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APPLICATIONS OF AN ANGLER DIARY FOR MUSKELLUNGE *ESOX MASQUINONGY*

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Applications of an Angler Diary for Muskellunge *Esox masquinongy*[1]

Jerry A. Younk and Mark F. Cook

Minnesota Department of Natural Resources
Section of Fisheries
500 Lafayette Road
St. Paul, MN 55155

Abstract.--An angler diary program was designed and implemented using volunteer muskellunge anglers. Some of the design and operational problems, and the corrective measures applied are described. Angler participation remained relatively low throughout the four year project. A total of 128 anglers participated in the project providing information on 4,912 trips totaling 56,068 angler-hours. Participants averaged 14.4 trips/season with an average trip length of 5.6 hours. Catch rates were low averaging 0.027 fish/hour and 0.011 legal-sized fish/hour. A total of 1,745 muskellunge were caught averaging 33.9 inches TL. Forty-seven percent of all reported muskellunge were 36 inches or longer. Most reported effort occurred at Leech and Cass lakes in northern Minnesota and Lobster Lake in west-central Minnesota. Expenditures were highest for trips to out-of-state waters and lowest for trips to Minnesota lakes.

Introduction

Native muskellunge *Esox masquinongy* populations in Minnesota occur primarily in the Mississippi River and Hudson Bay drainages. The species has been propagated and stocked into many more lakes statewide (Figure 1). Muskellunge management has been limited by deficiencies in the available information and the cost of collecting biological information on the species. The Minnesota Department of Natural Resources' (MNDNR) standard lake survey methodology is inadequate to assess the muskellunge resource. Estimates of muskellunge size-age structures and population trends are rare.

Muskellunge are seldom abundant in any lake where they occur (Eddy and Underhill 1973). Muskellunge anglers comprise a small portion of licensed anglers. MNDNR standard survey techniques including creel

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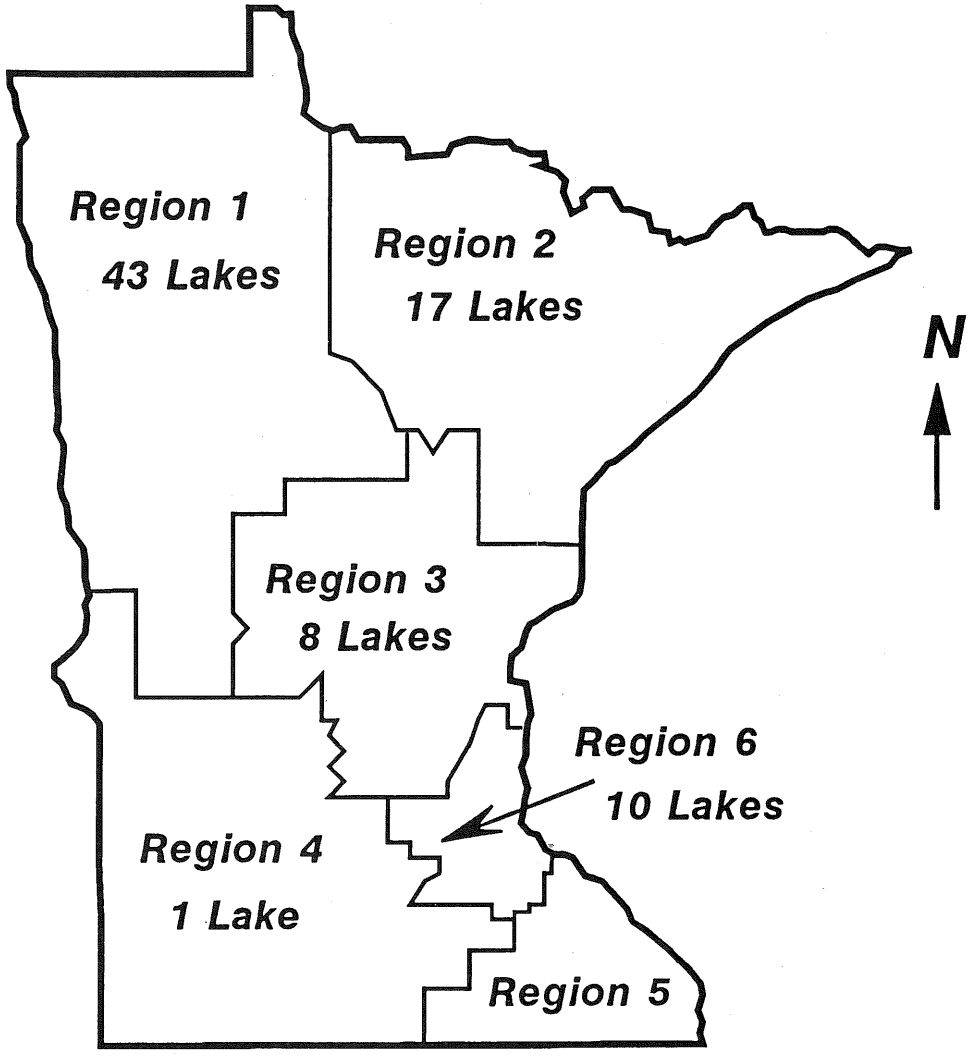

Figure 1. Statewide distribution of lakes managed for muskellunge in Minnesota. MNDNR administrative regions are indicated on the map, 1987.

surveys, fall electrofishing, and spring trap netting are presently the best sources of information about muskellunge for fishery managers. Each method has its strengths and weaknesses, and no one method or combination of methods supplies all the needed information.

Estimates of fishing pressure directed specifically at muskellunge and of the statewide harvest are unavailable. It is generally accepted that fishing pressure, including fishing for muskellunge, has increased in Minnesota.

Costs of collecting data from muskellunge populations could be reduced by having volunteer anglers provide vital statistics from the fish they catch. Volunteer anglers have provided reliable data on a Minnesota largemouth bass *Micropterus salmoides* population (Ebbers 1987). Angler-supplied data has also been used for muskellunge (Hacker 1973; Brege 1986; Hanson 1986; Oehmcke 1986; Mick 1992) to supplement traditional data sources. Results from these programs, for the most part, were successful. Many states have patterned their program after the *Husky Musky Club* established by Ohio (Ohio Department of Natural Resources 1990).

The purpose of this study was to design a voluntary reporting system to collect more detailed information on relative fishing pressure and catch of muskellunge from Minnesota waters. Also of interest were biological data about muskellunge and the economic impact of muskellunge anglers. Diaries distributed to volunteer anglers were used to gather the information. The program was presented to volunteer anglers as *Project Muskie*.

Methods

Volunteer Anglers

Project Muskie was a cooperative project between the MNDNR and the Paul Bunyan Heartland Chapter of Muskies Inc. (PBHC-MI). Promotion of the project was accomplished by posters, newspaper releases, presentations, and solicited recommendation of participating anglers. The design and distribution of diaries and other materials was accomplished with the aid of PBHC-MI. At the start of the project, a one time training session was conducted for interested anglers and Muskies Inc. (MI) chapter representatives. The diary program was introduced and detailed instructions for completing the diary were provided. Anglers were specifically instructed to record all muskellunge fishing trips regardless of success. The proper techniques for measuring fish, recording data, and obtaining scale samples were demonstrated. There are eight MI chapters in Minnesota. All participated to some extent. During the first year, additional diaries were distributed to resorts (16) and bait shops (13) to include non-MI muskellunge anglers in the project. Diaries were distributed to muskellunge anglers annually from 1986-1989.

Two methods were used to distribute and retrieve diaries. The first year diaries were broadly distributed to all MI chapters, resorts, and bait stores. Diaries were initially returned to the PBHC-MI where the information was extracted from the booklets and summarized by the chapter's representative. The tabulated information and the original diaries were then forwarded to MNDNR personnel for analysis. After the first year, a mailing list of previous participants and other anglers who had expressed a desire to participate was established. Anglers on the mailing list were provided diaries with return postage, and were requested to forward diaries to the MNDNR bi-monthly.

Embroidered jacket emblems and certificates of appreciation were given to participants as incentives. Upon completion of *Project Muskie*, baseball caps with the project logo were mailed to all participating anglers.

Diary Design

The diary was designed to gather specific information on fishing trips, catch,

population parameters (age, size, growth, and sex), and fish behavior (habitat characteristics, weather, and depth of catch). Anglers were also asked to report the distance traveled, and to estimate the total cost of each fishing trip (Figure 2). Costs were to include gas, food, lodging, and bait.

Each diary contained general and detailed instructions on recording information. In addition, each diary also contained the following: a brief description of *Project Muskie* and its objectives; an Esocid picture identification key depicting muskellunge, northern pike *Esox lucius*, and tiger muskellunge *E. masquinongy x E. lucius*; and detailed pictorial instructions on the correct way to measure fish length (TL), collect scales, and to determine muskellunge sex. External sexual characteristics described by Lebeau and Pageau (1989) were used to distinguish between males and females. Anglers were instructed not to guess the sex of captured fish. Scale envelopes were provided with the diaries for anglers to collect scale samples.

Analytical Methods

Estimates of fishing pressure are total reported effort and relative pressure (expressed as percentages) among all the lakes. It was not possible to estimate total statewide muskellunge fishing pressure collected from the information collected. Some anglers recorded fishing effort in hours while others reported numbers of trips. Because of this, catch rates are expressed as both fish/hour and fish/trip. Catch rates were also calculated on a monthly and annual basis for each water body.

Some data were poorly or inconsistently reported. This information was either discarded or, if possible, interpreted by the biologist. Data was sorted by geographic region (Minnesota or Minnesota lake specific, Ontario, and Wisconsin waters), and pooled from all geographic regions (grand means). All three geographic areas had minimum length limits that varied among lakes and jurisdictions. The majority of length limits were from 30 to 40 inches, with 36 inches being the most common minimum legal-size. Standard parametric and non-parametric statistics were used to evaluate the diary results (Steel and Torrie 1980; Snedecor and Cochran 1989).

Results and Discussion

Angler participation in *Project Muskie* fluctuated annually. A total of 128 anglers participated during the study with a high of 91 in 1987 (Figure 3). Eleven percent of the anglers participated in all years of the study, and 33% participated from 1987-89. Drop out rates averaged 29% annually. The highest proportion (27%) left the program after only one year. Anglers were recruited throughout the study period averaging 29 new participants annually.

The annual number of participating muskellunge anglers remained low throughout the study. Low participation rates by muskellunge anglers in cooperative studies seems to be a common problem. Haas (1978) reported only 50% of the members from the Michigan-Ontario Muskie Club responded to a mail survey after receiving two reminders. A muskellunge angler diary program failed in New York (Oehmcke 1986). Also in New York, a state law requires muskellunge anglers to submit reports with appropriate catch data within 10 days after the close of the season. License reports were returned annually at rates below 25%, even though fines or imprisonment were possible for failure to comply (Oehmcke 1986). An exception to low numbers of participating anglers was a voluntary creel survey at Little Green Lake, Wisconsin, where angler cooperation was described as extraordinary (Hacker 1973).

The return rate of diaries also varied annually, with the lowest rate occurring in 1986. The initial low return rate might indicate a lack of commitment by volunteer anglers, and poor communication links between anglers and the MNDNR. Many anglers were reluctant to participate because of concerns about confidentiality. In subse-

Lake/River _____ County _____

Date _____ Total Trip Expenses $ _____

Distance Traveled _____ Number Anglers _____

Time: Started _____ AM/PM Ended _____ AM/PM

Total Fish Caught _____

Tag Number _____

							Method	Bait	Bottom	Plants
Tag	Released	Sex	Length	Weight	Muskie / Hybrid	Depth	Cast Troll Other	Live Mixed Artificial	Muck Sand Gravel Rock Mixed	None Light Moderate Heavy- Reeds Cabbage Other

Weather: ☐ Clear ☐ Ptly Cldy ☐ Overcast ☐ Fog ☐ Rain ☐ Thunderstorm ☐ Snow

Wind: ☐ Calm ☐ Light ☐ Moderate ☐ Strong

Please Use Pencil

REMARKS:

Figure 2. A sample page from an angler diary that was distributed during *Project Muskie*.

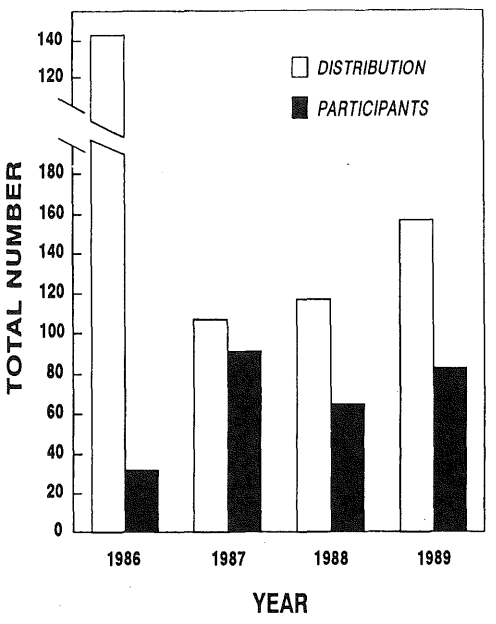

Figure 3. Number of diaries distributed and participants in *Project Muskie* from 1986-1989.

quent years, changes were made in the method of distributing and collecting diaries. A routine schedule for the return of diaries was established and return postage was included. Communication was further improved in 1988 by appointing MI chapter coordinators to promote and oversee diary distribution and collection at the chapter level. Newsletters were routinely sent out supplying participants with updated data summaries. Recording problems along with corrective measures were also addressed in newsletters. Follow-up letters to volunteers who failed to return diaries was time-consuming and usually unproductive.

The various changes after the first year improved responses. Response rates increased from 4% in 1986 to 63% during the 1987-89 period. The 63% return rate compares favorably with reported rates from other angler diary programs, for example largemouth bass (49%) (Green et al. 1986), Lake Erie (38-66%) (Sztramko et al. 1991), and Great Bear Lake (42-63%) (Anderson and Thompson 1991).

During *Project Muskie,* participants provided information on 4,912 trips totaling 56,068 angler-hours. Angling information was recorded from waters in three geographic areas; Minnesota, Ontario, and Wisconsin. Ninety-four percent of anglers reported trips to Minnesota muskellunge waters, and 43% of these anglers also fished out-of-state waters. The remaining 6% only fished out-of-state (Wisconsin or Ontario) waters. Angling information was provided for 58 Minnesota lakes and 6 rivers. More than 100 trips per lake annually were reported for 5% of the lakes. Data from lakes and rivers with few reported trips was usually of limited value.

Minnesota muskellunge lakes fall into two categories, lakes with introduced populations and those with native populations. Most of the angling occurred on waters with native populations (Table 1). Lakes of the Upper Mississippi River drainage basin are the most important and productive trophy muskellunge waters in Minnesota. Leech and Cass lakes, which support native populations, accounted for one-third of the total reported trips. Lobster Lake, in west-central Minnesota, ranked second in reported trips and third in reported pressure. Lobster Lake supports an introduced muskellunge population.

Diary information was also useful in identifying shifts in angling patterns. This was most evident for Minnesota's muskellunge "broodstock" lakes, which were established in 1982 for the purpose of propagating parental stock. The first evidence of angling on these lakes (Eagle, Elk, Owasso, Plantagenette, Rebecca, and Little Wolf Lakes) was observed in 1987. Throughout the study, pressure increased on these lakes resulting in a change in harvest regulations (Table 2). The minimum size limit on these brood stock lakes was increased from 36 inches to 48 inches in 1990 to reduce the potential harvest of female muskellunge. Mille Lacs Lake, known primarily for walleye fishing, began to receive muskellunge stockings in the early 1980s. A few fishing trips were reported in 1986 and in subsequent years reported effort for muskellunge

Table 1. Fishing pressure and catch rates from Minnesota waters, compiled from angler diaries during *Project Muskie,* 1986-1989.

Lake/River	Number of trips (*N*)	Pressure		Catch			
		Total trips (%)	Total hours (%)	Per trip		Per hour	
				Total	Legal	Total	Legal
Native Populations							
Leech	772	20.9	26.3	0.25	0.13	0.020	0.011
Cass	455	12.3	14.7	0.20	0.10	0.017	0.008
Mississippi River	253	6.9	6.7	0.17	0.10	0.017	0.010
Big Mantrap	87	2.4	4.5	0.31	0.11	0.027	0.010
Wabedo	194	5.3	4.1	0.12	0.05	0.015	0.007
Baby	138	3.7	3.9	0.19	0.06	0.018	0.005
Little Boy	131	3.5	3.4	0.11	0.03	0.011	0.003
Moose/Deer	160	4.3	3.0	0.42	0.30	0.063	0.044
Inguadona	98	2.7	2.3	0.13	0.06	0.015	0.007
Big	114	3.1	1.7	0.06	0.05	0.010	0.009
Kitchi	14	0.4	0.8	0.07	0.00	0.002	0.000
Little Winnibigoshish	34	0.9	0.7	0.22	0.09	0.018	0.008
Big Winnibigoshish	18	0.5	0.6	0.00	0.00	0.000	0.000
Woman	11	0.3	0.3	0.00	0.00	0.000	0.000
Pike Bay	12	0.3	0.3	0.37	0.13	0.033	0.013
St. Croix River	9	0.2	0.2	0.10	0.00	0.013	0.000
Snake River	1	<0.1	0.1	0.00	0.00	0.000	0.000
Prairie River	6	0.2	<0.1	0.00	0.00	0.000	0.000
Long	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Big Sand	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Big Fork River	2	0.1	<0.1	0.00	0.00	0.000	0.000
Mann	5	0.1	<0.1	0.56	0.00	0.111	0.000
Little Fork River	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Child	2	0.1	<0.1	0.00	0.00	0.000	0.000
Bad Axe	1	<0.1	<0.1	1.00	0.00	0.167	0.000
Big Wolf	2	0.1	<0.1	0.00	0.00	0.000	0.000
Introduced Populations							
Lobster	457	12.4	9.1	0.39	0.12	0.064	0.022
West Battle	83	2.2	3.1	0.20	0.13	0.019	0.014
Beers	76	2.1	2.0	0.25	0.17	0.025	0.017
Indian	87	2.4	1.7	0.22	0.09	0.033	0.014
Bald Eagle	64	1.7	1.5	0.86	0.53	0.099	0.061
Sugar	73	2.0	1.5	0.79	0.41	0.093	0.036
Mille Lacs	43	1.2	1.4	0.30	0.20	0.026	0.018
Little Wolf	71	1.9	1.3	1.23	0.14	0.155	0.020
Elk	34	0.9	0.8	0.29	0.06	0.029	0.005
Independence	31	0.8	0.5	0.35	0.11	0.061	0.019
Orange	16	0.4	0.4	0.45	0.33	0.046	0.033
Miltona	16	0.4	0.3	0.00	0.00	0.000	0.000
Plantagenette	10	0.3	0.2	0.19	0.00	0.033	0.000
French	8	0.2	0.2	0.11	0.00	0.013	0.000
Alexander	4	0.1	0.2	0.83	0.33	0.049	0.018
Rush	6	0.2	0.1	0.25	0.00	0.042	0.000
Harriet	7	0.2	0.1	0.42	0.17	0.068	0.020
Howard	4	0.2	0.1	0.00	0.00	0.000	0.000
Bush	4	0.1	0.1	0.00	0.00	0.000	0.000
Bemidji	9	0.2	0.1	0.22	0.22	0.062	0.062
Grace	4	0.1	0.1	0.00	0.00	0.000	0.000
Owasso	7	0.2	0.1	0.25	0.08	0.065	0.022
South Twin	3	0.1	0.1	0.00	0.00	0.000	0.000

Table 1. Continued.

Lake/River	Number of trips (*N*)	Pressure: Total trips (%)	Pressure: Total hours (%)	Catch: Per trip: Total	Catch: Per trip: Legal	Catch: Per hour: Total	Catch: Per hour: Legal
Introduced Populations							
Eagle	4	0.1	0.1	0.00	0.00	0.000	0.000
Six Mile	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Beaver	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Spider	2	0.1	<0.1	0.00	0.00	0.000	0.000
Rebecca	2	0.1	<0.1	0.00	0.00	0.000	0.000
Cross	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Pughole	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Pelican	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Sand	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Rice	2	0.1	<0.1	0.00	0.00	0.000	0.000
North Star	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Twin	1	<0.1	<0.1	0.00	0.00	0.000	0.000
North Twin	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Nokomis	1	<0.1	<0.1	0.00	0.00	0.000	0.000
Unknown	30	0.8	1.0	0.03	0.00	0.003	0.000

Table 2. Annual fishing pressure (percent total trips) on Minnesota's broodstock lakes and Mille Lacs Lake from 1986-1989 compiled during *Project Muskie*.

Lake	Year: 1986	1987	1988	1989
Mille Lacs	0.2	0.1	0.9	3.1
Broodstock lakes				
Eagle	-	0.3	0.1	-
Elk	-	0.1	2.6	0.8
Little Wolf	-	1.6	2.7	2.7
Owasso	-	0.1	-	0.6
Plantagenette	-	0.3	0.3	0.4
Rebecca	-	-	0.1	0.1
Broodstock mean	0.0	0.4	1.0	0.8

at Mille Lacs Lake gradually increased (Table 2).

Muskellunge angling occurred mainly from early June throught September although the muskellunge angling season extends from the first Saturday in June to mid-February (Table 3). Angling effort was highest early in the season. Over 50% of the total effort reported occurred in June and July. By the end of September, effort had decreased to less than 10% of the total. Limited angling occurred during the months of November and December, and no angling was reported during the remaining two months of the season. Reported effort during April and May occurred on Minnesota-Wisconsin border waters.

Total catch rates from Minnesota waters varied little from year-to-year, but catch rates of legal-sized fish fluctuated (Table 4). Total catch rates for all sizes of muskellunge were low, averaging 0.027 fish/hour and 0.26 fish/trip. These values are slightly lower than the 0.038 fish/hour reported for eight northern Wisconsin lakes (Hanson 1986). The average annual catch rate of legal-sized fish was 0.011 fish/hour, and ranged from 0.006-0.016 fish/hour. For Minnesota lakes with adequate data, catch rates were similar to those from Chautauqua Lake, New York (0.012) (Mooradian and Shepherd 1973), Lake Pomme de Terre, Missouri (0.015) (Belusz 1978), Cave Run Lake, Kentucky (0.017) (Axon 1978), and Wisconsin (0.014) (Hanson 1986). The best angling year in Minnesota occurred in 1986 and was followed by the worst in 1987. Anglers fishing out-of-state waters averaged higher total catch rates per trip (Table 4). Sample sizes were usually small for lakes with extremely high or low reported catch rates.

In Minnesota, the highest catch rates occurred in lakes with introduced populations of muskellunge (Table 1). Catch rates of all sizes for introduced populations averaged 0.027 fish/hour and ranged from 0.000-0.155 fish/hour. Catch rates of legal-sized fish averaged 0.010 fish/hour (range 0.000-0.061 fish/hour). Catch rates from lakes with native populations of muskellunge averaged 0.021 fish/hour and 0.005 legal-sized fish/hour. Minnesota catch rates were highest in late fall, averaging 0.050 fish/hour (0.037 fish/trip), and 0.087 fish/hour (0.33 fish/trip) for October and November, respectively. Catch rates varied from 0.021 fish/hour (September) to 0.028 fish/hour (August) during the peak angling season (Table 3). Only one comparison was possible with previous creel surveys conducted in Minnesota. Diarists averaged 0.020 muskellunge/hour on Leech Lake,

Table 3. Monthly fishing pressure and catch rates from Minnesota waters, compiled from angler diaries during *Project Muskie,* 1986-1989.

Month	Number of trips (*N*)	Pressure		Catch			
		Total trips (%)	Total hours (%)	Per trip		Per hour	
				Total	Legal	Total	Legal
April	2	0.1	0.1	0.50	0.50	0.041	0.041
May	8	0.2	0.1	0.13	0.00	0.026	0.000
June	824	22.4	21.2	0.26	0.07	0.027	0.008
July	1,073	29.1	29.4	0.25	0.08	0.025	0.008
August	712	19.3	20.6	0.29	0.05	0.028	0.005
September	670	18.2	21.8	0.25	0.07	0.021	0.005
October	345	9.4	6.9	0.37	0.13	0.050	0.017
November	57	1.5	0.6	0.33	0.11	0.087	0.027
December	1	<0.0	<0.0	0.00	0.00	0.000	0.000

which was similar to the 0.018 fish/hour observed during a 1991 creel survey (Haukos 1992).

Trips per angler, average length of trip, and party size varied among geographical areas. The average angling trip for muskellunge on Minnesota waters was 5.6 hours (Table 4). Participants fishing Minnesota waters averaged 14.5 trips/season, however, the median was 11.0 trips/season. Although participants averaged 14.5 days/season, less than 50% fished more than 10 days (Figure 4). Very few anglers fish for muskellunge more than 35 times per year. In comparison, the United States Fish and Wildlife Service (1988) estimated that a typical muskellunge angler fished an average of 22 days/season. Anglers reporting out-of-state fishing trips averaged 7.9 trips/season and 6.9 hours/trip. Angler outings to Minnesota and Wisconsin waters were typically less than two days. Extended outings, averaging 4.4 days, were common for Ontario fishing trips (Table 4). Angler characteristics such as party size, trip length, and hours fished varied little from year-to-year for Minnesota angling trips. Party size rarely exceeded two anglers except for trips to Ontario.

Successful anglers were asked to record their fishing method and specific biological information on each captured muskellunge, whether fish were harvested or released. During the four years, details were recorded for 1,745 muskellunge from all three geographic areas. The completeness of the reporting was highly variable ranging from a high of 100% for date of catch to a low of 1.5% for weight of muskellunge (Table 5). Numbers of fish recorded peaked in June and July (Figure 5) except for catches from Wisconsin where proportionately more fish were caught in late fall.

One of the more useful items recorded by anglers was the length of muskellunge caught. Mean lengths of fish reported for the three major geographic areas were similar, varying less than one inch (Table 6). Length frequency distributions, however, differed among geographic areas (Figure 6). A higher proportion of muskellunge 40 inches and longer was reported from Ontario waters. Modes for Minnesota and Wisconsin muskellunge were 36 and 38 inches, while the Ontario mode was 30 inches. The right limb of muskellunge length frequencies from Minnesota and Wisconsin was steeper for fish larger than 38 inches than from Ontario. This may indicate a higher rate of exploitation for larger fish in these states. The lower proportion of large fish from Minnesota may also reflect fishing on lakes with recently introduced populations. Few fish from these lakes would have been expected to exceed 40 inches during this study (Figure 7).

Muskellunge anglers seek trophy-sized fish. A comparison of length frequencies for harvested and released fish bears this out (Figure 7). Harvested fish averaged 9.5 inches TL longer than released fish (Table 7). A creel survey on Leech Lake found the average size of harvested and released muskellunge to be 47.3 and 35.2 inches, respectively. This is similar to the mean lengths reported for fish from lakes with native populations (Table 7). Mean lengths of harvested fish were larger from Ontario than from Minnesota and Wisconsin (Table 7). None of the differences were statistically significant (Mann-Whitney two sample test: MN vs. ONT, $P = 0.26$; MN vs. WS, $P = 0.13$). The mean length of all fish reported was 33.9 inches TL.

Correctly sexing muskellunge by examination of urogenital openings is difficult for trained observers, so it is not surprising that few attempts were made by anglers. Only 21.2% (370 fish) of the muskellunge were sexed by anglers. They reported significantly more females than males from Minnesota ($Z = -2.24$, $P = 0.025$) and Ontario ($Z = -2.52$, $P = 0.012$) (Table 6). There are three possible explanations for the higher proportion of females: (1) fish were sexed wrong; (2) the proportion of females caught by anglers may accurately reflect the sex ratio of wild muskellunge populations; or (3) muskellunge angling as a sampling tool is biased and selects proportionately more female fish. We suspect a combination of

Table 4. Summary of angler effort and catch rates from Minnesota and out-of-state waters, compiled from angler diaries during *Project Muskie* from 1986-1989.

Year	Mean number of trips	Mean number anglers/ trip	Mean hours/ trip	Mean trip length (days)	Catch			
					Per trip		Per hour	
					Total	Legal	Total	Legal
Minnesota								
1986	19.1	1.7	5.7	1.3	0.27	0.15	0.028	0.016
1987	12.9	1.8	5.8	1.4	0.20	0.06	0.026	0.006
1988	15.2	1.8	5.3	1.4	0.30	0.15	0.028	0.012
1989	13.6	1.8	5.7	1.4	0.25	0.10	0.027	0.010
Ontario								
1986-89	7.8	2.4	8.5	4.4	0.73		0.045	
Wisconsin								
1986-89	8.0	1.8	5.3	1.2	0.54		0.065	

Table 5. Reporting frequency (%) for successful anglers of the various items in the angler diary of *Project Muskie*.

Location	Diary entries (*N*)	Date	Lake/ River	Scale sample	Total length	Weight	Sex	Method fished	Bait type	Depth	Bottom type	Aquatic plants
Minnesota	977	100.0	100.0	3.9	99.3	1.3	23.5	98.8	98.8	90.9	94.6	97.6
Ontario	515	100.0	97.7	0.4	99.8	1.9	22.3	99.2	98.3	85.0	97.3	95.7
Wisconsin	224	100.0	99.2	1.3	98.4	1.6	9.0	100.0	100.0	92.6	89.3	97.5
Grand mean*	1745	100.0	98.7	2.5	99.3	1.5	21.2	99.1	98.8	89.5	94.7	97.1

* Includes fish of unknown capture location.

Table 6. Numbers and mean lengths of captured muskellunge reported in angler diaries during *Project Muskie* from 1986-1989.

Location	Numbers		
	Males (%)	Females (%)	All fish (%)
Minnesota	98 (42.6%)	132 (57.4%)	977 (56.0%)*
Native waters	66 (39.5%)	101 (60.5%)	504 (28.9%)
Introduced waters	32 (50.8%)	31 (49.2%)	472 (27.0%)
Ontario	44 (38.3%)	71 (61.7%)	515 (29.5%)
Wisconsin	11 (50.0%)	11 (50.0%)	244 (14.0%)
Grand Mean*	155 (41.9%)	215 (58.1%)	1,745 (100.0%)

	Mean Length (Inches)		
	Males (*SE*)	Females (*SE*)	All fish (*SE*)
Minnesota	33.5 (5.3)	38.7 (5.9)	34.0 (6.3)
Native waters	35.0 (4.7)	39.5 (5.8)	35.2 (6.8)
Introduced waters	30.4 (5.0)	35.9 (5.2)	32.7 (5.3)
Ontario	30.2 (6.8)	38.2 (8.1)	33.9 (7.1)
Wisconsin	29.7 (3.5)	38.6 (6.8)	33.1 (5.7)
Grand Mean*	32.3 (5.8)	38.5 (6.7)	33.9 (6.5)

*Includes fish of unknown capture location.

Table 7. Fate of captured muskellunge during *Project Muskie*, 1986-1989.

Location	Number harvested		Number released		Average Size (*SE*)	
	N	Percent	*N*	Percent	Harvested	Released
Minnesota*	12	1.2%	965	98.8%	44.0 (4.6)	33.9 (6.2)
Native lakes	9	1.8%	495	98.2%	45.1 (4.0)	35.1 (6.7)
Introduced lakes	3	0.6%	469	99.4%	40.8 (5.4)	32.7 (5.3)
Ontario	13	2.5%	502	97.5%	44.9 (7.2)	33.6 (6.9)
Wisconsin	5	2.0%	239	98.0%	40.7 (5.2)	32.9 (5.6)
Grand Mean*	30	1.7%	1,715	98.3%	43.2 (6.9)	33.7 (6.3)

*Includes fish of unknown capture location.

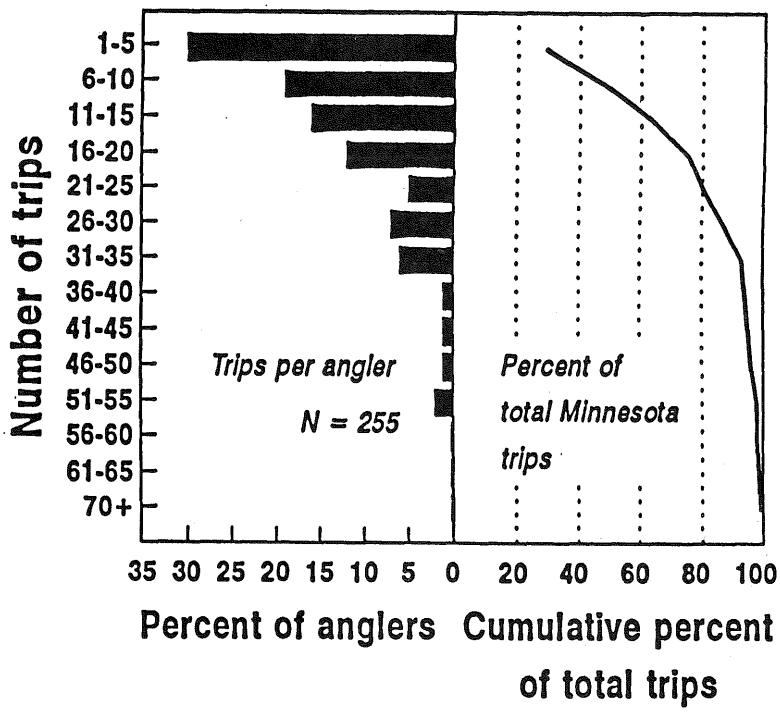

Figure 4. Number of Minnesota trips per angler during *Project Muskie* 1986-1989.

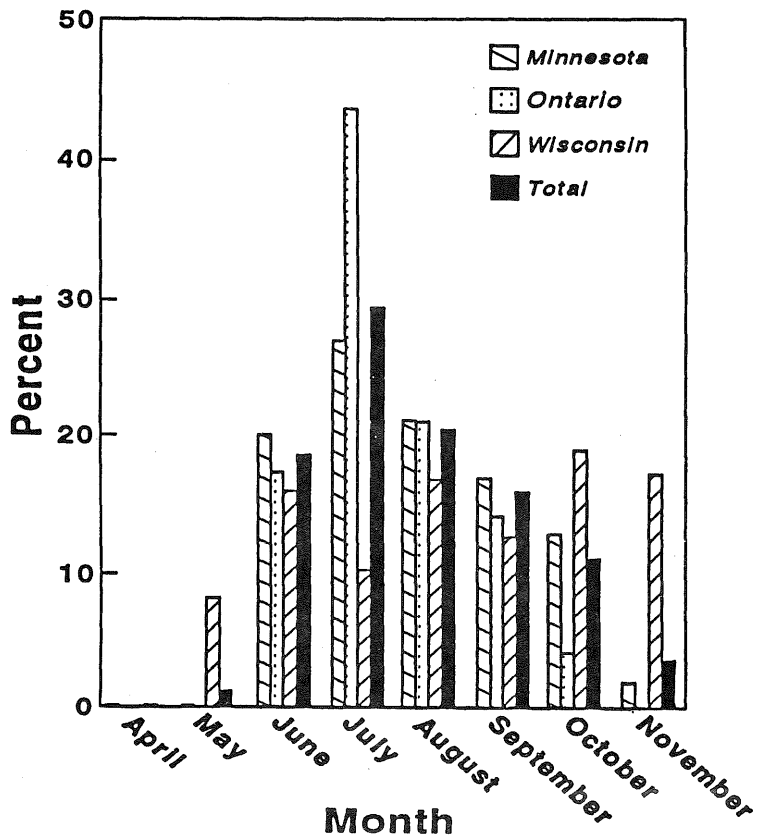

Figure 5. Distribution by month of muskellunge catch during *Project Muskie*, 1986-1989.

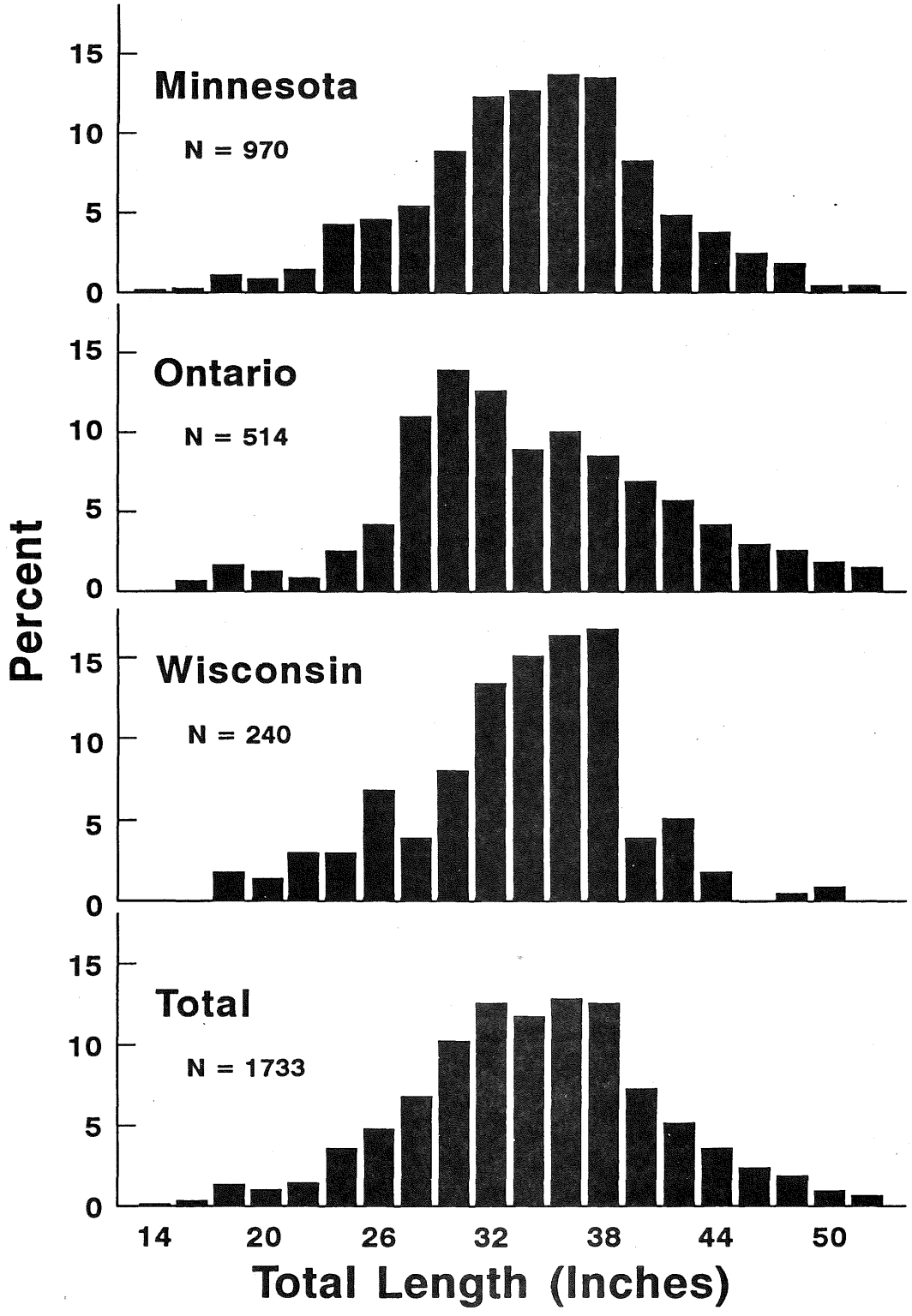

Figure 6. Geographic breakdown of muskellunge length distributions from angler diaries during *Project Muskie*, 1986-1989.

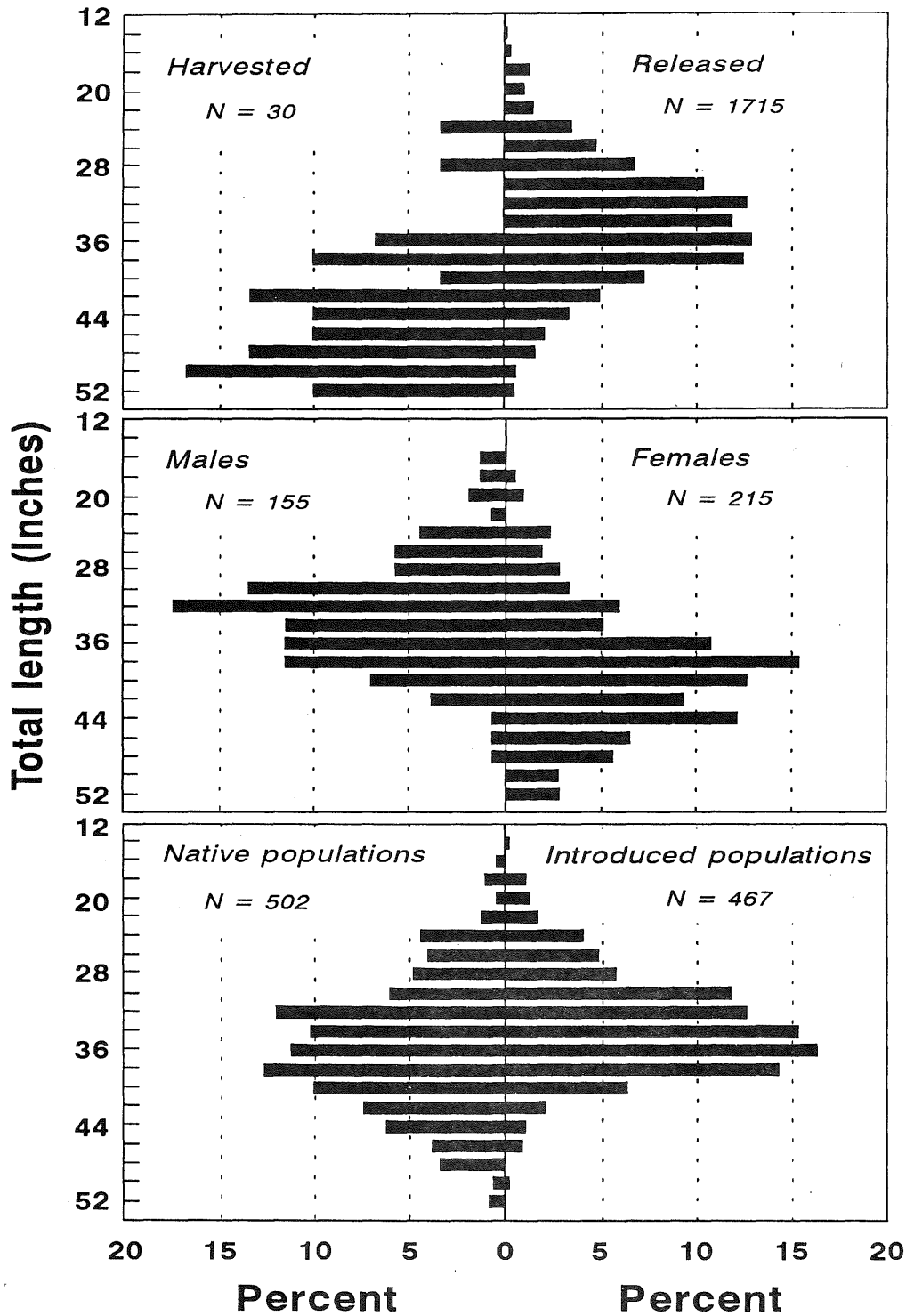

Figure 7. Length frequency distributions for harvested versus released muskellunge (top), males versus females, (middle), and native versus untroduced populations (bottom) from angler recorded muskellunge lengths during *Project Muskie*, 1986-1989.

the explanations affected the observed sex ratios.

Minnesota broodstock lakes contained populations of young, unexploited muskellunge, and the sex ratio was close to 1:1. The sex ratio from Minnesota lakes with native populations was 1.53 females:1 male (Z = -2.71, P = 0.007) (Table 6). Minnesota's native muskellunge waters have mature, exploited populations and the sex ratio was similar to that from Ontario waters. The bias of angling may also partially explain these unequal sex ratios. About 35% of the sexed fish were 40 inches or longer. Very few males would be expected to attain this length. A sample of trophy muskellunge from the St. Lawrence River favored females 2.1:1 (Casselman and Crossman 1986).

Length-frequencies of males and females sexed by anglers differed; the larger fish were females (Figure 7; Table 6). Biologists have observed sexual dimorphism in length between the sexes of muskellunge (Hanson 1986). Fish sexed by anglers also reflected this dimorphism and this indicates that fish were sexed accurately.

Most muskellunge caught were released by diarists (Table 7). Participants in this study reported releasing more of their catch (98.3%) than anglers from Wisconsin (76.3%) (Hanson 1986), or from Illinois (86%) (Mick 1992). During a creel survey on Leech Lake, Minnesota, 95.2% of muskellunge reported caught were released (Haukos 1992).

There was a negative relationship between muskellunge size and reported release rates, with diarists harvesting a greater percentage of larger fish (Figure 8). This is similar to observations from Illinois where the harvest rate was higher for fish larger than 40 inches than for fish smaller than 40 inches. Minnesota anglers appeared to be about twice as likely to harvest a muskellunge when travelling out-of-state (Table 7), although the differences were not statistically significant (MN vs. ONT, P = 0.064; MN vs. WS, P = 0.30). We believe economic and social incentives make an angler more likely to harvest a fish when traveling out-of-state.

Catches of muskellunge are not randomly distributed among anglers (Figure 9). Three anglers accounted for 23% of the total reported catch. Most anglers (73%) caught fewer than 10 muskellunge per year from Minnesota waters. They accounted for 29%

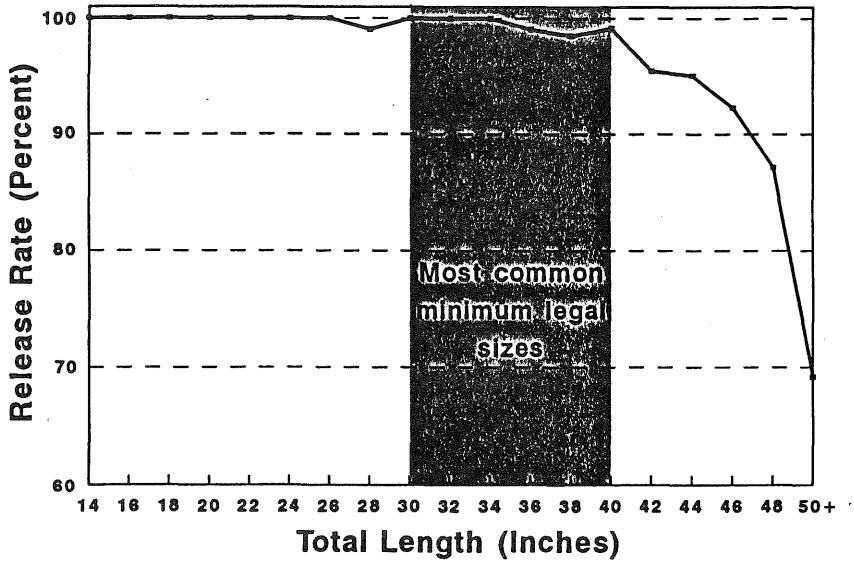

Figure 8. Percent of muskellunge released by length group during *Project Muskie*, 1986-1989.

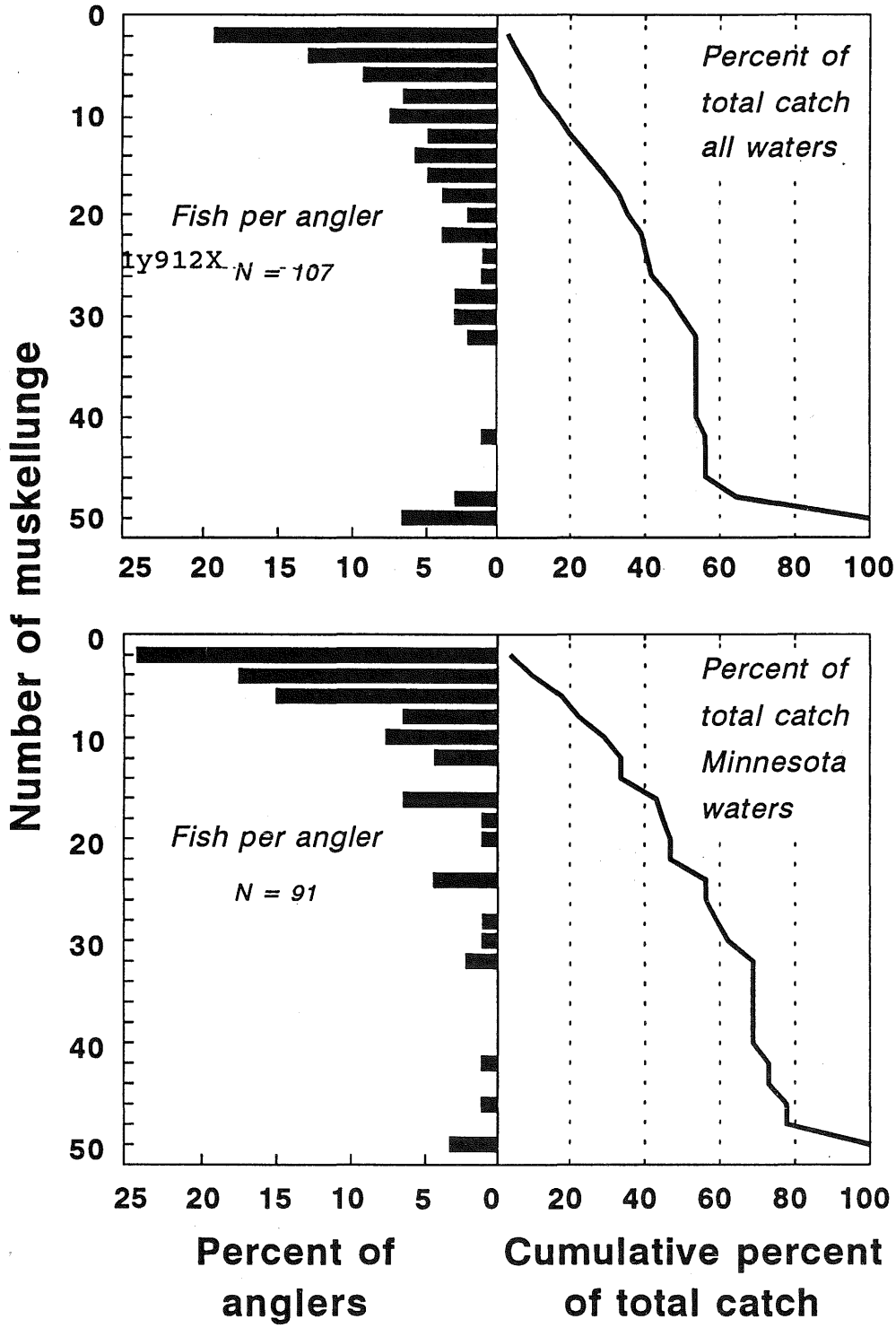

Figure 9. Percentage of anglers capturing various numbers of muskellunge from all waters (top), and Minnesota waters (bottom) during *Project Muskie* 1986-1989.

of the total catch. Conversely, about 25% of the anglers caught more than 65% of the fish. When all geographic areas were combined, 10 anglers (8%) accounted for 42% of the catch. These anglers fished more hours than other anglers and were probably more skillful. Similar observations have been reported for largemouth bass; the top 30% of anglers accounted for 75% of the total reported catch (Green et al. 1986).

The predominant fishing method was casting with artificial lures (Table 8). Anglers fishing Wisconsin waters were more likely to use live bait.

Expenditures for fishing trips on Minnesota waters were similar among the four years (Table 9). The relatively low mean cost of $23.81/day reflected short traveling distances and short fishing trips. Few participants traveled farther than 70 miles or stayed longer than 2 days. A regional breakdown of expenses indicated that the highest cost/day ($26.53) was incurred in Region 1 while costs were lowest ($10.90) in Region 6 (Table 10, Figure 1). Muskellunge waters in Regions 3, 4, and 6 attracted mainly local anglers, as indicated by the relatively low mean distances traveled (Table 10). More than 50% of the muskellunge waters are located in Region 1, and the costs reflect the increased distances traveled to reach these lakes.

Expenses for out-of-state angling trips increased with distance traveled and length of trip. Angler expenditures for fishing trips to Wisconsin and Ontario averaged $27.91 and $86.72/day, respectively (Table 9). In both cases, expenses varied more annually than for Minnesota based trips. Assuming certain costs for travel and time, Menz and Wilton (1983) projected a cost per angler day for New York anglers ranging from $8.43 (Chautaugua Lake) to $41.86 (St. Lawrence River).

Management Implications

Angler diaries are potentially valuable sources of information about muskellunge populations, and the effects of angling. To be truly successful, however, participation must be higher than the levels attained in this study. Inducing anglers to participate is a major problem. Recruitment of anglers requires a considerable amount of time. Because initial enthusiasm declines after only one year, constant recruitment of new participants is necessary.

Frequent communication is required to keep volunteers involved with the project and to provide them with accurate information. A great deal of time is spent contacting anglers, providing newsletters, training volunteers, and preparing oral reports. If an angler group such as MI is involved, appointing a chapter coordinator is essential for maintaining enthusiasm and for distributing information.

Table 8. Angling methods (%) and bait used by volunteers during *Project Muskie*, 1986-1989. Total sample size (*N*) for each location is indicated by parenthesis.

	Angling Method					Bait				
Location	Cast	Troll	Jig	Other	*N*	Artificial	Live	Mixed	Other	*N*
Minnesota	96.7%	2.8%	0.4%	0.1%	965	99.6%	0.4%	0.0%	0.0%	965
Ontario	97.5%	2.1%	0.0%	0.4%	511	99.6%	0.0%	0.0%	0.4%	506
Wisconsin	91.4%	6.6%	0.4%	1.6%	244	95.1%	2.0%	2.9%	0.0%	244
Grand mean*	96.2%	3.1%	0.3%	0.4%	1,729	99.0%	0.5%	0.4%	0.1%	1,724

*Includes fish of unknown capture location.

Table 9. Summary of expenses and distance traveled for muskellunge anglers, 1986-1989.

Year	N	Cost/trip Mean	Cost/trip SE	Cost/day Mean	Cost/day SE	Mean distance traveled one-way (miles) Mean	Mean distance traveled one-way (miles) SE
				Minnesota			
1986	358	$47.96	10.31	$23.13	1.81	59.8	3.7
1887	824	$47.50	4.44	$25.29	1.57	64.8	2.7
1988	583	$43.29	2.97	$23.89	0.97	61.2	2.9
1989	687	$38.41	2.62	$22.93	1.02	56.1	2.4
				Ontario			
1986	10	$292.30	59.79	$57.01	8.20	269.0	26.1
1987	65	$291.30	38.76	$98.84	23.75	321.0	13.8
1988	52	$367.80	36.83	$84.14	7.88	327.0	22.3
1989	45	$516.62	106.85	$106.89	16.76	284.0	22.3
				Wisconsin			
1986	7	$19.86	9.30	$14.50	4.08	55.7	14.1
1987	139	$42.64	5.29	$28.61	2.08	91.1	5.2
1988	93	$45.27	7.43	$35.03	3.87	102.0	6.4
1989	67	$56.70	14.49	$33.51	5.62	88.8	7.6

Table 10. Comparison of muskellunge angler expenses and distance traveled, compiled from angler diaries and stratified by MNDNR administrative regions, 1986-1989.

Region	N	Cost/trip Mean	Cost/trip SE	Cost/day Mean	Cost/day SE	Mean distance traveled one-way (miles) Mean	Mean distance traveled one-way (miles) SE
1	1,830	$52.19	15.06	$26.53	3.52	69.3	7.2
2	177	$38.86	19.82	$23.83	14.19	62.4	25.2
3	298	$16.53	4.58	$14.57	2.65	27.8	6.9
4	8	$20.88	2.87	$20.89	2.87	33.3	-
5	-	-	-	-	-	-	-
6	139	$11.53	3.65	$10.90	2.60	19.5	5.9

Any future attempts to implement an angler diary program should include the successful features of this study. In addition, Green et al (1986) and Anderson and Thompson (1991) outline design and operational improvements that should be reviewed and considered.

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