3.0	0.000	0.000
Black crappie	Yes	31	31	37	5.5	7	24	31	9.5	0.651	0.594
Bluegill	No	57	57	52	3.4	23	37	31	4.2	0.001	0.000
Bluegill	Yes	22	57	57	5.2	3	52	38	13.9	0.168	0.156
Crappie species	No	81	31	37	3.6	31	13	17	3.2	0.000	0.005
Crappie species	Yes	33	33	37	5.2	9	17	24	8.6	0.209	0.194
Lake trout	No	18	10	15	3.8	42	33	37	4.0	0.002	0.004
Largemouth bass	No	106	77	77	1.7	13	13	27	10.0	0.000	0.000
Northern pike	No	119	63	62	2.1	44	18	26	4.0	0.000	0.000
Northern pike	Yes	59	39	42	3.9	9	33	38	12.2	0.677	0.820
Sunfish species	No	112	58	57	2.3	30	41	38	4.2	0.000	0.000
Sunfish species	Yes	43	53	50	2.7	10	68	61	6.6	0.047	0.089
Walleye	No	118	41	46	2.3	48	38	38	4.1	0.112	0.081
Walleye	Yes	68	39	42	2.8	22	32	35	6.1	0.131	0.078
Yellow perch	No	105	88	75	2.9	55	43	44	4.0	0.000	0.000
Yellow perch	Yes	12	52	57	6.5	9	36	37	7.0	0.070	0.206

Table 10. Pearson correlation coefficients of the percentage of the catch released with harvest and catch rates (fish per hour) of Minnesota anglers, by both all and targeting anglers.

	All anglers				Targeting anglers			
Species	Harvest rate coefficient	*P*-value	Catch rate coefficient	*P*-value	Harvest rate coefficient	*P*-value	Catch rate coefficient	*P*-value
All fish species	-0.166	0.055	0.242	0.004	--	--	--	--
Black crappie	-0.182	0.118	0.035	0.764	-0.208	0.262	0.226	0.221
Bluegill	-0.056	0.695	0.241	0.883	-0.313	0.157	0.249	0.263
Bullhead species	-0.392	0.004	-0.262	0.061	--	--	--	--
Crappie species	-0.131	0.256	0.019	0.867	-0.209	0.242	0.223	0.213
Largemouth bass	-0.343	0.000	-0.020	0.841	-0.661	0.000	0.108	0.475
Northern pike	-0.184	0.051	0.111	0.241	-0.293	0.024	0.100	0.451
Rainbow trout	-0.527	0.036	-0.579	0.019	--	--	--	--
Smallmouth bass	0.011	0.950	0.236	0.160	-0.715	0.001	-0.017	0.948
Sunfish species	-0.137	0.165	0.237	0.016	-0.057	0.718	0.237	0.125
Walleye	-0.236	0.012	0.130	0.177	0.053	0.669	0.460	0.000
Yellow perch	-0.251	0.013	-0.026	0.801	-0.356	0.256	0.276	0.385

rates decline, correlations indicate that anglers will often keep a higher percentage of their catch (Table 10). Second, winter anglers harvest smaller fish than summer anglers, which results in less fish being released.

Paired comparisons of the percentage of the catch released between targeting and all anglers did not differ significantly in most cases (Table 11). However, for all species that had a significant difference, targeting anglers released fewer fish than all anglers. Largemouth and smallmouth bass anglers were an exception, since targeting bass anglers released more of their catch than all anglers. We believe this to confirm that genuine catch-and-release fishing is more widely practiced with black bass than most other fish species in Minnesota, except for muskellunge (Younk and Cook 1992).

Size and Age of the Recreational Catch

Age and size of the recreational catch has been reported several ways in Minnesota including: mean length, mean weight, age frequencies, and length frequencies. Most creel survey reports contain mean weight and/or mean length values for the harvest, and length frequencies only for the most common species creeled. The age of the harvest has been infrequently reported. The catch curves (age and length) for the most desired species (crappie, northern pike, and walleye) have a steep ascending limb, while the slope of the descending limb is more gradual. This indicates that the minimum size at which a species becomes acceptable is relatively consistent from angler to angler, and probably lake to lake. Most species have some harvest of age 1 fish, and harvest increases noticeably by age 2. Nearly all comparisons of harvested versus released fish length frequencies show that most released fish are too small to be of an acceptable harvest size. Largemouth bass and muskellunge are the exception to this with many larger fish being released, and in recent years to a lesser degree, some large walleyes as well. As a rule, winter anglers usually harvest younger and smaller fish than summer anglers. This is especially true for bluegill, sauger, and walleye. The exceptions to this rule are the trout species, where winter anglers are more successful in harvesting larger and older fish than summer anglers. Several studies have shown that anglers can provide high quality length information for harvested fish (Ebbers 1977; and Ferguson et al. 1984). However, lengths reported by anglers can be more variable due to rounding by anglers, but not necessarily biased (Ferguson et al. 1984). We also observed this tendency for anglers to round fish lengths to even numbers (as opposed to odd numbers).

Table 11. Paired comparisons of the percentage of the catch released by all and targeting anglers fishing lakes in Minnesota as determined by creel survey.

			Percentage of catch released						
		Number of	All anglers			Targeting anglers			Wilcoxon
Species	Season	seasons	Median	Mean	SE	Median	Mean	SE	rank-sum
Black crappie	Summer	28	38	41	4.9	34	40	5.7	0.561
Bluegill	Summer	21	62	60	5.1	57	59	5.2	0.211
Crappie species	Summer	30	40	42	4.6	37	40	5.4	0.355
Crappie species	Winter	5	34	30	3.4	24	38	11.6	0.787
Largemouth bass	Summer	45	70	74	2.4	78	76	2.9	0.611
Northern pike	Summer	49	53	51	3.4	34	41	4.9	0.000
Northern pike	Winter	6	25	34	11.9	44	43	16.1	0.834
Smallmouth bass	Summer	14	74	70	4.6	79	74	5.4	0.925
Sunfish species	Summer	43	54	54	2.6	53	50	2.7	0.008
Sunfish species	Winter	5	67	65	8.8	70	61	13.3	0.787
Walleye	Summer	57	41	42	2.9	43	44	3.0	0.422
Walleye	Winter	15	41	46	6.9	33	39	8.4	0.094
Yellow perch	Summer	10	66	72	5.2	52	58	7.8	0.019
Yellow perch	Winter	5	40	44	6.4	33	26	8.0	0.281

More length and age information has been collected on the recreational catch of walleye than all other species combined in Minnesota creel surveys. In general, anglers harvested walleye of a greater mean size from Lake Classes 1, 2, 23, 24, 25, 26, and 41, with Lake Classes 2 and 26 yielding the highest proportions of large fish (Chi-square tests: $P < 0.001$). Winter anglers harvested younger and smaller walleye than summer anglers (Chi-square tests: $P < 0.001$). The harvest catch curves peaked at age 2 and 13 inches for winter anglers, and at age 3 and 14 inches for summer anglers (Tables 12-13 and Figure 12). During the summer, the largest walleye are harvested in October (Table 14). Length frequencies of walleye harvested in Minnesota were very similar to walleye length frequencies harvested from northern Wisconsin lakes (Staggs 1989). Less than 6% of the catch was over 20 inches in both states, so fish of quality or trophy sizes were relatively rare in the harvest. In Minnesota, over 90% of harvested walleye are 18 inches (approximately 2.2 pounds) or smaller (Figure 13). In addition, where catch-and-release information was available, most walleye longer than 12 inches were harvested (Table 15). Both winter and summer anglers are starting to release more walleye longer than 22 inches, but winter anglers release a smaller percentage. This is an encouraging trend, since most large fish reported released in creel surveys have been voluntarily released by anglers, rather than mandated releases by special or experimental regulations. We believe this trend toward releasing larger walleye to be very recent, but since few creel surveys before the 1980s reported the lengths of released walleye, it is impossible to quantify how much catch-and-release was practiced before then.

Statewide the walleye harvest has shifted over the years (Figure 14) to younger and smaller fish (Chi-square tests: $P < 0.001$). Median harvested walleye size declined from 15.8 inches and 1.8 pounds prior to 1970, to 14.7 inches and 1.2 pounds after 1970. Declines in walleye mean size at Lake Winnibigoshish is the most cited Minnesota example. Weight of harvested walleye declined from a mean of 2.3 pounds in 1938 and 2.2 pounds in 1939, to 1.1 pounds by 1977 (Stoudt and Eddy 1939; Johnson and Johnson 1971; Osborn and Schupp 1985). Since 1977, mean harvest weights have increased slightly in Lake Winnibigoshish to 1.6 pounds (Albert 1996). Year-class abundance has been shown to play an important role, and influences the

Table 12. Age frequencies of fish harvested by anglers from Minnesota lakes as determined by creel survey.

Species	Season	Number of lakes	Number of seasons	Number of fish	Percent of fish by age (years)														
					0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Black crappie	Summer	21	42	2,613	0.0	0.3	8.3	27.3	25.7	19.4	11.8	4.0	2.6	0.5	0.1	0.0	0.0	0.0	0.0
Black crappie	Winter	7	22	1,338	0.0	0.9	17.1	38.3	14.0	14.4	11.4	3.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Bluegill	Summer	22	37	3,761	0.0	0.0	14.5	14.9	13.7	30.3	12.2	5.4	5.0	3.5	0.4	0.0	0.0	0.0	0.0
Brook trout	Summer	6	14	2,605	0.5	85.5	11.3	2.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lake trout	Summer	6	12	1,068	0.0	0.0	1.1	19.6	32.8	27.4	12.5	3.5	3.2	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth bass	Summer	14	51	22,308	0.0	0.7	10.6	24.6	27.7	18.0	17.3	0.5	0.4	0.1	0.0	0.0	0.0	0.0	0.0
Northern pike	Summer	27	71	4,927	0.0	5.3	33.2	34.0	17.2	7.0	2.0	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0
Northern pike	Spearing	5	9	1,246	0.0	5.9	12.1	31.9	24.2	15.9	5.8	2.5	1.1	0.5	0.2	0.0	0.0	0.0	0.0
Rainbow trout	Summer	6	12	26,340	0.4	81.9	16.0	1.5	0.1	0 .0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth bass	Summer	15	24	739	0.0	0.1	1.5	27.2	21.4	26.0	15.2	5.4	2.0	1.0	0.3	0.0	0.0	0.0	0.0
Walleye	Summer	58	136	92,935	0.0	3.1	19.6	30.5	21.8	16.3	3.8	3.1	0.9	0.3	0.2	0.3	0.0	0.0	0.0
Walleye	Winter	10	21	8,506	0.2	7.3	39.1	14.8	16.5	9.6	5.8	4.3	1.0	0.7	0.4	0.1	0.0	0.0	0.1

Table 13. Length frequencies of predator species caught by anglers from Minnesota lakes as determined by creel survey.

Species	Season	Number of lakes	Number of seasons	Number of fish	Percent of fish by length (inches)																		
					≤4.9	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	≥39
										Harvested fish													
Lake trout	Summer	8	20	1,613	0.0	0.0	0.0	0.4	6.4	30.3	41.2	12.0	4.3	2.7	1.5	0.5	0.6	0.1	0.0	0.0	0.0	0.0	0.0
Lake trout	Winter	24	81	4,552	0.1	0.4	2.1	8.1	14.1	24.7	20.5	12.1	8.3	5.0	2.4	1.3	0.6	0.3	0.0	0.0	0.0	0.0	0.0
Northern pike	Summer	111	193	18,262	0.0	0.0	0.1	0.2	0.4	1.8	7.5	18.0	22.1	20.0	13.9	7.2	4.1	1.9	1.2	0.8	0.5	0.2	0.2
Northern pike	Winter angling	31	36	1,455	0.0	0.0	0.0	0.0	0.1	0.6	5.9	16.8	27.2	23.0	13.8	6.9	2.5	1.4	1.0	0.4	0.2	0.1	0.0
Northern pike	Spearing	33	40	3,492	0.0	0.0	0.0	0.0	0.2	0.3	1.0	5.9	12.4	20.7	19.5	13.7	10.1	6.6	4.0	3.1	1.5	0.8	0.2
Walleye	Summer	122	236	161,562	0.0	0.0	0.1	2.4	17.1	34.5	25.8	11.4	4.6	2.2	1.1	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
Walleye	Winter	52	95	21,937	0.0	0.0	0.6	7.1	7.1	29.0	23.4	11.4	5.0	2.4	1.3	0.7	0.3	0.1	0.0	0.0	0.0	0.0	0.0
										Released fish													
Northern pike	Summer	21	24	7,177	0.0	0.2	0.4	1.8	10.1	21.4	21.7	16.3	13.6	5.9	5.2	1.7	0.9	0.5	0.0	0.1	0.1	0.0	0.0
Northern pike	Winter	7	8	77	0.0	0.0	0.0	1.1	23.0	19.5	16.1	20.7	13.8	3.4	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Walleye	Summer	18	28	25,465	0.0	1.7	9.1	33.7	36.9	11.5	3.3	0.9	0.4	0.4	0.6	0.7	0.6	0.1	0.0	0.0	0.0	0.0	0.0
Walleye	Winter	6	13	2,903	0.1	3.6	11.0	53.0	27.3	4.1	0.3	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0

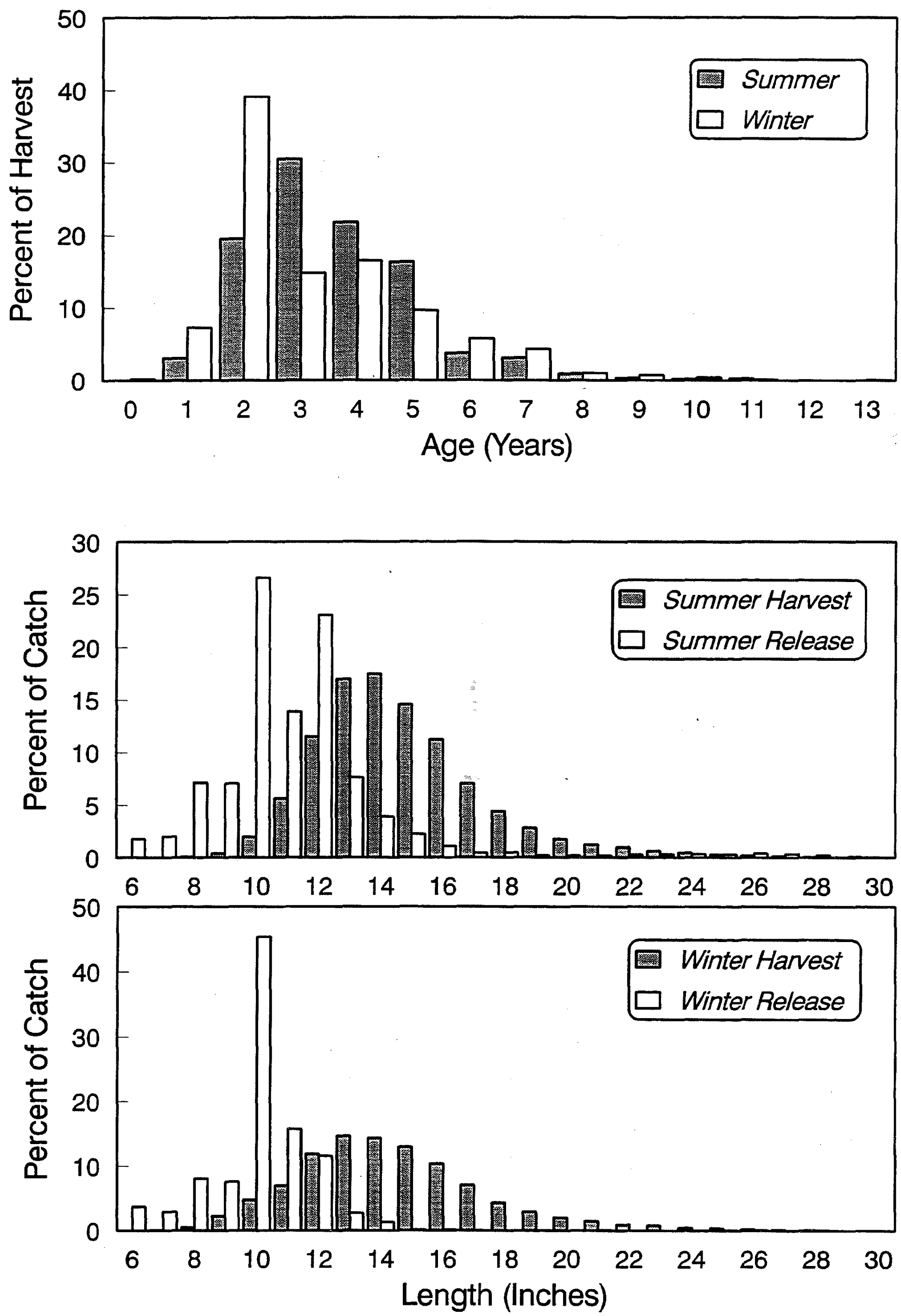


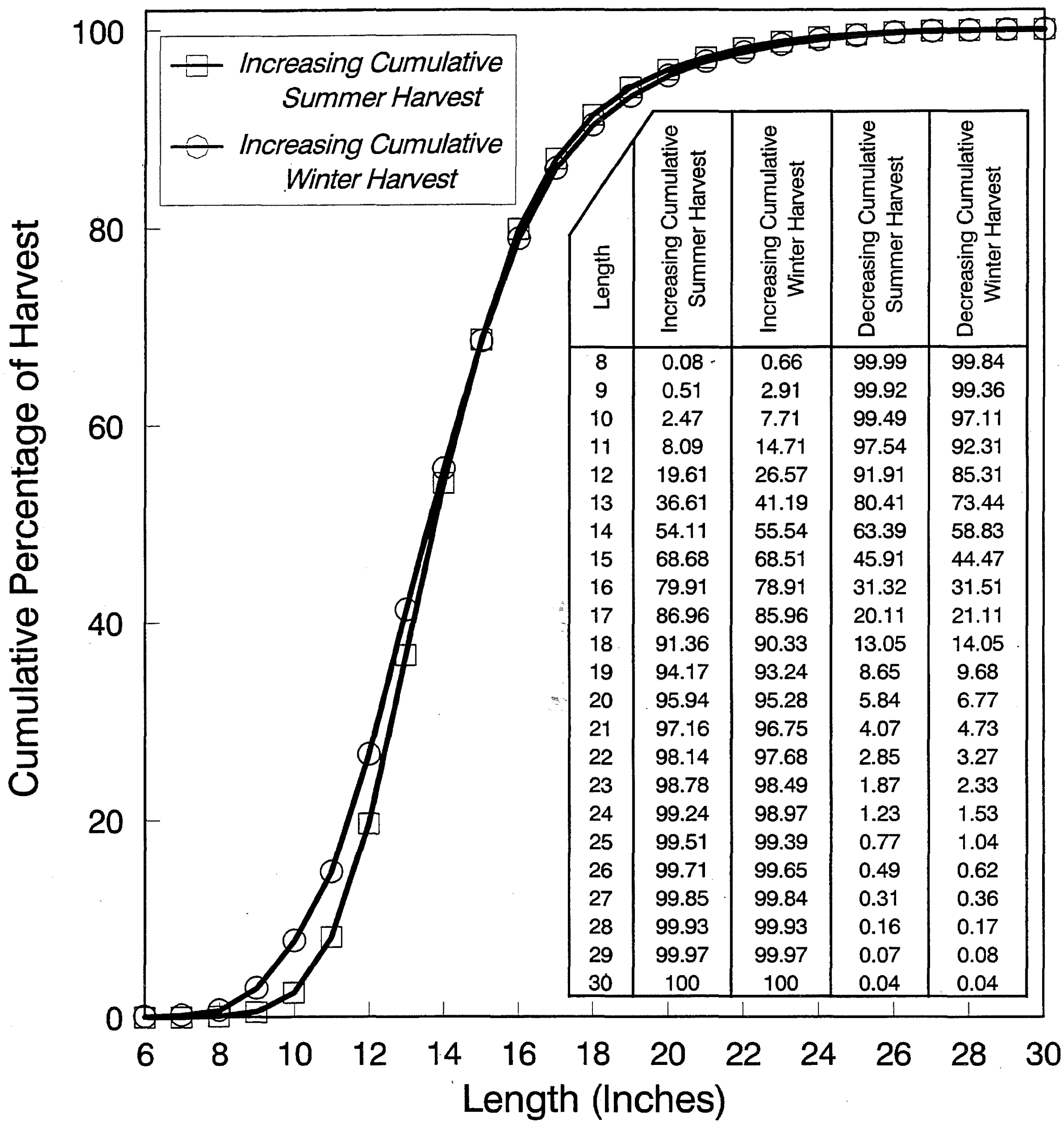
Figure 12. Distributions of angler harvested walleye ages (top), and length frequencies of harvested and released walleye (bottom) from Minnesota lakes as determined by creel survey.

Table 14. Mean length and weight of rainbow trout, brook trout, northern pike, and walleye harvested from Minnesota lakes as determined by creel survey.

	Length (inches)					Weight (pounds)				
Strata	Number of lakes	Number of seasons	Median	Mean	SE	Number of lakes	Number of seasons	Median	Mean	SE
				Brook trout						
Opening	5	6	8.7	9.2	0.7	5	6	0.2	0.3	0.1
May	5	7	8.4	9.1	0.5	5	7	0.2	0.3	0.1
June	5	7	9.3	9.1	0.3	5	7	0.3	0.3	0.0
July	5	7	10.3	10.0	0.5	5	7	0.4	0.4	0.1
August	4	6	11.4	11.0	0.7	4	6	0.6	0.6	0.1
September	5	6	12.3	11.7	0.8	5	6	0.7	0.6	0.1
				Rainbow trout						
Opening	5	8	9.8	10.2	0.4	4	5	0.4	0.5	0.1
May	6	10	10.2	10.6	0.5	6	8	0.4	0.3	0.1
June	6	9	10.0	10.4	0.4	6	7	0.5	0.5	0.1
July	6	9	11.1	11.5	0.5	7	8	0.6	0.7	0.1
August	6	9	11.5	11.7	0.6	6	7	0.7	0.7	0.1
September	6	9	12.1	11.7	0.7	6	7	0.7	0.6	0.1
				Northern pike						
May	-	-	-	-	-	6	24	3.1	3.6	0.4
June	-	-	-	-	-	4	18	2.8	3.2	0.3
July	-	-	-	-	-	4	18	3.6	3.7	0.3
August	-	-	-	-	-	4	17	5.2	4.6	0.3
September	-	-	-	-	-	5	21	3.8	4.8	0.6
October	-	-	-	-	-	2	7	6.3	6.3	1.1
				Walleye						
May	-	-	-	-	-	7	30	1.2	1.4	0.1
June	-	-	-	-	-	6	22	1.5	1.5	0.1
July	-	-	-	-	-	6	22	1.6	1.5	0.1
August	-	-	-	-	-	6	19	1.4	1.6	0.1
September	-	-	-	-	-	6	23	1.5	1.4	0.1
October	-	-	-	-	-	2	10	1.7	1.7	0.2

mean sizes and ages of walleye harvested from Lake Winnibigoshish (Osborn and Schupp 1985; Albert 1996). However, we consider the chances of harvested walleye mean weights ever exceeding 2 pounds again to be extremely unlikely, without the implementation of special regulations to restrict the harvest. In another long-term study, the harvest of Atlantic salmon from the River Severn (1940-1989) shifted from 3 and 4 year old fish to 1 year old fish (Churchward and Hickley 1991). The authors also mention that annual reports of trophy fish (>30 pounds) were once common, but were almost unheard of when the study was published.

Less information has been reported for the two other percids in the creel of Minnesota anglers, sauger and yellow perch. Sauger are found primarily in Lake Classes 2 and 26, of those Lake Class 26 yields larger fish. Winter anglers harvested smaller sauger (Table 16) than summer anglers (Chi-square: $P < 0.001$), though winter length frequencies were only from Lake of the Woods. Winter anglers also harvest slightly smaller yellow perch than summer anglers (Table 17), although length frequencies for both groups peak at 9 inches (Table 16). The largest yellow perch are harvested from Lake Class 26.



Length	Increasing Cumulative Summer Harvest	Increasing Cumulative Winter Harvest	Decreasing Cumulative Summer Harvest	Decreasing Cumulative Winter Harvest
8	0.08	0.66	99.99	99.84
9	0.51	2.91	99.92	99.36
10	2.47	7.71	99.49	97.11
11	8.09	14.71	97.54	92.31
12	19.61	26.57	91.91	85.31
13	36.61	41.19	80.41	73.44
14	54.11	55.54	63.39	58.83
15	68.68	68.51	45.91	44.47
16	79.91	78.91	31.32	31.51
17	86.96	85.96	20.11	21.11
18	91.36	90.33	13.05	14.05
19	94.17	93.24	8.65	9.68
20	95.94	95.28	5.84	6.77
21	97.16	96.75	4.07	4.73
22	98.14	97.68	2.85	3.27
23	98.78	98.49	1.87	2.33
24	99.24	98.97	1.23	1.53
25	99.51	99.39	0.77	1.04
26	99.71	99.65	0.49	0.62
27	99.85	99.84	0.31	0.36
28	99.93	99.93	0.16	0.17
29	99.97	99.97	0.07	0.08
30	100	100	0.04	0.04

Figure 13. Cumulative percentage of the summer and winter walleye harvest from Minnesota lakes as determined by creel survey. Actual values for increasing and decreasing cumulative percentages are listed in the table insert.

Table 15. Percent of fish released by length group for selected species caught by anglers (both winter and summer) in Minnesota lakes as determined by creel survey. Except for walleye, sample sizes were not large enough to separately describe species release rates by season.

Species	Number of lakes	Number of seasons	Number of fish	Percent of fish by length (inches) ≤3.9	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	≥38
Northern pike	28	32	10,658	-	100	93	80	89	95	92	72	60	50	32	46	39	39	28	25	22	17	0
Walleye - summer	24	41	66,393	100	99	100	96	85	48	12	4	6	7	17	29	44	50	36	-	-	-	-
Walleye - winter	7	13	6,474	-	95	99	92	84	32	5	1	1	3	1	6	11	27	0	-	-	-	-

Species	Number of lakes	Number of seasons	Number of fish	Percent of fish by length (inches) ≤3.9	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	≥21
Black crappie	16	17	2,730	100	97	93	93	39	18	10	10	1	1	-	-	-	-	-	-	-	-	-
Bluegill	12	14	5,823	100	98	95	69	30	6	2	-	-	-	-	-	-	-	-	-	-	-	-
Largemouth bass	14	15	1,398	100	100	100	97	100	98	85	90	71	76	69	71	68	59	59	60	77	75	100
Smallmouth bass	6	6	2,346	100	100	100	100	100	99	96	77	32	15	8	42	38	9	0	0	-	-	-

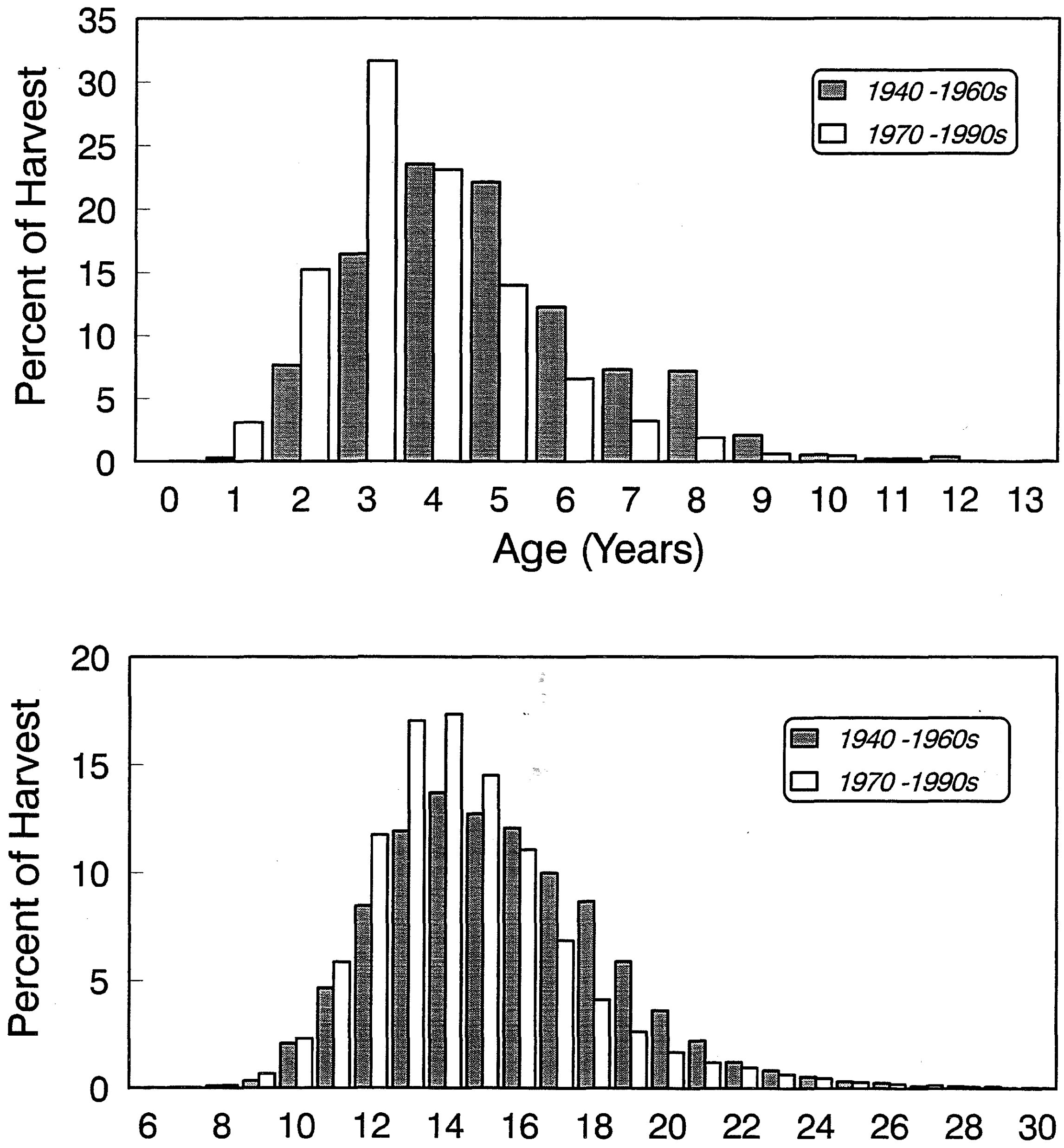


Figure 14. Decade comparisons of angler harvested walleye ages (top) and length frequencies of harvested walleye (bottom) from Minnesota lakes as determined by creel survey.

Table 16. Length frequencies of game fish species caught by anglers from Minnesota lakes as determined by creel survey.

Species	Season	Number of lakes	Number of seasons	Number of fish	Percent of fish by length (inches) ≤3.9	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	≥21
Harvested fish																							
Black bullhead	Summer	17	18	1,342	0.0	0.0	1.3	1.3	2.8	19.4	39.1	26.1	9.2	0.8	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Black crappie	Summer	89	134	8,787	0.0	0.0	0.1	2.3	10.8	25.9	27.8	15.8	9.0	5.6	2.1	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Black crappie	Winter	46	58	6,158	0.0	0.0	0.1	1.7	10.4	32.4	33.4	13.1	6.1	1.6	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bluegill	Summer	81	108	16,374	0.0	0.3	3.9	30.9	44.3	16.4	3.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bluegill	Winter	44	50	3,837	0.0	0.3	8.6	48.4	32.6	8.6	1.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brook trout	Summer	7	12	4,574	0.0	1.4	9.0	31.7	35.6	14.3	3.4	1.3	1.6	0.9	0.3	0.5	0.1	0.0	0.0	00	0.0	0.0	0.0
Brook trout	Winter	10	13	555	0.0	5.8	8.3	6.7	10.3	18.7	17.1	18.4	6.9	1.1	2.9	1.3	1.4	1.3	0.0	0.0	0.0	0.0	0.0
Largemouth bass	Summer	82	109	3,102	0.0	0.0	0.0	0.4	0.8	2.0	4.7	8.6	15.0	18.1	16.3	14.2	8.5	5.2	3.3	1.9	0.8	0.3	0.0
Largemouth bass	Winter	16	17	128	0.0	0.0	0.0	0.0	0.0	1.6	0.0	6.3	1.3	27.3	15.6	14.8	8.6	7.0	1.6	3.1	0.0	0.8	0.0
Pumpkinseed	Summer	42	60	1,124	0.0	1.2	11.9	42.0	36.7	7.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rainbow trout	Summer	17	39	7,149	0.0	0.0	0.6	3.2	10.6	18.4	17.7	13.7	10.3	10.4	7.1	3.4	1.9	1.7	0.5	0.2	0.1	0.1	0.0
Rainbow trout	Winter	17	30	919	0.0	0.0	0.0	2.5	2.6	3.9	3.7	9.0	10.5	20.0	18.5	13.5	6.4	4.2	1.6	0.7	0.4	0.9	1.5
Rock bass	Summer	44	56	2,157	0.1	0.0	1.0	5.4	19.1	31.2	28.7	12.1	2.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sauger	Summer	6	38	14,268	0.0	0.0	0.0	0.0	0.1	0.3	2.4	9.2	17.5	21.3	20.4	15.9	8.7	3.2	0.8	0.2	0.1	0.0	0.0
Sauger	Winter	1	7	15,522	0.0	0.0	0.0	0.0	0.1	0.6	6.8	16.7	24.0	17.9	16.8	10.1	4.9	1.5	0.4	0.1	0.0	0.0	0.0
Smallmouth bass	Summer	36	78	2,626	0.0	0.0	0.0	0.2	1.3	3.5	8.4	15.3	19.6	18.9	13.2	8.5	4.7	3.7	1.6	1.0	0.2	0.0	0.0
White crappie	Summer	12	12	363	0.0	0.0	0.3	1.1	12.1	39.4	30.6	11.9	3.9	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White crappie	Winter	7	7	199	0.0	0.0	0.0	1.0	12.6	43.2	31.7	6.5	3.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow perch	Summer	76	120	20,411	0.0	0.1	0.5	2.7	10.3	28.2	31.3	18.4	6.7	1.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow perch	Winter	37	56	31,557	0.0	0.5	1.6	5.9	13.4	24.4	27.2	19.3	6.1	1.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Released fish																							
Black crappie	Summer	10	11	599	0.0	1.0	15.5	20.5	27.7	21.0	8.7	4.8	0.3	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Black crappie	Winter	6	6	149	0.7	14.8	14.1	60.4	8.7	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bluegill	Summer	7	8	3,715	3.1	11.1	37.0	38.7	9.0	0.4	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bluegill	Winter	6	6	280	12.1	48.2	36.8	2.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth bass	Summer	25	26	1,788	0.6	0.7	1.3	2.9	1.9	8.5	6.1	9.4	8.4	15.5	11.1	15.6	8.5	4.3	2.1	2.1	0.7	0.5	0.3
Pumpkinseed	Summer	3	4	138	4.4	12.3	49.3	23.9	6.5	2.9	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rainbow trout	Summer	2	2	81	0.0	0.0	0.0	0.0	9.9	29.6	0.0	9.9	3.7	17.3	0.0	4.9	0.0	17.3	3.7	2.5	0.0	1.2	0.0
Rock bass	Summer	5	6	1,045	0.6	2.6	8.7	21.8	16.7	15.0	11.4	16.9	2.3	3.8	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth bass	Summer	6	6	1,816	0.1	0.3	1.1	24.0	11.2	21.9	21.3	12.0	3.3	1.2	0.3	1.8	1.3	0.2	0.0	0.0	0.0	0.1	0.0
Yellow perch	Summer	11	11	2,556	3.6	17.3	25.5	25.6	13.6	7.2	3.6	2.2	0.8	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow perch	Winter	1	8	9,576	1.3	9.7	20.4	39.5	20.8	6.5	1.1	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 17. Historical mean fish sizes of the recreational catch from Minnesota lakes as determined by creel survey.

		Length (inches)					Weight (pounds)				
Species	Season	Number of lakes	Number of seasons	Median	Mean	SE	Number of lakes	Number of seasons	Median	Mean	SE
Harvested fish											
Black bullhead	Summer	23	24	9.4	9.9	0.4	56	61	0.5	0.6	0.1
Black crappie	Summer	66	79	10.1	10.3	0.2	133	216	0.5	0.6	0.0
Black crappie	Winter	32	38	9.3	9.5	0.2	42	58	0.5	0.6	0.0
Bluegill	Summer	54	62	7.3	7.3	0.1	99	123	0.3	0.3	0.0
Bluegill	Winter	27	29	6.8	6.9	0.1	37	40	0.3	0.4	0.0
Brook trout	Summer	7	8	9.1	9.7	0.5	12	25	0.4	0.5	0.1
Brook trout	Winter	16	23	11.4	11.2	0.3	10	14	0.5	0.5	0.1
Brown bullhead	Summer	5	5	11.1	11.8	0.7	15	17	0.8	0.9	0.1
Brown trout	Summer	1	1	12.9	12.9	-	3	6	1.0	1.6	0.8
Bullhead species	Summer	31	34	10.0	10.4	0.4	96	169	0.8	0.8	0.0
Burbot	Winter	8	11	22.9	23.0	1.0	8	28	1.8	2.2	0.2
Channel catfish	Summer	2	2	16.0	16.0	2.0	4	5	1.6	1.5	0.2
Crappie species	Summer	60	74	10.3	10.4	0.2	154	282	0.6	0.6	0.0
Crappie species	Winter	23	28	9.7	9.9	0.3	49	81	0.5	0.6	0.0
Lake trout	Summer	13	32	15.5	16.9	0.6	7	41	1.9	2.1	0.2
Lake trout	Winter	26	106	16.6	16.6	0.3	33	88	1.7	2.0	0.1
Largemouth bass	Summer	65	80	12.9	12.7	0.2	140	230	1.2	1.4	0.1
Largemouth bass	Winter	21	22	13.5	13.5	0.4	22	28	1.6	1.7	0.2
Northern pike	Summer	99	159	21.9	21.8	0.2	183	431	2.4	2.6	0.1
Northern pike	Winter	48	58	22.4	22.6	0.4	73	166	3.1	3.4	0.1
Pumpkinseed	Summer	28	35	6.6	6.4	0.1	48	56	0.2	0.2	0.0
Rainbow trout	Summer	25	38	12.3	12.3	0.4	23	80	0.8	1.0	0.1
Rainbow trout	Winter	17	30	14.8	14.6	0.4	19	33	1.0	1.2	0.1
Rock bass	Summer	27	36	8.4	8.3	0.1	61	131	0.6	0.6	0.0
Sauger	Summer	6	22	12.9	12.9	0.2	7	54	0.7	0.7	0.0
Smallmouth bass	Summer	35	64	12.4	12.4	0.2	46	123	1.2	1.3	0.0
Splake	Summer	5	7	14.6	16.6	1.9	4	6	1.6	1.5	0.3
Splake	Winter	13	15	12.3	12.0	0.5	8	9	0.8	1.0	0.2
Sunfish species	Summer	27	29	7.1	7.2	0.2	122	213	0.3	0.4	0.0
Sunfish species	Winter	19	20	7.0	7.1	0.2	49	66	0.3	0.3	0.0
Walleye	Summer	96	190	14.7	15.2	0.2	159	397	1.3	1.6	0.1
Walleye	Winter	46	73	14.8	15.1	0.3	60	130	1.5	1.7	0.1
White bass	Summer	5	5	12.1	12.7	1.5	13	19	1.2	1.2	0.1
White crappie	Summer	18	18	8.7	8.8	0.1	26	27	0.4	0.0	0.4
White crappie	Winter	6	6	8.4	9.1	0.7	8	8	0.5	0.5	0.1
Yellow bullhead	Summer	2	2	10.8	10.8	0.1	9	9	0.7	0.7	0.1
Yellow perch	Summer	74	104	8.8	8.8	0.1	134	302	0.4	0.4	0.0
Yellow perch	Winter	34	49	8.5	8.2	0.2	49	92	0.4	0.4	0.0
Released fish											
Black crappie	Summer	7	8	7.1	7.1	0.4	2	3	0.4	0.4	0.1
Black crappie	Winter	3	3	6.1	6.1	0.3	-	-	-	-	-
Bluegill	Summer	7	8	5.7	5.5	0.2	2	3	0.2	0.2	0.0
Bullhead species	Summer	2	3	9.7	9.2	1.0	-	-	-	-	-
Crappie species	Summer	8	9	7.0	7.1	0.4	3	3	0.4	0.4	0.1
Crappie species	Winter	3	3	6.1	6.1	0.3	-	-	-	-	-
Largemouth bass	Summer	10	10	10.5	10.4	0.8	3	3	1.6	1.6	0.1
Northern pike	Summer	12	14	17.0	17.6	1.0	4	6	2.3	2.9	0.8
Northern pike	Winter	3	3	20.0	18.6	2.3	-	-	-	-	-
Pumpkinseed	Summer	4	5	5.2	5.3	0.2	2	3	0.2	0.2	0.0
Smallmouth bass	Summer	6	6	9.1	9.2	0.4	2	2	0.6	0.6	0.2
Sunfish species	Summer	5	5	5.0	4.9	0.2	-	-	-	-	-
Sunfish species	Winter	4	4	4.7	4.5	0.2	-	-	-	-	-
Walleye	Summer	12	13	11.1	11.7	1.1	4	12	0.5	0.6	0.1
Walleye	Winter	4	4	8.7	9.0	0.6	1	8	0.4	0.4	0.1
Yellow perch	Summer	4	10	5.3	5.7	0.3	4	4	0.2	0.1	0.0
Yellow perch	Winter	4	4	5.4	5.2	0.2	1	4	0.1	0.1	0.0

Lake Classes 1, 26, and 43 produce northern pike of larger mean size than other lake classes. During summer, harvested northern pike mean size is smallest in June, and mean size progressively increases until October (Table 14). Most northern pike released by summer and winter anglers are smaller than 21 inches (Table 13), and the released fish length distributions were significantly smaller than harvested fish (Chi-square tests: $P = 0.000$). In general, the larger a northern pike is, the less likely it is to be released (Table 15).

Largemouth bass harvest peaks at age 3 (Table 12) and 12 inches (Table 16). Nearly all largemouth bass less than 9 inches were released, the release rate decreased from 10 to16 inches, but beyond 17 inches the percentage of fish released increased (Table 15). These data show that more catch-and-release is practiced with largemouth bass than with any other species. In spite of this, creel survey evidence suggests that the median size of largemouth bass harvested has decreased 0.5 pounds through the years (Wilcoxon rank-sum: $P < 0.001$), from 1.6 pounds during the early years (1930-1960) to 1.1 pounds (1970-1990). Relatively little information exists on lengths of smallmouth bass caught, but length distributions indicate most smallmouth bass longer than 9 inches are harvested (Table 15). The majority of smallmouth bass harvested are 3-6 years old and between 9-14 inches long (Tables 12 and 16). Available data suggests that catch-and-release may not be as widely practiced with smallmouth bass as it is with largemouth bass (Table 15).

Panfish are a favorite target for many Minnesota anglers, but the harvest size has been inconsistently reported. We summarized panfish mean lengths, weights (Table 17), and length frequencies (Table 16) when sufficient samples were available. Black crappie are accepted by anglers at age 2 (Table 12) and 8 inches long (Table 16), and very few over 8 inches are released (Table 15). The crappie lengths and ages in the harvest suggest that catch-and-release is not practiced with black crappie. The average size of harvested black crappie was about 1 inch larger than white crappie, during both winter and summer (Table 17). Approximately 30% of 6 inch long bluegill were harvested, whereas at only 1 inch longer, 70% of 7 inch bluegill were harvested (Table 15). Length frequency analysis revealed that higher proportions of larger bluegill were harvested in the 1950-70s (Figure 15) than in 1980-90s (Chi-square test: $P < 0.001$). The proportion of large bluegill and black crappie harvested by anglers in Wisconsin lakes has also decreased (Beard et al. 1992). Winter anglers harvest significantly smaller bluegill (Chi-square: $P < 0.001$) than summer anglers (Tables 16 and 17). Mean length of harvested pumpkinseed is about 0.5 inches smaller than bluegill (Table 17).

Trout are stocked as fingerlings or yearlings, in late fall or early spring, and grow rapidly throughout the summer as reflected in the harvest sizes (Table 14). The slight increase in rainbow trout harvest size during May is likely due to the harvest of winter carry-over fish. Most stream trout are harvested by age 2 from Minnesota lakes (Figure 16). The mean size of harvested rainbow trout was largest from the northeast Minnesota lake classes (1-19). The obvious reason for this would be lower fishing pressure due to location and limited access to some of these lakes. Summer anglers harvested smaller brook, rainbow, and lake trout (Chi-square tests: $P < 0.001$) than winter anglers (Table 17). Length frequencies indicate that anglers in the 1980-90s harvested larger rainbow trout (Figure 17) than anglers who fished the 1950-70s (Chi-square, $P < 0.001$). This mimics the finding of Olson and Cunningham (1989), who attributed larger rainbow trout to successful fisheries management programs.

Summer anglers start to harvest lake trout about age 3, while winter anglers begin to harvest lake trout at age 5. The oldest and largest lake trout were harvested from Lake Superior. Contrary to other trout species, the summer angler harvests larger splake than winter anglers, but sample sizes are much smaller than other species of trout.

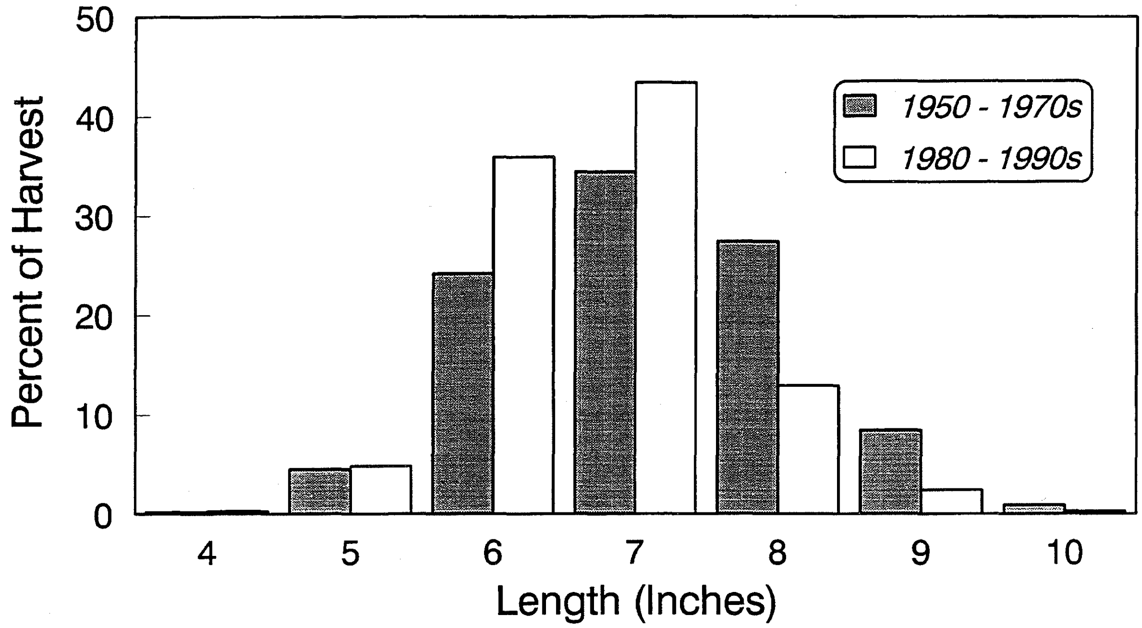


Figure 15. Decade comparisons of angler harvested bluegill lengths from Minnesota lakes as determined by creel survey.

Interrelationships of Creel Estimates

We compared two lake productivity indices to actual fish yields from Minnesota lakes: the Morphoedaphic Index (MEI: Ryder 1965) and the Trophic State Index (TSI: Carlson 1977). Regression analyses revealed that both MEI and TSI were positively related to recreational yields, but coefficients of variation were low for both regressions (Figure 18). Although both regressions were significant, more variation in yield was explained by MEI than TSI (Table 18). Angler selectivity undoubtedly plays the biggest role in the lack of fit with these regressions, since many species are rarely harvested by anglers. We suspect that if anglers pursued and harvested all species (e.g., common carp, bullheads and catastomids, etc.) there would be significant improvement in these regressions. Neither MEI or TSI showed promise for predicting fish yield from Minnesota lakes. In comparing MEI indices to sport fishing harvests from reservoirs across the U.S., the relationship was determined to be curvilinear with little variation in harvest explained (R^2 = 0.28: Jenkins and Morais 1971; R^2 = 0.08 Jenkins 1982). As Jenkins (1982) stated, low values of R^2 for this relationship are not surprising considering the many other factors that influence angling. In studies of the relationship between fish yields and water quality in Finnish lakes, water quality variables were also found to be poor predictors of fish yields (Ranta and Lindström 1990; Ranta et al. 1992).

The relationship of bigger water bodies producing more fish biomass has been previously described (Jenkins and Morais 1971; Youngs and Heimbuch 1982). Surface acreage of Minnesota lakes was significantly correlated with the total number and weight of fish harvested (Table 18). Lake size was better correlated with total weight of harvest than with total numbers harvested. By regressing total fish catch of a lake against lake area, Ranta and Lindström (1989) accounted for 72% of the variation in fish catch from Finnish lakes. Similarly, our regressions explained slightly more than 70% of variation in yield. Youngs and Heimbuch (1982) explained 94% of the

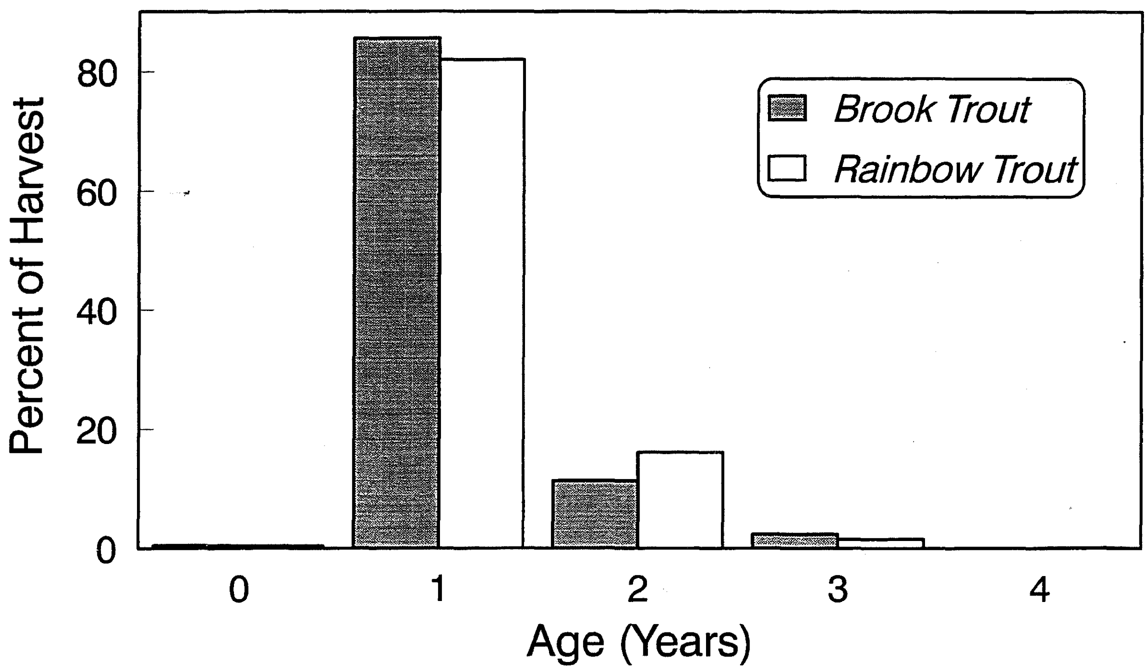


Figure 16. Age frequencies of rainbow and brook trout harvested by anglers from Minnesota lakes as determined by creel survey.

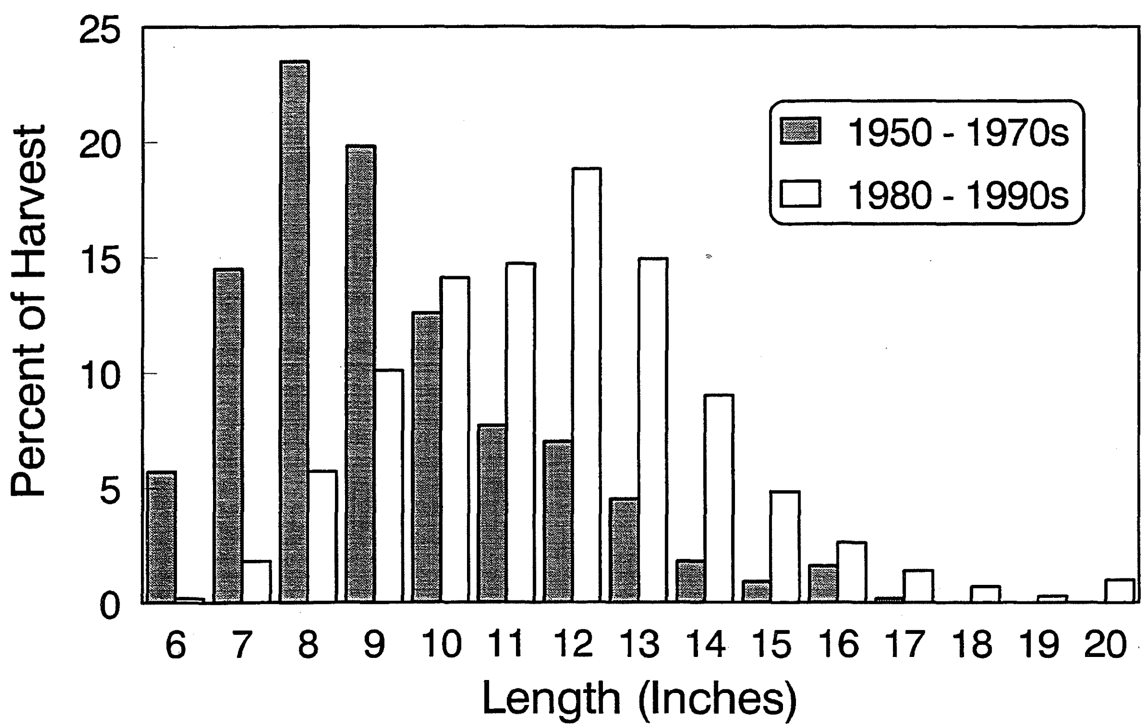


Figure 17. Decade comparisons of angler harvested rainbow trout lengths from Minnesota lakes as determined by creel survey.

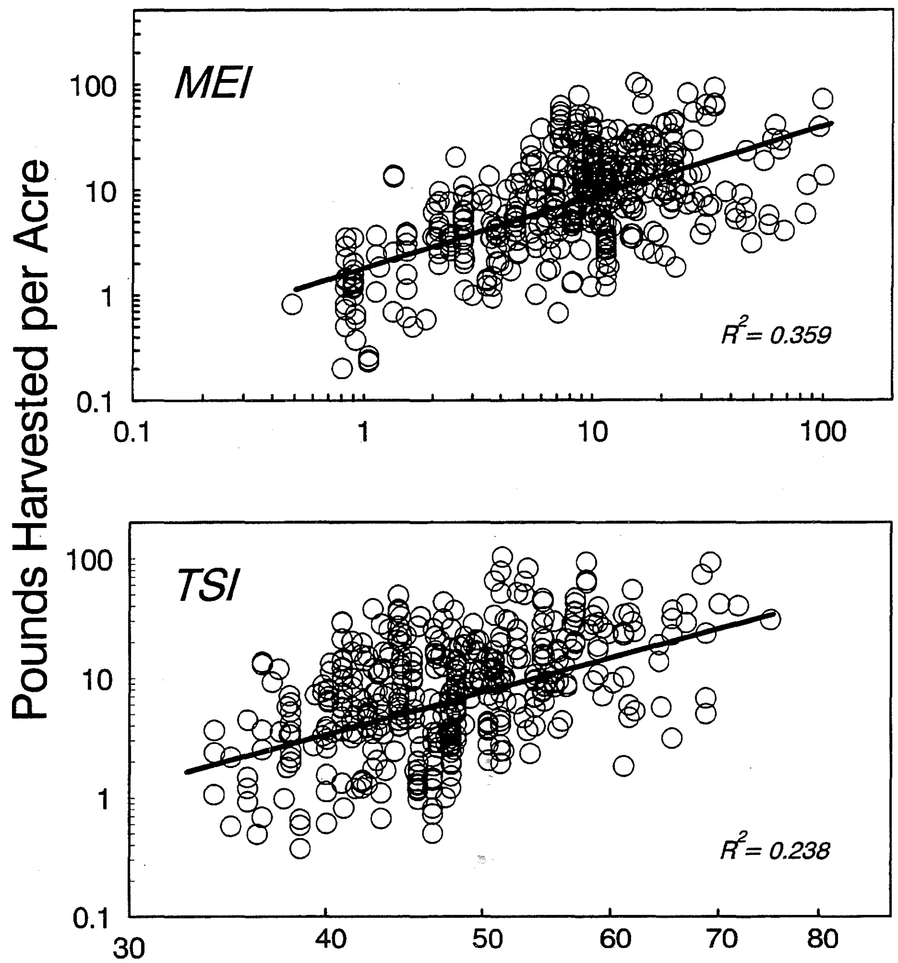


Figure 18. Least-square regressions of total fish harvest (pounds per acre) and two lake productivity indices, Morphoedaphic Index (MEI) and Trophic State Index (TSI).

Table 18. Correlation coefficients of lake acreage, percent littoral area , MEI, and TSI with total number or weight harvested by anglers from Minnesota lakes as determined by creel survey. All variables were transformed with $\log^{10}$.

Independent variable	Dependant variable	*N*	Slope	R^2	Probability	Press -R^2
Lake acreage	Number harvested	530	Positive	0.527	0.000	0.524
Lake acreage	Weight harvested	509	Positive	0.725	0.000	0.723
Lake acreage	Number harvested per acre	529	Negative	0.248	0.000	0.243
Lake acreage	Weight harvested per acre	512	Negative	0.180	0.000	0.174
Morphoedaphic Index	Weight harvested per acre	489	Positive	0.359	0.000	0.353
Trophic State Index	Weight harvested per acre	466	Positive	0.238	0.000	0.232
Percent littoral area	Number harvested per acre	507	Positive	0.159	0.000	0.152
Percent littoral area	Weight harvested per acre	493	Positive	0.152	0.000	0.145

variation in yield with surface area, but lakes in their study spanned a much larger size range than ours. Potter (1995) also used lake area in developing regression equations of species specific yield from Wisconsin lakes. Harvest per acre was found to decrease with increasing lake size of Minnesota lakes (Table 18). Thus, it can be assumed, that the smaller the lake, the more likely it is that anglers will potentially affect the fish population. Here again we want to stress, although lake size may slow noticeable changes in fish populations due to angling, no lake in Minnesota is immune from these changes due to size alone. The percent littoral area of lakes was positively correlated to total fish yield, for both numbers and weight (Table 18), although percent littoral area explained very little of the variation in total harvest.

Yield (numbers or pounds per acre) was positively correlated to fishing pressure per acre (Table 19), except for walleye harvested from non-classic walleye lakes which had a nonsignificant negative relationship. Previous investigators have also reported positive relationships between fishing pressure and total harvest, including Scidmore's (1961) analysis of bass-panfish lakes from Minnesota and Michigan. Positive relationships between yield and fishing effort have also been described for Finnish lakes (Ranta et al. 1992)

Table 19. Correlation coefficients of fishing pressure with numbers harvested, weight harvested, all angler harvest rate, and targeting anglers harvest rate. Fishing pressure, numbers, and weight harvested were standardized on a per acre basis, while harvest rates were based on fish per hour. Correlation coefficients that were not statistically significant are indicated by NS ($P > 0.1$).

	Number harvested		Harvest weight		All angler harvest rate		Targeting angler harvest rate	
Species or lake type	Pearson correlation coefficient	*N*	Pearson correlation coefficient	*N*	Pearson correlation coefficient	*N*	Pearson correlation coefficient	*N*
Bullhead species	0.412	188	0.428	146	0.134	184	-0.172^{NS}	10
Brook trout	0.644	28	0.593	28	0.331	27	-	-
Lake trout	0.222	63	0.049^{NS}	33	-0.209	63	-0.447^{NS}	10
Largemouth bass	0.552	261	0.518	248	-0.164	251	-0.258	67
Northern pike	0.547	458	0.647	441	-0.111	443	0.127^{NS}	119
Rainbow trout	0.889	117	0.871	67	0.278	111	0.291^{NS}	4
Rock bass	0.276	163	0.266	132	-0.047^{NS}	159	-	-
Smallmouth bass	0.252	136	0.350	102	0.127^{NS}	157	0.070^{NS}	46
Sunfish species	0.703	256	0.698	222	0.327	247	0.122^{NS}	60
Yellow perch	0.378	351	0.246	313	0.049^{NS}	345	0.258^{NS}	20
			All fish species					
By individual lakes	0.874	548	0.865	520	0.240	541	-	-
By lake class	0.880	36	0.723	36	0.228	36	-	-
			Crappie species					
In all lakes	0.714	296	0.663	254	0.392	294	0.014^{NS}	73
Classic crappie lakes	0.666	164	0.580	145	0.257	157	-0.265^{NS}	30
Non-classic crappie lakes	0.698	132	0.686	109	0.409	137	0.070	43
			Walleye					
In all lakes	0.189	421	0.259	400	-0.481	403	-0.240	133
Classic walleye lakes	0.670	186	0.724	177	-0.392	177	-0.247	74
Non-classic walleye lakes	-0.003^{NS}	235	0.045^{NS}	223	-0.349	226	0.093^{NS}	59

and a high correlation between angler-hours per acre and pounds harvested per acre from reservoirs across the U.S. was described by Jenkins and Morais (1971). Species that are likely to be harvested by anglers (or preferred) such as brook and rainbow trout, sunfish, crappie, and walleye have the highest correlation coefficients (Table 19). Species that many anglers consider less fit for table fare such as black bass, bullhead, and rock bass had lower correlation coefficients with fishing pressure. Correlation coefficients were also found to vary between species in Finnish lakes (Ranta et al. 1992).

Harvest rates were more likely to be negatively correlated with fishing pressure (Table 19), especially for long-lived predatory fish such as northern pike, walleye, and lake trout. Although statistically significant, none of these negative relationships were extremely strong based on correlation coefficients. Obviously, other factors such as population size, available forage, angler selectivity, and weather conditions also influence the harvest rate. Nonetheless, as fishing pressure increases, the harvest per angler-hour of these predatory species would be expected to decrease. Interestingly, in a survey of walleye anglers, Quinn (1992) found that "too many anglers" was considered unimportant in contributing to poor walleye fishing. Although it was unclear from the survey results whether 'too many anglers" was interpreted to be crowding at a fishing location or a component of over-harvest caused by anglers. In either case, our data suggests that fisheries personnel will have to do a more effective job in communicating the effects of increasing fishing pressure to anglers.

The relationship between harvest rates and fishing pressure for more prolific and abundant species such as bullhead, sunfish, crappie, and yellow perch is less clear. When harvest rates and fishing pressure were compared for panfish species, many had positive relationships (Table 19). This suggests that at present fishing pressure levels in Minnesota, the angler harvest rate for panfish species has not been affected as much as the harvest rate for predator species. Angler selectivity also plays a larger, but unknown role with panfish. Bennett (1962) found that angler-hours per acre needed to exceed 200-300 hours before panfish harvest rates rapidly fell in Illinois farm ponds. Fishing pressure rarely exceeds 200 hours per acre for most Minnesota lakes, so it is possible as fishing pressure continues to increase that the relationship between fishing pressure and harvest rates will become more clear. These correlations do not, however, explain any size structure changes that may have simultaneously occurred in panfish populations.

Fishing pressure and the total number of fish harvested by anglers was strongly correlated (Table 19 and Figure 19). Since fishing pressure is negatively correlated with predator fish harvest rates and positively correlated with some panfish harvest rates, panfish species are apparently responsible for maintaining the increasing number of fish harvested as fishing pressure increases. We believe that as fishing pressure per acre increases, harvest per acre can increase due to anglers accepting or fishing for alternative species. Although, with enough fishing pressure all lakes will exceed their production capabilities. Weight harvested per acre also increased with fishing pressure (Figure 20). Similar correlation analyses were made by using medians from lake classes for the total fish harvest and fishing pressure. There was little change in the correlation coefficients when the medians for a lake class were used (Table 19). However by using medians, the contribution of certain lake classes to the regression became clear (Figures 19 and 20). Medians from larger lakes such as Lake Classes 2 and 26 are near the left side of the regression, representing low fishing pressure and harvest per acre due to the large size of these lakes. Smaller more urban lake classes (Lake Classes 24, 33, 38, and 43) are located higher on the regression line. Lake Classes 20 and 21 which are frequently managed for stream trout also received a large amount of fishing pressure (Figures 19 and 20).

The relationship of increasing harvest with increasing fishing pressure was also explored after grouping lake classes by dominant species assemblages. Correlations with

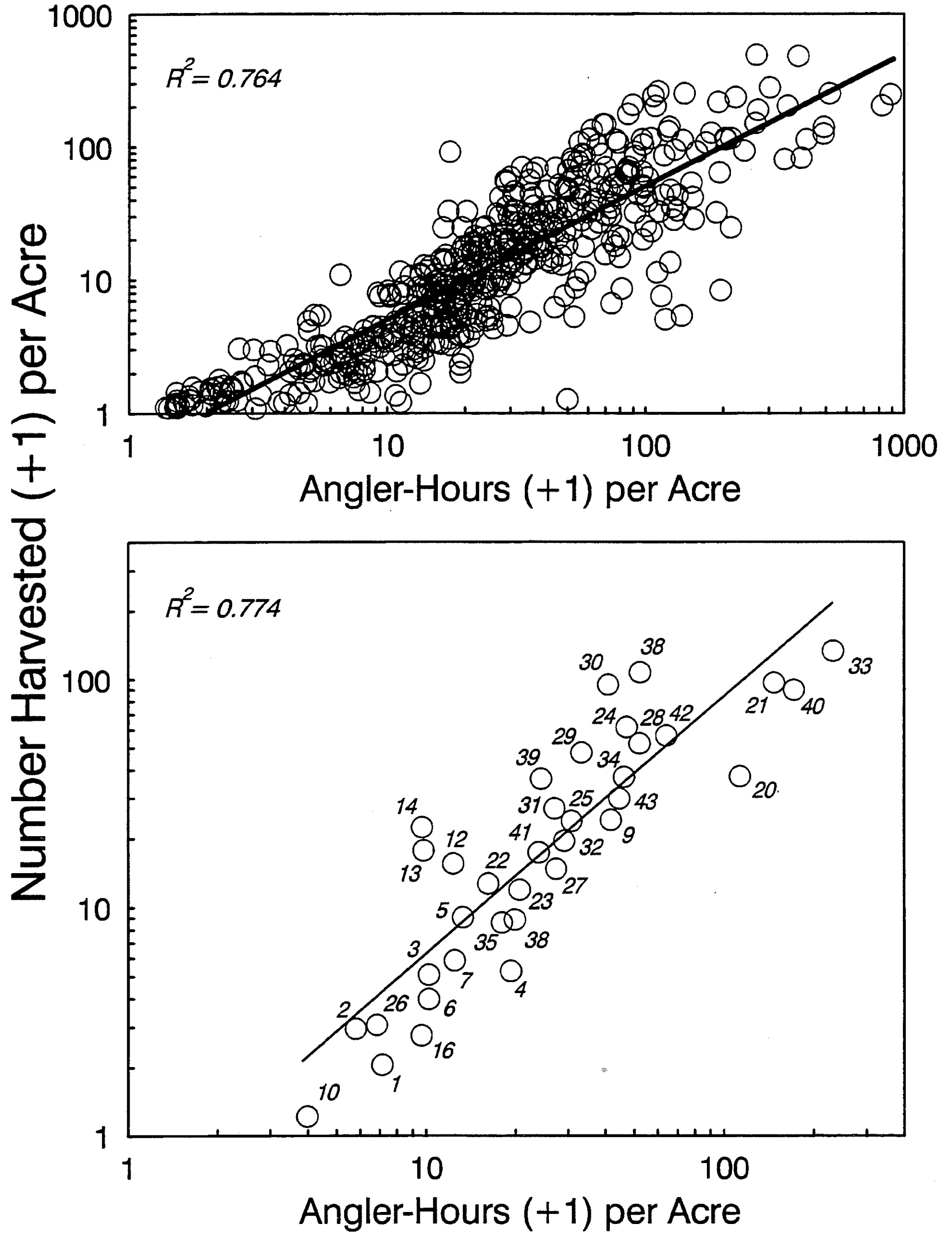


Figure 19. Relationship between fishing pressure and total number of fish harvested by anglers as determined by creel survey. More than 500 lake specific observations are presented on top graph, while lake class medians are presented on the bottom graph for clarity of contribution by individual lake class.

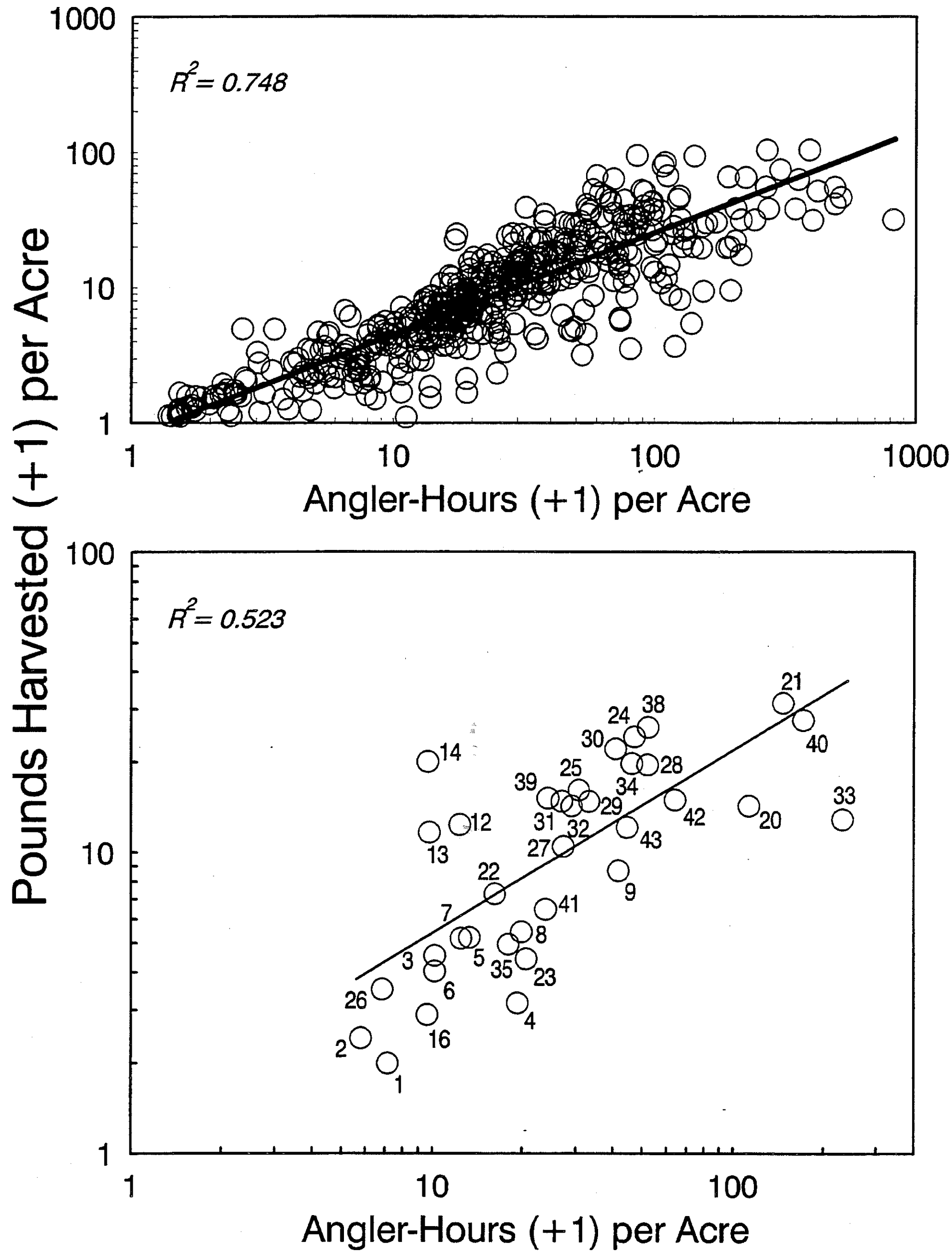


Figure 20. Relationship between fishing pressure and total weight of fish harvested by anglers as determined by creel survey. More than 500 lake specific observations are presented on top graph, while lake class medians are presented on the bottom graph for clarity of contribution by individual lake class.

walleye harvest statistics improved when lakes were grouped into classic walleye lakes and non-classic walleye lakes. In this case, the correlation coefficients significantly improved for the walleye lakes, while the non-classic walleye lakes had no predictable harvest trends with increasing fishing pressure (Table 19). This same analysis was completed for crappie and non-crappie lakes, but it did little to improve the harvest relationships with fishing pressure.

Fishing pressure was also negatively correlated with mean size of harvested fish for most species (Table 20). Only walleye and sauger had positive correlations with fishing pressure. When classic walleye lakes were separated from non-classic walleye lakes, the classic walleye lakes had no correlation with fishing pressure, while the non-classic walleye lakes remained positively correlated (Table 20). We hypothesize that this observed difference occurred because of different management strategies between these lake groups. First, for many years walleye have been the target species for most anglers fishing classic walleye lakes. Because of this, any reduction in size structure of walleye populations due to angling may have occurred years ago and this decline was missed by earlier creel surveys. The decrease in mean size of harvested walleye from the 1930s to the 1950s, followed by a period of stable mean weights at Lake Winnibigoshish supports this hypothesis. Likewise, no long-term trends were evident in the mean size of walleye in the Fuller's contest records from 1930-1987 (Olson and Cunningham 1989). Non-classic walleye lakes are often maintained by stocking, which may produce sporadic recruitment and year-classes. Many of these lakes are located in central and southwest Minnesota and when a strong year-class is produced, they grow quickly to a large-size. These lakes receive higher fishing pressure per acre than classic walleye lakes, and word of a strong walleye year-class will further increase fishing pressure. Mean harvest weights of rainbow and brook trout had the strongest negative correlations with fishing pressure. Again, this is consistent with the put-grow-and-take management of these fisheries and their susceptibility to fishing pressure since most trout lakes are small. Of the panfish

Table 20. Correlation coefficients of fishing pressure with mean size of harvested fish from Minnesota lakes as determined by creel survey. Fishing pressure was standardized on a per acre basis and both variable were transformed with $\log^{10}$.

Species	*N*	Pearson correlation coefficient	Probability
Brook trout	24	-0.746	0.000
Black crappie	215	-0.418	0.000
Bluegill	122	-0.258	0.004
Bullhead species	168	-0.275	0.000
Brown trout	13	-0.430	0.142
Crappie species	280	-0.469	0.000
Lake trout	52	-0.587	0.000
Largemouth bass	228	-0.251	0.000
Northern pike	429	-0.259	0.000
Rainbow trout	84	-0.687	0.000
Rock bass	130	-0.133	0.130
Sauger	54	0.370	0.006
Smallmouth bass	123	-0.191	0.035
Sunfish species	211	-0.344	0.000
Yellow perch	298	-0.481	0.000
		Walleye	
In all lakes	393	0.207	0.000
In classic walleye lakes	171	0.071	0.357
In non-classic walleye lakes	222	0.149	0.029

species, crappie mean sizes had the strongest negative relationship with fishing pressure, suggesting that fishing pressure quickly affects the size structure of crappie populations. Our findings disagreed with those of Olson and Cunningham (1989) who concluded that bluegill were more susceptible to exploitation than crappie. Perhaps the more important point is that both species can be affected by increasing fishing pressure and the accompanying higher exploitation.

Northern pike and walleye are species that have been managed by stocking or use of spawning areas connected to lakes. A comparison of harvest rates from lakes that were stocked versus those that were not stocked was made by using qualitative descriptions of stocking rates provided by fishery managers (Table 21). Non-stocked lakes had higher mean and median harvest rates in all cases (Table 21). We are not intending to imply that creating a fishery through stocking is impossible, some very good fisheries have been created by stocking fish. However, we would argue that natural fisheries are more successful (based solely on harvest rates) on average than those maintained or supplemented by use of stocked fish. Stocked fish when used in the proper situation can create tremendous amounts of fishing opportunity.

Northern Pike Harvest and Allocation

The controversy over the allocation of the northern pike harvest between anglers and spearers has been around for a long time (Cook et al. 1997). Spearers are almost exclusively seeking northern pike, although some occasionally harvest nongame fish. Therefore, we considered spearing creel estimates to be from individuals targeting northern pike. The best comparison with spearers would be anglers targeting northern pike as well. Unfortunately, estimates from anglers targeting northern pike are often lacking and those available are primarily harvest rates. The creel survey estimates presented here are listed by six groups: three groups specifically targeting northern pike (spearers, summer anglers targeting northern pike, and winter anglers targeting northern pike), and three general categories of fishing (all summer anglers, all winter anglers, and total winter harvest of anglers and spearers combined).

Table 21. Mean and median harvest rates (fish per angler-hour) for lakes primarily and secondarily managed for northern pike and walleye. Results are presented for all anglers and targeting anglers for each management strategy.

	All anglers					Targeting anglers				
Stocking frequency	Number of lakes	Number of seasons	Median	Mean	SE	Number of lakes	Number of seasons	Median	Mean	SE
Northern pike - primary species management										
No	22	31	0.040	0.083	0.018	7	7	0.040	0.087	0.041
All stocking	7	7	0.020	0.037	0.014	5	5	0.150	0.166	0.059
Northern pike - primary and secondary species management										
No	98	262	0.037	0.061	0.014	36	66	0.145	0.191	0.052
All stocking	21	34	0.020	0.031	0.027	17	17	0.150	0.148	0.082
Walleye - primary species management										
No stocking	29	130	0.187	0.211	0.012	20	36	0.210	0.242	0.027
Moderate	12	39	0.135	0.131	0.013	6	19	0.170	0.179	0.026
Frequent	79	133	0.050	0.071	0.006	50	70	0.127	0.146	0.013
Annual	10	19	0.071	0.072	0.012	5	8	0.118	0.119	0.026
All stocking	101	191	0.060	0.083	0.006	61	97	0.140	0.150	0.011

Harvest rates from the six groups of anglers were used to compare their relative success (Table 22). No difference was observed in the mean harvest rate among the three groups targeting northern pike. Likewise, there was no difference in harvest rates of summer and winter anglers not specifically targeting northern pike. However, the angler groups targeting northern pike had higher harvest rates than those of all anglers combined. In terms of northern pike harvested, summer anglers generally take home more northern pike than any winter group (Table 23). This is mainly due to more summer anglers fishing a longer season. The winter harvest of northern pike is split equally between anglers and spearers.

Northern pike harvest peaked at age 3 for all summer anglers and darkhouse spearers (Table 12), but spearers harvested a larger percentage of older fish (Chi-square: P = 0.000). Northern pike length frequencies harvested by all summer and all winter anglers peaked at 19-20 inches (Table 13), but summer anglers harvested a larger percentage of fish longer than 25 inches (Chi-square: P = 0.000). Northern pike released by all summer and winter anglers tended to be small fish (Table 15). Darkhouse spearers harvested a higher proportion of larger fish than all summer or all winter anglers (Chi-squares: P = 0.000). Likewise, mean sizes (length and weight) of northern pike harvested by darkhouse spearers are longer and larger than those harvested by all summer or all winter anglers (Table 24). However, mean lengths of fish harvested by spearers and those harvested by summer anglers targeting were similar (Wilcoxon rank-sum: P = 0.979), although the speared fish were generally heavier than those harvested by summer anglers fishing northern pike (Wilcoxon rank-sum: P = 0.044).

Several previous studies have examined the differences in northern pike harvested by spearing and angling with similar findings (Johnson and Peterson 1955; Johnson et al. 1957; Schupp 1981; Diedrich 1992). Johnson and Peterson (1955) found that spearers harvested older and larger northern pike in Ball Club Lake, Minnesota. They also stressed that year-class strength and age-class composition of the fishable population would effect harvest, and concluded that spearers were more likely to harvest the less numerous, older fish. Using

Table 22. A comparison of seasonal northern pike mean harvest rates (fish per angler-hour) by angler groups that fish Minnesota lakes. Mean harvest rates presented are grand means across all lake classes. Probability levels (inside lower right corner) were determined with an unequal-variance T-test. Comparisons that were not statistically significant are indicated by NS (P > 0.1). Targeting anglers (both during summer and winter) were specifically seeking northern pike. Total winter harvest is the winter angling and spearing harvest combined. Sample size indicates the number of creel seasons surveyed.

		All summer anglers	Targeting summer anglers	All winter anglers	Targeting winter anglers	Spearers
	Harvest rate (N)	0.045 (446)	0.185 (117)	0.055 (167)	0.193 (28)	0.175 (180)
Total winter harvest	0.078 (113)	0.00	0.00	0.01	0.00	0.00
Spearers	0.175 (180)	0.00	0.80[NS]	0.00	0.65[NS]	
Targeting winter anglers	0.193 (28)	0.00	0.77[NS]	0.00		
All winter anglers	0.055 (167)	0.14[NS]	0.00			
Targeting summer anglers	0.185 (117)	0.00				

Table 23. A comparison of mean number and weight (pounds) of northern pike harvested per acre by angler groups that fish Minnesota lakes. Mean harvest per acre values presented are grand means across all lake classes. Probability levels (inside lower right corner) were determined with an unequal-variance T-test. Comparisons that were not statistically significant are indicated by NS ($P > 0.1$). Total winter harvest is the winter angling and spearing harvest combined. Sample size indicates the number of creel seasons surveyed.

		All summer anglers	All winter anglers	Spearers
	Mean number per acre (N)	1.198 (454)	0.365 (181)	0.344 (184)
Total winter harvest	0.532 (238)	0.00	0.00	0.01
Spearers	0.344 (184)	0.00	0.58^{NS}	
All winter anglers	0.365 (181)	0.00		

		All summer anglers	All winter anglers	Spearers
	Mean weight per acre (N)	2.456 (443)	0.827 (166)	1.105 (167)
Total winter harvest	1.380 (220)	0.00	0.00	0.27^{NS}
Spearers	1.105 (167)	0.00	0.00	
All winter anglers	0.827 (166)	0.00		

data collected from 32 Minnesota lakes, Johnson et al. (1957) also found that spearers harvested a higher proportion of larger fish than all anglers, but summer anglers removed the largest biomass. All previous comparisons of anglers and spearers, including this one, have been lacking several useful pieces of information including: size distribution of northern pike caught by northern pike anglers during summer and winter, size distribution of northern pike passed by spearers, how often northern pike are passed by spearers, and the northern pike annual harvest by length group for spearers and targeting anglers. Obviously, a complete suite of data from all groups targeting northern pike would be valuable information in evaluating this allocation controversy.

In conclusion, when the harvest rate of spearers is compared with anglers specifically targeting northern pike, we see no difference. The spearing harvest contains a larger proportion of big fish, but the summer anglers harvest more northern pike. It is assumed that the elimination of spearing would reduce the annual harvest of northern pike and result in a higher proportion of large fish in the population. However, the released fish length data indicates that many large northern pike saved by a spearing closure would likely be harvested if caught by angling (Table 15). The data also indicate that if a lake is going to be managed for large northern pike, the harvest of both anglers and spearers will have to be reduced in order to maintain a desirable northern pike population. If the number of spearing licenses sold in Minnesota continues to decline (Cook et al. 1997), we expect the proportion of northern pike harvested by spearing should also decline.

Bag Limits

Daily creel limits, or bag limits are often instituted to more equitably distribute the harvest or reduce the harvest of the more skilled anglers (Porch and Fox 1990). Anglers often perceive that a reduction in bag limits will result in reduced annual harvest (Quinn 1992). Very few Minnesota anglers harvest

Table 24. Long-term mean lengths and weights of harvested northern pike by fishing method from Minnesota lakes as determined by creel survey.

Season	Fishing method	Anglers targeting northern pike	Number of lakes	Number of seasons	Median	Mean	SE
			Mean length (inches)				
Summer	Angling	No	99	159	21.9	21.8	0.2
Winter	Angling	No	27	30	21.6	21.7	0.4
Summer	Angling	Yes	3	3	22.7	24.8	2.3
Winter	Spearing	Yes	36	36	23.8	23.6	0.3
			Mean weight (pounds)				
Summer	Angling	No	183	431	2.4	2.6	0.1
Winter	Angling	No	62	127	2.4	2.6	0.1
Summer	Angling	Yes	10	12	2.7	2.9	0.3
Winter	Spearing	Yes	75	166	3.5	3.6	0.1

their daily bag limit during a fishing trip (Tables 25 and 26). In fact, most anglers failed to harvest a single fish for the six species we examined. In contrast, anglers targeting a species are more likely to harvest that particular species than all anglers combined. As a general rule, targeting anglers are more successful in harvesting panfish than predator fish species. Lorenz curves also confirm that panfish harvest is distributed among more anglers than the predator harvest (Figure 21), although Gini coefficients indicate that the harvest of northern pike is slightly more equitable than crappie (Figure 21). Harvest of panfish species was more evenly distributed among anglers than predator species in Murphy Flowage and Escanaba Lake, Wisconsin (Churchill and Snow 1964). In Minnesota, yellow perch harvest by targeting anglers was the only Lorenz curve that even suggested a hint of harvest equality.

Churchill and Snow (1964) and Snow (1978) were among the first authors to use the phrase "10% of the anglers harvest 50% of the fish." Analysis of bag limits from Minnesota waters showed little deviation from this general rule. Staggs (1989) found the walleye harvest was even less equally distributed in Wisconsin lakes, where 93% of all fishing trips were unsuccessful. While Minnesota walleye anglers were more successful than Wisconsin anglers, most only harvested a single walleye.

If bag limits were to be used as a management tool to control harvest in Minnesota waters, current bag limits would need to be drastically cut. Large reductions in bag limits would save moderate numbers of fish while affecting few anglers (Tables 25 and 26). Reducing bag limits by two-thirds would result in a harvest savings of approximately 20%. Larscheid (1992) also demonstrated that walleye bag limits would need to be reduced from five walleye to one to effectively reduce harvest on three Iowa lakes, and that yellow perch limits would have to be reduced from 25 to 10 fish. Even though large reductions in bag limits would affect relatively few anglers, we feel as did Larscheid (1992), that such reductions in bag limits would not be acceptable by anglers. It is unknown how much of the savings in harvest would be lost due to these fish being redistributed among less successful anglers.

Species Targeted by Anglers

When anglers go fishing they are usually seeking one or two specific species. Mail surveys of Minnesota license buyers in 1971 and Minnesota resident anglers in 1986 (Leitch and Baltezore 1987) found that walleye and northern pike were the most popular species with anglers. These two species were targeted most often by nonresident anglers as well. Sunfish and crappie were the next most

Table 25. Numbers of walleye, largemouth bass, and northern pike harvested by anglers in Minnesota as determined by creel surveys, 1980-1996. The percent savings from creel limit reductions and percentage of angler trips that would be directly affected by a reduction are also presented.

	Species					
	Walleye		Largemouth bass		Northern pike	
Creel limit	All anglers	Targeting	All anglers	Targeting	All anglers	Targeting
	Number of lakes surveyed					
	26	26	34	34	42	36
	Number of interviews					
	13,918	6,660	15,150	1,150	21,817	1,762
	Percentage of anglers harvesting					
0	79.2	72.8	90.6	74.8	87.8	66.2
1	11.1	16.7	7.9	18.3	9.8	26.3
2	5.5	6.5	0.7	5.0	1.4	3.5
3	1.5	2.0	0.2	0.4	1.1	4.0
4	1.2	1.0	0.2	0.6		
5	0.4	0.5	0.2	0.6		
6	1.1	0.4	0.1	0.3		
	Percent harvest would be reduced at various bag limits					
0	100.0	100.0	100.0	100.0	100.0	100.0
1	48.3	39.4	24.6	31.2	22.5	25.5
2	24.1	16.1	13.0	12.4	6.8	8.9
3	13.5	7.3	7.1	7.3		
4	6.7	3.1	3.1	3.2		
5	2.8	1.0	0.9	0.7		
	Percentage of angler trips affected at various reductions in bag limits					
0	20.9	27.2	9.4	25.2	12.3	33.8
1	9.8	10.5	1.5	6.9	2.5	7.6
2	4.3	3.9	0.7	1.9	1.1	4.0
3	2.8	1.9	0.5	1.5		
4	1.6	0.9	0.3	0.9		
5	1.1	0.4	0.1	0.3		

popular species with anglers (Scidmore and Wroblewski 1973). Results from the 1986 survey showed that sunfish remained more popular than crappie with resident anglers, but crappie were more popular than sunfish with nonresident anglers. The 1986 survey revealed a large percentage of both resident and nonresident anglers go fishing for "whatever is biting." Creel surveys indicated that the species anglers targeted varied little from these angler preferences studies. Which species anglers were targeting was summarized by lake class, walleye and northern pike were the two most popular species with anglers, followed closely by sunfish species (Table 27).

Angler success in catching a particular species depends partly on the fish community composition. Likewise, the fish community present in a lake will influence what species anglers will pursue. We made a three-way comparison of the species anglers were targeting, with the species actually harvested, and with the species comprising the majority of fish biomass within a lake class. Only the top three species for each category were used (Table 27). Species of fish in Minnesota are not equally distributed in all lake classes (Schupp 1992), and therefore it follows that fishing pressure for a particular species will not be equally distributed. Lake trout were the species of preference in the coldwater fisheries of northeastern Minnesota where they are most commonly found. In the coolwater fisheries of central Minnesota, walleye and northern pike

Table 26. Numbers of sunfish, yellow perch, and crappie harvested by anglers in Minnesota as determined by creel surveys, 1980-1996. The percent savings from creel limit reductions and percentage of angler trips that would be directly affected by a reduction are also presented.

Sunfish			Yellow perch			Crappie		
Creel limit	All anglers	Targeting anglers	Creel limit	All anglers	Targeting anglers	Creel limit	All anglers	Targeting anglers
			Number of lakes surveyed					
	34	34		8	4		30	34
			Number of interviews					
	14,507	1,976		5,975	1,619		6,931	1,392
			Percentage of anglers harvesting					
0	74.8	39.0	0	92.4	17.1	0	87.8	58.4
3	12.1	22.8	10	6.9	56.8	1	6.1	15.3
6	5.1	15.5	20	0.5	15.1	2	1.1	4.2
9	2.4	7.7	30	0.1	5.4	3	1.8	6.3
12	2.4	6.8	40	0.0	2.7	4	0.6	4.2
15	0.6	0.9	50	0.0	1.6	5	0.4	2.4
18	0.9	2.8	60	0.0	0.3	6	0.5	1.6
21	0.5	1.2	70	0.0	0.1	7	0.4	1.9
24	0.4	1.1	80	0.0	0.2	8	0.4	0.7
27	0.6	1.3	90	0.0	0.1	9	0.2	0.6
29	0.0	0.5	100	0.0	0.3	10	0.1	0.7
30	0.2	0.7				11	0.5	2.4
						12	0.0	0.2
						13	0.0	0.0
						14	0.2	0.8
						15	0.1	0.4
			Percent harvest would be reduced at various bag limits					
0	100.0	100.0	0	100.0	100.0	0	100.0	100.0
3	61.4	63.6	10	19.1	53.6	1	62.3	66.9
6	39.1	39.9	20	4.4	24.5	2	51.4	54.7
9	25.5	26.1	30	0.8	12.4	3	34.5	37.2
12	16.8	17.4	40	0.3	6.4	4	26.5	27.7
15	10.9	11.6	50	0.1	3.4	5	19.9	20.8
18	6.7	7.3	60	0.0	2.2	6	14.3	15.5
21	3.6	4.2	70	0.0	1.4	7	9.9	11.2
24	1.5	2.0	80	0.0	0.8	8	6.7	8.1
27	0.4	0.7	90	0.0	0.3	9	4.3	5.3
29	0.1	0.2				10	2.6	3.0
						11	1.0	1.1
						12	0.8	0.8
						13	0.5	0.5
						14	0.3	0.3
			Percentage of angler trips affected at various reductions in bag limits					
0	25.2	61.1	0	7.5	82.7	0	12.4	41.6
3	13.0	38.3	10	0.7	25.9	1	6.3	26.3
6	7.9	22.9	20	0.2	10.8	2	5.2	22.1
9	5.5	15.2	30	0.0	5.4	3	3.4	15.9
12	3.2	8.4	40	0.0	2.7	4	2.9	11.6
15	2.6	7.5	50	0.0	1.0	5	2.5	9.2
18	1.7	4.7	60	0.0	0.7	6	1.9	7.6
21	1.2	3.5	70	0.0	0.6	7	1.5	5.8
24	0.8	2.4	80	0.0	0.4	8	1.1	5.1
27	0.2	1.1	90	0.0	0.3	9	0.9	4.5
29	0.2	0.7				10	0.8	3.8
						11	0.3	1.4
						12	0.3	1.2
						13	0.3	1.2
						14	0.1	0.4

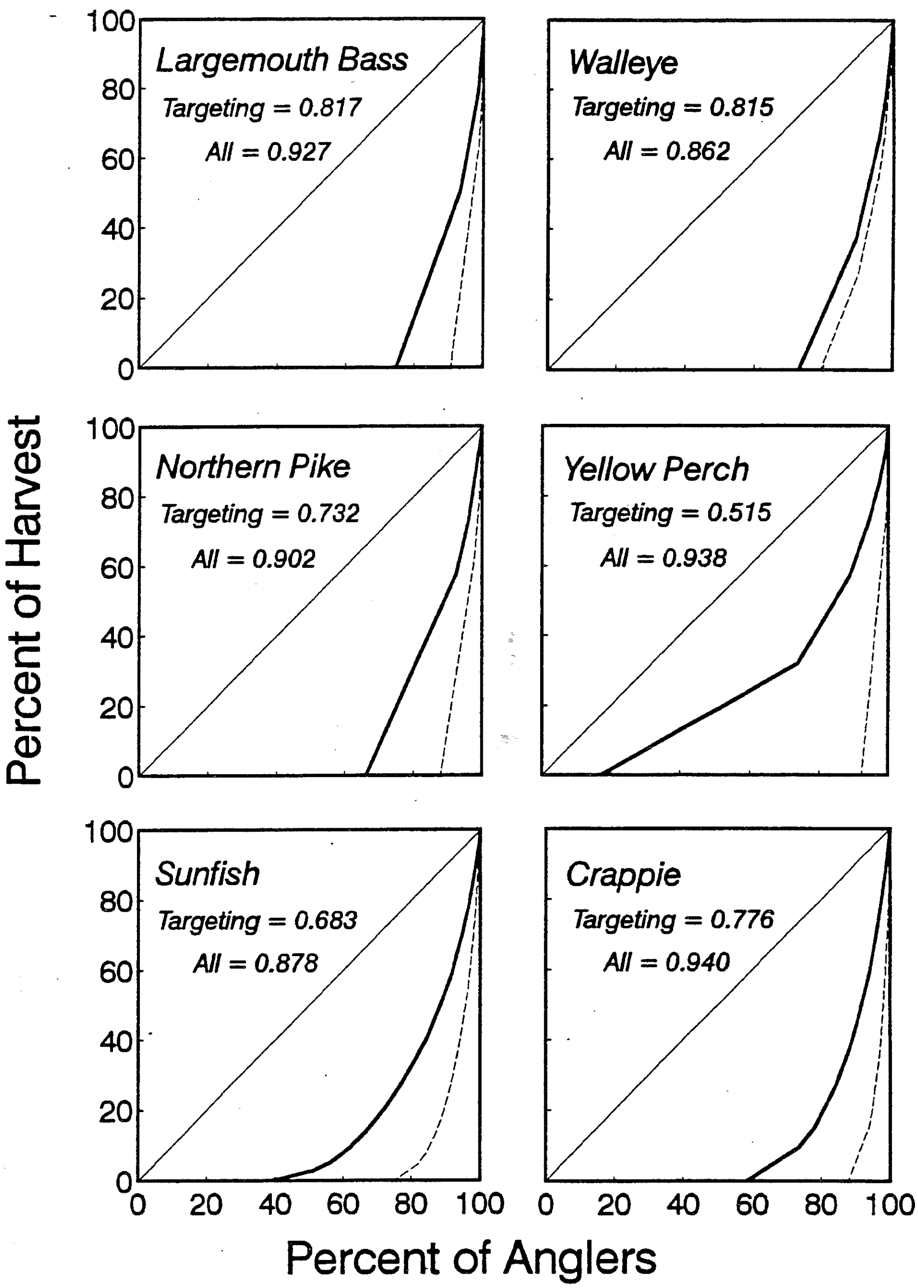


Figure 21. Lorenz curves for six commonly harvested species of fish from Minnesota waters. Curves were formed for anglers targeting specific species (solid lines) and all anglers (dashed lines). The 45° line represents perfect equality of harvest among anglers (Gini coefficient = 0.0), Gini coefficients for targeting and all anglers are presented within the graphs.

Table 27. The three most commonly targeted, harvested (number and weight per acre), and primary fish assemblages associated with each lake class. Comparisons were assigned a relative ranking dependant upon how close species targeted matched actual harvest or species assemblages present. The species targeted in each lake class were based on angler creel surveys and species assemblages were taken from Schupp (1992). Species within a lake class are presented in no particular order.

Lake class	Species targeted by anglers	Species harvested: By number	Species harvested: By weight	Primary species assemblages present	Targeted species compared with angler harvest	Targeted species compared with species assemblages	Species assemblages compared with harvest
1	Lake trout	Lake trout	Lake trout	Lake trout			
	Walleye	Walleye	Walleye	Walleye	Fair	Fair	Fair
	Smallmouth bass	Rainbow trout	Rainbow trout	White sucker			
2	Walleye	Walleye	Walleye	Walleye			
	Northern pike	Northern pike	Northern pike	Northern pike	Fair	Fair	Fair
	Lake trout	Sunfish	Sunfish	White sucker			
3	Walleye	Walleye	Walleye	Walleye			
	Lake trout	Northern pike	Northern pike	Northern pike	Fair	Poor	Fair
	Smallmouth bass	Smallmouth bass	Smallmouth bass	White sucker			
22	Walleye	Walleye	Walleye	Walleye			
	Northern pike	Northern pike	Northern pike	Northern pike	Fair	Fair	Excellent
	Crappie	Sunfish	Sunfish	Sunfish			
23	Trout	Rainbow trout	Rainbow trout	Walleye			
	Northern pike	Largemouth bass	Northern pike	Northern pike	Fair	Poor	Fair
	Walleye	Sunfish	Sunfish	Sunfish			
24	Crappie	Crappie	Crappie	Northern pike			
	Walleye	Sunfish	Sunfish	Sunfish	Fair	Poor	Fair
	Northern pike	Bullhead	Northern pike	Common carp			
25	Northern pike	Northern pike	Northern pike	Northern pike			
	Sunfish	Sunfish	Sunfish	Sunfish	Fair	Fair	Fair
	Walleye	Crappie	Largemouth bass	Yellow Bullhead			
26	Walleye	Walleye	Walleye	Walleye			
	Yellow perch	Yellow perch	Yellow perch	Yellow perch	Excellent	Excellent	Excellent
	Northern pike	Sunfish	Northern pike	Northern pike			
27	Walleye	Walleye	Walleye	Walleye			
	Northern pike	Northern pike	Northern pike	Northern pike	Excellent	Excellent	Excellent
	Sunfish	Sunfish	Sunfish	Sunfish			
29	Crappie	Crappie	Northern pike	Northern pike			
	Sunfish	Sunfish	Sunfish	Sunfish	Excellent	Poor	Fair
	Largemouth bass	Largemouth bass	Largemouth bass	Yellow Bullhead			
30	Sunfish	Sunfish	Sunfish	Sunfish			
	Northern pike	Black bullhead	Black bullhead	Northern pike	Poor	Fair	Fair
	Largemouth bass	Crappie	Common carp	Black bullhead			
31	Walleye	Sunfish	Sunfish	Sunfish			
	Northern pike	Walleye	Northern pike	Northern pike	Fair	Poor	Fair
	Crappie	Crappie	Crappie	Yellow Bullhead			
32	Sunfish	Sunfish	Sunfish	Sunfish			
	Northern pike	Largemouth bass	Northern pike	Northern pike	Fair	Fair	Fair
	Largemouth bass	Crappie	Crappie	Common carp			

Table 27. Continued.

Lake class	Species targeted by anglers	Species harvested: By number	Species harvested: By weight	Primary species assemblages present	Targeted species compared: with angler harvest	Targeted species compared: with species assemblages	Species assemblages compared with harvest
34	Sunfish Northern pike Walleye	Sunfish Northern pike Crappie	Sunfish Northern pike Smallmouth bass	Black Bullhead Northern Pike Common carp	Fair	Poor	Poor
38	Sunfish Crappie Largemouth bass	Sunfish Crappie Northern pike	Sunfish Crappie Northern pike	Sunfish Black bullhead Northern pike	Fair	Poor	Fair
40	Sunfish Northern pike Largemouth bass	Sunfish Bullhead Crappie	Sunfish Bullhead Largemouth bass	Northern pike Black bullhead Common carp	Fair	Poor	Poor
41	Walleye Northern pike Yellow perch	Walleye Bullhead Crappie	Walleye Northern pike Sunfish	Walleye Black bullhead Common carp	Fair	Poor	Fair
43	Bullhead Walleye Sunfish	Bullhead Walleye Sunfish	Bullhead Walleye Sunfish	Black bullhead Northern pike Common carp	Excellent	Fair	Poor

are targeted by anglers in many lake classes. In the south-central and southwestern lake classes, largemouth bass, sunfish and bullhead are frequently targeted. This comparison demonstrated that the species anglers targeted did not always match well with the species assemblages present in many lake classes. Within most lake classes, anglers were seeking one or two species that had a low occurrence. In spite of this, anglers did harvest the most prevalent species in a lake class and usually those species that they were seeking.

Creel Surveys on Streams and Rivers

Few creel surveys have been conducted on Minnesota's rivers and streams and this limited the analyses that were possible. However, a broad comparison of rivers and streams was made with medians from selected lake classes to show the relative use of the these two resources by Minnesota's anglers (Table 28). Trout streams in southeastern Minnesota receive more fishing pressure per acre than any lake class. Number and weight of the harvest suggests that anglers heavily harvest the stream trout resource. Warmwater streams also receive moderate to high levels of fishing pressure when compared with lakes. Harvest levels were similar between large rivers and large walleye lakes (Lake Class 26). Harvest levels from warmwater streams were similar with lakes managed for largemouth bass and panfish. This is not surprising since a large component of the harvest from warmwater streams was crappie, sunfish, and smallmouth bass. The harvest rates from rivers and lakes were fairly equal, comparatively speaking. Based on these summarized fishing pressure and harvest levels, Minnesota's rivers and streams have not been adequately creel surveyed.

Management Implications

We have demonstrated that fishing pressure is a dominating force affecting Minnesota fisheries. Increasing fishing pressure will usually result in fewer and smaller fish caught by individual anglers. The findings presented in this report confirm what many anglers and fisheries workers have intuitively felt was happening to Minnesota fisheries. However, as these changes continue to manifest themselves in Minnesota's fisheries, it is to be expected that fishery managers will receive

Table 28. A comparison of summer fishing pressure and harvest from Minnesota rivers with heavily fished lake classes and large walleye lakes. Lake classes presented in this table are recipients of high fishing pressure and harvest when compared other lake classes. Northeast coldwater streams surveyed were managed for stream trout species (estimates do not include Lake Superior anadromous runs).

Waterbody type	Primary species management	Fishing pressure (hours per acre)	Number harvested (total fish per acre)	Weight harvested (total pounds per acre)	Harvest rate (total fish per hour)
			Rivers		
Coldwater NE	Trout	-	180	27	1.305
Coldwater SE	Trout	430	217	34	0.440
Warmwater streams	Warmwater spp	60	30	23	0.413
Large rivers	Warm and coolwater spp	22	2	-	0.245
			Lakes		
Lake Class 20	Trout	112	23	13	0.279
Lake Class 21	Trout	146	112	30	0.250
Lake Class 26	Walleye	6	2	3	0.382
Lake Class 29	Northern pike	32	33	14	1.110
Lake Class 33	Trout	231	125	-	0.240
Lake Class 38	Bass-panfish	51	50	25	0.970
Lake Class 39	Walleye-panfish	23	34	14	1.218
Lake Class 40	Bass-panfish	74	50	26	0.458

more requests to maintain quality fisheries, both in terms of fish size and higher catch rates.

1. Most anglers assess the quality of a fishery in terms of their individual harvest, and not the overall yield of a fishery. Minnesota lakes continue to produce an equal or increasing weight of fish annually, but the individual angler's share of fish continues to decrease. Length frequencies of released fish indicate that for most species catch-and-release fishing is still not widely practiced. While Minnesota fisheries have been resilient in terms of yield, changes in the size structure have occurred. Much of the information contained in this report should be useful in communicating to anglers the effect, or control, they potentially have on a fishery. This control can be exercised by any angler when they consider whether to harvest or release a particular fish.
2. Similar to Schupp's (1992) lake classification and quartiles of test net catches, quartiles of creel survey estimates have been prepared by lake class. This will allow managers to compare historical and recent creel survey estimates. The same five questions Schupp (1992) proposed for lake survey results are now possible for creel surveys. They are repeated here for the readers convenience:
   a. Is the unusual catch (catch per angler-hour or size) a problem?
   b. Do I want to do something about it?
   c. Can I do something about it?
   d. What are the possible consequences of a management action on the target species and the associated fish community?
   e. How will the results of the management action be evaluated?

   While catch estimates are obviously valuable indicators of a fishery's performance, they are inadequate measures of stock performance (Shuter et al. 1987; Clarke et al. 1991). Care should be taken not to extrapolate creel survey estimates as being a reflection of stock performance.

3. Trends in recreational catch were analyzed on a statewide perspective. While it was possible to illustrate and explore many different aspects of the recreational catch, inconsistent and incomplete information in creel survey reports limited the possible analyses. While these shortcomings were not the fault of anyone, they were a result of how the Section of Fisheries historically did business. This study identified deficiencies in our creel survey coverage of Minnesota fisheries that need to be addressed. One of these deficiencies is to make all creel surveys as complete and comprehensive as possible. A listing of many items that are important in terms of the "big picture" was included in the *Creel Survey Report Format and Guidelines* (Cook 1996). All future creel surveys reports should provide the mandatory estimates listed in that publication. In addition, authors should be encouraged to report many of the recommended and optional estimates as well.
4. To manage Minnesota's waters efficiently, fishery managers must have information on long-term trends in fishing pressure and harvest. Except for a few large lakes, long-term data sets are lacking. This shortcoming in the data has been partially overcome by combining creel information from lakes within a lake class. However, the strictest of statistical assumptions were precariously bent in this approach. The lack of long-term creel data from smaller lakes needs to be addressed as soon as possible. Minnesota would benefit from a periodic and systematic statewide monitoring of the recreational fishery on selected smaller lakes.
5. The quality of fishing in Minnesota has declined with exploitation. This is not meant to imply that Minnesota fish stocks are not healthy, but they do show visible symptoms of exploitation. In other words, there is a limit to how much can be annually harvested from Minnesota's fish stocks. A recent publication by Smith (1990) suggests that when a resource is limited, management is a no-win situation with respect to efficiency and equality. Minnesota's recreational fishery users are increasing, and the resource is decreasing from habitat losses. As fisheries resources become scarce (or use increases), the catch will be less evenly distributed among anglers (Smith 1990; Baccante 1995). Ultimately, the number of people seeking the resource may need to be reduced, and each decision to reduce the population of those using the resource will become more difficult (Smith 1990). An alternative approach would be to plan ahead and develop long range-plans for the number of anglers, harvest, and advances in technical efficiencies that the fisheries of Minnesota can support (Smith 1990). These decisions will only become more complex, as fishery managers will be forced to view recreational fisheries as multiple-use resources with many types of traditional and non-traditional user groups (Malvestuto and Hudgins 1996). It is also logical to assume that in the future, all user groups will ask for representation in the decision-making process about Minnesota fisheries.

Appendix A

Table A1. A phylogenetic listing of fish names used in this publication.

Common name	Family or scientific name
Common carp	*Cyprinus carpio*
Sucker species	*Catostomus sp.*
White sucker	*Catostomus commersoni*
Buffalo species	*Ictiobus sp.*
Bullhead species	*Ameiurus sp.*
Black bullhead	*Ameiurus melas*
Yellow bullhead	*Ameiurus natalis*
Brown bullhead	*Ameiurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Rainbow trout	*Oncorhynchus mykiss*
Atlantic salmon	*Salmo salar*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Lake trout	*Salvelinus namaycush*
Splake	*S. fontinalis* * *S. namaycush*
Burbot	*Lota lota*
White bass	*Morone chyrsops*
Rock bass	*Amblopites rupestris*
Sunfish species	*Lepomis sp.*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieu*
Largemouth bass	*Micropterus salmoides*
Crappie species	*Pomoxis sp.*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Yellow perch	*Perca flavescens*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum*

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