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WISCONSIN DEPARTMENT OF NATURAL RESOURCES

# RESEARCH REPORT 159

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## The Muskellunge Fishery in Nine Northern Wisconsin Lakes

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### Abstract

A comprehensive survey of population characteristics and angler use of muskellunge (*Esox masquinongy*) was conducted for 9 northern Wisconsin lakes to provide baseline information and guidelines for the muskellunge management program. Physical-chemical characteristics, stocking history, predominant fish species, muskellunge population characteristics, fishing pressure, and recommendations for managing the muskellunge fishery are presented for each lake. This report should be viewed as a supplement to Hanson (1986) which presents the major results for 8 of the lakes. The primary objectives of this report are to report results for a ninth lake and to present data from individual lakes in more detail than previously reported.

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## **Contents**

**Introduction, 3**

**Study Sites, 4**

**Methods, 4**

Lake and Population Characteristics, 4

Angler Use, 5

Data Analysis, 5

**Results, 6**

Mud/Callahan Lake, 6

Lake Winter, 7

Sissabagama Lake, 7

Little Arbor Vitae Lake, 7

Big McKenzie Lake, 8

Sand Lake, 8

Day Lake, 9

Big Lake, 9

Big Arbor Vitae Lake, 9

**Appendix: Scientific Names of Pertinent Species, 18**

**Literature Cited, 18**



PHOTO: TERRY MARGENAU

## Introduction

The muskellunge<sup>1</sup> is Wisconsin's premier trophy sport fish. In 1979, the Wisconsin Department of Natural Resources (DNR) muskellunge management plan for Wisconsin expressed concern that angler use and harvest of muskellunge would increase in Wisconsin at the same time that populations were expected to decline and that harvest of muskellunge would be higher than levels at which viable populations could be maintained (Wis. Dep. Nat. Resour. 1979). The plan, however, also stated that there were insufficient data regarding the muskellunge fishery to guide the management program. Because of the large number of muskellunge waters in the state and the paucity of information about the muskellunge fishery, a study was conducted to determine muskellunge population characteristics, angler use, harvest, and exploitation in 9 representative northern Wisconsin Class A muskellunge lakes from 1979-83. Angling regulations during the study included an open-season for muskellunge from the first Saturday in May through 30 November, a 30-inch minimum size limit, and a daily bag limit of one fish. Motor trolling was prohibited on 7 of the 9 lakes.

Results from this study for 8 of the 9 study lakes were reported previously Hanson (1986). Although that is the major report for this study, it does not provide the detail needed by managers conducting field operations. The objective of the present report is to provide this greater level of detail for the 8 lakes (Lake Winter and Sissabagama, Little Arbor Vitae, Big Arbor Vitae, Big McKenzie, Sand, Day and Big lakes) and to present similar data and discussion for a ninth lake (Mud/Callahan Lake), which was not included in the earlier report due to extreme differences in population characteristics (Fig. 1). This report emphasizes data (Tables 1-15), and interpretations and management recommendations are limited to an overview summary of each lake. Recommendations regarding acceptable levels of exploitation for muskellunge in Wisconsin are discussed by Hanson (1984a). Further data from this study are available from the Wisconsin Department of Natural Resources (1985) and from the DNR Bureau of Fisheries Management's computerized creel survey files.

<sup>1</sup>Scientific names of species are listed in the appendix.

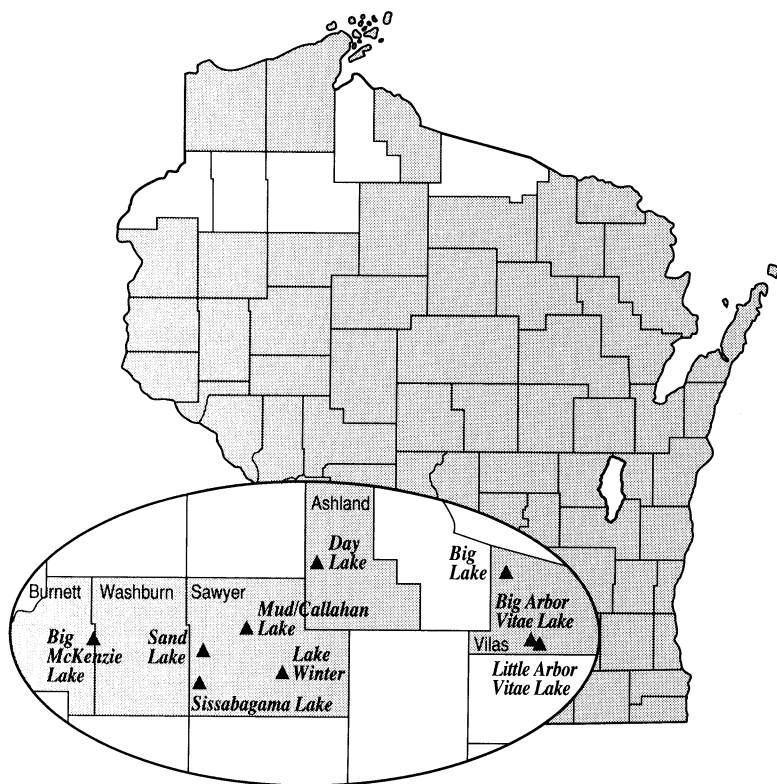


Figure 1. Location of study lakes.

## Study Sites

Study lakes were selected to represent considerable variation in muskellunge growth rates and population density, type of lake (impoundment versus natural lake), species composition for other game fish, water clarity, and depth. Very large and very small lakes were not considered for this study. Mean size of the 8 lakes (excluding Mud/Callahan Lake) was 826 acres, somewhat larger than the average size (591 acres) of all Class A Wisconsin muskellunge waters. All the lakes had mixed warm- and cool-water fish populations. Lake Winter, Mud/Callahan Lake, and Day Lake had game fish populations dominated by muskellunge and largemouth bass; the other 6 lakes had game fish populations dominated by muskellunge and walleye. Northern pike was common in 3 lakes (Sand, Big McKenzie, and Big lakes).

## Methods

### Lake and Population Characteristics

Morphometric data for each study lake were obtained from contour maps published by the DNR. Water quality data were obtained by collecting a summer composite sample from either late July or early August of 1980 or

1981. Analyses were completed by the Wisconsin State Lab of Hygiene.

Fyke nets were used to capture muskellunge from ice-out until after peak spawning activity for 2 consecutive springs in each study lake. Lake Winter and Mud/Callahan Lake were netted in 1979 and 1980; Sissabagama and Little Arbor Vitae lakes were netted in 1980 and 1981; Sand, Big, Day, and Big McKenzie lakes were netted in 1981 and 1982; and Big Arbor Vitae Lake was netted in 1982 and 1983. From 8 to 20 fyke nets were used in various combinations of 4- by 5-ft frames with 4-ft hoops and 5- by 6-ft frames with 5-ft hoops, with mesh sizes ranging from 1/2 to 1-1/2 inches and leads 35-100 ft long.

All captured muskellunge were measured to the nearest 0.1 inch (total length), weighed (in a wet net on a spring-loaded scale) to the nearest 0.1 lb, sexed by presence of eggs or sperm, and tagged with a numbered metal tag placed around the preopercular bone or at the anterior base of the dorsal fin. The latter tag location was used for large females if the tag was too small for the preopercular bone (Johnson 1971). Approximately 5 scales were removed from the area below the anterior end of the dorsal fin and above the lateral line for aging. Occasional year classes of known-age fish (i.e., fin-clipped stocked fish) were present in some lakes and were used to verify scale-aging accuracy. Accuracy of aging agreed with that previously reported by Johnson (1971). Data from both years of spring netting were pooled for each lake for age and growth assessment. No mortality estimates were made due to small sample sizes of individual year classes within each lake.

Population estimates of legal-sized fish ( $\geq 30$  inches total length) were determined by the Bailey modification of the Petersen estimate (Ricker 1975) for fish marked in the first spring-netting sample and recaptured by netting the following spring. Recruitment was accounted for by determining the one-year growth increment for a 30-inch muskellunge in each lake (mean of male and female from Table 5), adding that amount to

30 inches, and using the result as the minimum size in the recapture period. Thus, population estimates were for the spawning population size > 30 inches and must be considered a minimum estimate of total density > 30 inches.

Potential forage for muskellunge was not systematically sampled. However, since it was suspected that muskellunge growth may have been related to the abundance of catostomids available, a qualitative assessment was carried out. Relative abundance (abundant, common, present, rare, and not present) of catostomids and 14 other species was estimated independently by field assistants based on casual observations made during the fyke-netting, electrofishing, and creel survey of this study (Table 3). A final estimation was made by consensus of opinion.

## Angler Use

Total fishing pressure on each study lake was estimated from a roving partial creel survey during the angling season between the springs each lake was fyke-netted. Each creel survey ended at freeze-up, usually 2-3 weeks prior to the official close of the muskellunge angling season, since little or no angling pressure occurred during that period and muskellunge harvest in that period was assumed to be zero. Survey data were processed by the computerized creel survey program. Estimates of total angling effort are for daylight hours only. Estimates for lakes that had a significant night fishery (e.g., Sissabagama Lake) are minimum estimates of pressure and harvest.

In 1979, creel surveys were carried out on Lake Winter and Mud/Callahan Lake. Each lake was surveyed for 7 consecutive days/lake on an alternate-week basis. The clerk, operating from a boat, made 3 instantaneous counts/day and interviewed anglers between counts. Survey hours were: 9:00 a.m. to 8:00 p.m. (except Wednesdays, 8:00 a.m. to 8:00 p.m.) from opening weekend (6 May) through 3 October, 9:00 a.m. to 7:00 p.m. from 4-6 October, and 8:30 a.m. to 6:30 p.m. from 7 October to freeze-up (7 November). No instantaneous counts were made on Lake Winter and Mud/Callahan Lake between sunrise and the start of the survey period, since angler pressure was generally less during this period than during survey hours. Expanded pressure estimates were reduced for the period from sunrise to the start of the survey, based on trends for angler-use from Day Lake, which had a similar species composition and angler-use trends during survey hours.

For 1980-82 creel clerks were assigned to all of the 9 lakes, and they surveyed one half the daylight hours, 5 days/week. Survey shifts were defined as sunrise to mid-day and mid-day until 1/2 hour past sunset. One shift was scheduled for each Saturday and each Sunday, with the remaining 3 shifts scheduled randomly Monday through Friday (maximum of 1 shift/day). Early and late shift assignments were determined on a random basis, except that no more than 2 consecutive shifts were the same (i.e., if 2 work-week shifts were in the evening, the next shift was automatically scheduled for morning). This procedure was also used for scheduling shifts throughout the study period (i.e., if 2 consecutive Fridays had evening shifts, the next scheduled Friday had a morning shift). Five instantaneous counts of angler pressure were made during each shift: at the beginning, 2 hours into the shift, at the mid-point, 2 hours before the end, and at the end of each shift. Angler interviews (both complete and incomplete trips) were conducted between instantaneous counts.

Additional catch and harvest data on legal-sized muskellunge caught (harvested or released) during the angling season were obtained from voluntary registration at cooperating resorts, taverns, and bait shops. This voluntary information was solicited by news releases at the beginning of the angling season and by signs posted at the public access and resorts on each lake.

Three different estimates of exploitation rates were made for each lake using data from: (1) voluntary registration, (2) creel survey estimates of the total number of tagged muskellunge caught by anglers, and (3) all sources combined (voluntary registration, tagged fish seen during the creel survey, mail, phone, or office visitor). Estimates of exploitation rates from (1) and (3), above, should be considered minimum estimates.

## Data Analysis

Anderson and Weithman (1978) introduced proportional stock density (PSD) as an index of population size structure to evaluate problems of reproduction, growth, or mortality of cool-water fish species. Anderson and Gutreuter (1984) revised the definition of size categories of PSD to be used for muskellunge and discussed the use of relative stock density (RSD). They defined RSD as:

$$\text{RSD}(\%) = \frac{\text{quality size} \times 100}{\text{stock size}}$$

where quality size is  $\geq 34$  inches and stock size is  $\geq 20$  inches. However, I did not use these definitions of PSD and RSD indices, due to systematic bias among sampling methods in this study (e.g., spring fyke-netting provided little data on sexually immature, stock-sized fish and no sublegal, stock-sized fish were reported in voluntary registration). Instead, I used RSD as an index of size structure but defined quality and stock sizes to be  $\geq 34$  inches and  $\geq 30$  inches, respectively. I used both spring fyke-net length frequency data ( $RSD_{FN}$ ) and population estimates ( $RSD_{PE}$ ) as 2 separate methods to describe RSD for each lake.

Tables 2, 3, 10, and 15 include previously unreported data. The rest of the tables at the end of this report are either expansions of similar tables reported in Hanson (1986) to include Mud/Callahan Lake or to include data from all 9 lakes when only means and standard deviations were previously reported.

All means in this report and in Hanson (1986) are unweighted means which therefore reflect muskellunge population characteristics and angler-use patterns in a "typical Wisconsin muskellunge lake" rather than a "typical Wisconsin muskellunge", which would require the use of means weighted by population size. Furthermore, data from Mud/Callahan Lake are excluded from all means due to that lake's peculiar population characteristics. Mud/Callahan Lake was deliberately selected for study because of its relative uniqueness. Results from this lake are relevant only to the 3 other lakes within the drainage of the North Fork of the Chief River (Spider and Tiger-Cat lakes).

## Results

As previously reported (Hanson 1986), the average density of muskellunge  $\geq 30$  inches (total length) was 0.33 fish/acre. Density was inversely related to mean depth and water transparency, but this probably reflected generally higher stocking quotas in the shallower lakes. No abiotic factors were correlated with muskellunge growth; however, there was evidence that growth was correlated with abundance of catostomids and that growth of males was inversely related to muskellunge density. In 5 of the 8 lakes, muskellunge was the species most sought after by anglers. Muskellunge anglers fished an average 16.8 hours/acre on each lake. Minimum exploitation rates averaged 27.5% (range 13.8%-42%). The quality of the size structure of the population was

inversely related to exploitation rate. In some lakes, high exploitation rates appeared to be limiting trophy muskellunge angling potential.

Results for each of the 9 study lakes are summarized below. Each summary covers the physical-chemical characteristics, stocking history, predominant fish species, muskellunge population characteristics, and fishing pressure for each lake. Recommendations for managing the muskellunge fishery in each lake are also provided. Supporting data are presented in tables organized by topic so that comparisons can be made between lakes (Tables 1-15).

### Mud/Callahan Lake

Mud/Callahan Lake, in Sawyer County, is a 586-acre, dark-water drainage lake of the North Fork of the Chief River. Water levels are maintained by a 2-ft head control structure with an estimated discharge of 10 cfs (Sather and Threinen 1968). Water depth is shallow compared with other study lakes (mean depth 6.7 ft) (Table 1). Muskellunge were stocked from 1936 to 1954 and again in 1961. No stocking was done from 1961 to 1979, and the population has maintained itself by natural reproduction. Two stockings, in 1979 and 1982 (Table 2), were made to evaluate genetic differences. In addition to muskellunge, black crappie, largemouth bass, bluegill, and yellow perch were the predominant fish species present (Table 3).

Muskellunge in Mud/Callahan Lake were much smaller than in other study lakes. Only 0.4% of the males and 4.0% of the females captured during spring netting were  $> 30$  inches (Table 4). This high proportion of sublegal-sized fish can be explained by slow growth (Tables 5, 6) and not simply as a function of age (i.e., a very strong year class of new recruits) (Table 7). This size structure has maintained itself through natural reproduction for many years (Wis. Dep. Nat. Resour., unpubl. data). Studies have indicated that the slow growth of muskellunge in Mud/Callahan Lake was related, at least in part, to genetic differences (Hanson et al. 1983, Hanson 1984b).

Population density of legal-sized muskellunge was much lower than in other lakes: 0.03 fish/acre compared with a mean of 0.33 fish/acre (Table 8). However, the density of muskellunge  $\geq 24$  inches appeared to be quite high.

Despite the small size and low density of legal-sized muskellunge in Mud/Callahan Lake, the lake received higher overall fishing pressure (35.7 hours/acre) than 4 of the other study lakes

and the second highest muskellunge fishing pressure (28.3 hours/acre) (Tables 9, 11). The catch rates for all sizes of muskellunge were the highest observed in this study, but the catch rate for legal-sized fish was the lowest (Table 12). Mud/Callahan Lake provides anglers who wish to catch a muskellunge, regardless of size, a good place to fish. The exploitation rate was quite high (Table 14) but this presently is a trivial concern compared with the lack of growth by most individuals to a harvestable size.

Hanson (1986) recommends that optimum growth and subsequent use of muskellunge can best be attained by managing each lake in accordance with its specific conditions rather than by uniform management goals and regulations. Mud/Callahan Lake muskellunge management provides a clear example of the need for this type of management. Further discussion regarding Mud/Callahan Lake and recommended management are deferred until progress is made in ongoing studies on muskellunge genetic variability.

## Lake Winter

Lake Winter, in Sawyer County, is a 676-acre impoundment of the Brunet River (impounded in 1966). Prior to 1973, Lake Winter was called Price Flowage. Normal discharge from the 14-ft control structure is 19 cfs (Frank Koshere, Wis. Dep. Nat. Resour., pers. comm.). Lake Winter is shallow compared with other study lakes (mean depth 8.9 ft) (Table 1). Muskellunge were routinely stocked prior to this study (Table 2). In addition to muskellunge, predominant fish species were redhorse, black crappie, yellow perch, and bluegill (Table 3). A single northern pike was observed in the lake during sampling and was removed.

Mean length-at-age and growth of muskellunge in Lake Winter was much above average (Tables 5, 6) probably due to the abundant redhorse population available for forage. The high density of legal-sized fish, 0.49 fish/acre (Table 8), was a result of the stocking. The size- and age-structure of muskellunge are below average compared with most other study lakes (Tables 4, 7) and can be attributed to the high angler pressure for muskellunge (29.2 hours/acre) (Table 9) and subsequent exploitation rate (42.0%) (Table 14). Conditions in Lake Winter were such that an improvement in quality of the age structure of the population and size structure of the angler catch (Tables 7, 13) could be expected with a reduction in exploitation rate.

## Sissabagama Lake

Sissabagama Lake, in Sawyer County, is a 719-acre, soft-water seepage lake with an intermittent outflow stream that drains into Sand Lake. Muskellunge were stocked routinely prior to this study (Table 2). In addition to muskellunge, predominant fish fauna included walleye, yellow perch, black crappie, bluegill, white sucker, rock bass, and pumpkinseed (Table 3). At the time of this study, northern pike had recently entered the lake, but abundance was still low.

Of the lakes studied, Sissabagama Lake, along with Big and Little Arbor Vitae lakes, was most representative of a typical or average muskellunge lake. Mean length-at-age, growth, and density in Sissabagama Lake were somewhat below average (Tables 5, 6, 8). Fishing pressure for muskellunge was moderate (13.4 hours/acre), while both total catch and legal-sized catch rates and possible exploitation rates were above average (Tables 9, 12, 14). The high voluntary release rate of legal-sized fish (50%) (Table 12) helped minimize the effect of potential overexploitation. Recommended management focuses on reducing the exploitation rate.

## Little Arbor Vitae Lake

Little Arbor Vitae Lake, in Vilas County, is a 534-acre drainage lake with an estimated outlet discharge of 11 cfs (Lloyd Andrews, Wis. Dep. Nat. Resour., pers. comm.). There is a 2-ft rock roller control structure at the outlet. The lake is much more fertile than most other lakes in the region, with common heavy summer algal blooms. Muskellunge were stocked routinely prior to this study (Table 2). Besides muskellunge, common fish species included walleye, yellow perch, black crappie, and white sucker (Table 3). Northern pike had recently entered the lake, but were low in number at the time of this study.

Growth and mean length-at-age for muskellunge in Little Arbor Vitae was average compared with other study lakes (Table 5, 6). Abundance of legal-sized muskellunge (0.49 fish/acre) (Table 8) was above average and is believed to be due to the relatively high stocking rate the lake had received. Both total and specific fishing pressure were high compared with other lakes (63.3 and 21.9 hours/acre, respectively), while catch rates were average (Tables 9, 12). The muskellunge was the species most sought after by anglers (Table 11). The smaller size of muskellunge in the anglers catch (Table 13) is believed to be a result of high



exploitation (Table 14). Recommended management includes reducing the level of exploitation and preventing the spread and establishment of northern pike.

## Big McKenzie Lake

Big McKenzie Lake, in Burnett County, is a 1,185-acre drainage lake of McKenzie Creek. There is no water control structure or fish barrier on McKenzie Creek. Estimated discharge flow is 7.4 cfs (Blackman et al. 1974). The water is hard and moderately fertile. Mean depth, 18.7 ft, was relatively deep compared with other lakes (Table 1). Management for muskellunge was terminated on Big McKenzie Lake in 1952 (except for one fry stocking in 1962) until 1970, when stocking and muskellunge management was resumed (Table 2). In addition to muskellunge, principle fish species present included walleye, yellow perch, bluegill, northern pike, white sucker, and black crappie (Table 3).

The size structure, mean length-at-age, and growth of muskellunge in Big McKenzie Lake were above average (Tables 4, 5, 6). The fast growth and heavy weight probably reflected the abundant white sucker population present for forage. Considering the high-quality size structure for female muskellunge, which provide the greatest trophy potential, muskellunge fishing pressure was much lower than might be expected (Table 9). This is believed to be due to 2 factors: Big McKenzie Lake is located on the western extreme of lakes intensively managed for muskellunge in Wisconsin, and many anglers may have been unaware of the lake's excellent quality with regard to muskellunge size.

Maintaining a low exploitation rate (13.8% in this study) (Table 14) will be important to maintain the favorable muskellunge size structure. A fisheries management survey report on this lake, which was completed in conjunction with this study, is available on file at the DNR Northwest District Headquarters or the Spooner DNR Ranger Station.

## Sand Lake

Sand Lake, in Sawyer County, is a 928-acre soft-water drainage lake with an outlet flow of 3.7 cfs (Sather and Threinen 1968). Water levels are maintained with a 2-foot control structure. The only inlet creek, Sissabagama Creek, enters 3.5 river miles downstream of Sissabagama Lake. Mean depth (21.1 feet) is greater than other study lakes (Table 1). Muskellunge populations had been

self-sustaining, requiring no stocking from 1955 to 1974 (Johnson 1981). Northern pike became established during the 1970s, and muskellunge stocking was initiated in 1975 to compensate for anticipated competition with the northern pike (Table 2). Johnson (1981) describes muskellunge population characteristics and changes in northern pike abundance during the 1970s. Besides muskellunge and northern pike, predominant fish species in Sand Lake were walleye and yellow perch (Table 3).

Although located downstream from Sissabagama Lake, the fishery in Sand Lake was somewhat different than that of Sissabagama Lake. The size structure of the walleye fishery was more favorable, northern pike were more abundant, and muskellunge were less dense. The density of muskellunge was among the lowest of all study lakes (Table 8). The comparatively low level of angler-use of Sand Lake for muskellunge (Tables 9, 11) is believed to be related to the low population density. The size structure of the population was relatively good (Table 4), presumably due to moderate exploitation levels (Table 14) and an adequate forage of white suckers.

The abundance of adult muskellunge reported from this study is not directly comparable to data reported from Sand Lake by Johnson (1981) because of the difference in minimum size included in the estimate (30 inches versus 20 inches). Johnson's estimates likely underestimated the abundance of muskellunge  $\geq 20$  inches total length and should more appropriately be considered the size of the spawning population. Reworking data from Johnson indicated the abundance of the legal-sized population had not changed significantly (Table 15). However, former populations did not require stocking.

The difference in muskellunge exploitation rates from Sand Lake reported here compared with data reported by Johnson (1981) can largely be explained by errors in his calculations (Table 15). Reported exploitation rates from both studies are minimum estimates, but since the present study had a more visible voluntary reporting procedure as well as a creel survey, it is not surprising that the most recent estimate was higher than most previous estimates. Consequently, no apparent trends of exploitation rates over time can be concluded.

A fisheries management report on this lake, which was completed in conjunction with this study, is available at the DNR Northwest District Headquarters or the Hayward DNR Ranger Station.

## Day Lake

Day Lake, in Ashland County, is a 641-acre soft-water impoundment of the West Fork of the Chippewa River (impounded in 1970). Estimated discharge at the 12-ft control structure is 20 cfs (Bonnie Ilhardt, U.S. For. Serv., pers. comm.). Mean depth (6.7 feet) is shallow relative to other study lakes (Table 1), with floating cattail bogs common. Besides muskellunge, black crappie and yellow perch were abundant. Muskellunge fingerlings have been stocked regularly since impoundment (Table 2). Day Lake has also been intensively managed for largemouth bass but with little success; their abundance was low (Table 3).

The muskellunge fishery of Day Lake was characterized by a below-average size structure (Table 4), high density (0.61 legal-sized fish/acre) (Table 8), and slow growth (Tables 5, 6). The condition of fish < 34 inches total length was above average, but this condition declined abruptly for larger fish. This is believed to be a result of high competition for an inadequate forage base. Day Lake had an abundance of small yellow perch and black crappie, which probably were the primary forage fish for muskellunge, but the lake lacked a potential larger forage (Table 3). Muskellunge was the predominant sport fish for anglers (67% of all angler trips) (Tables 9, 11), and catch rates for both sublegal- and legal-sized fish were above average (Table 9, 12). The relative remoteness of the lake is probably responsible for the level of fishing pressure not being higher than it was. Recommendations for management consideration include diversifying the forage base in terms of size of prey available and possibly the type of prey available, particularly white sucker or redhorse. A lake management report on this lake, which was prepared in conjunction with this study, is available on file at the DNR Northwest District Headquarters and the Mercer DNR Ranger Station.

## Big Lake

Big Lake, in Vilas County, is an 835-acre hard-water drainage lake. Estimated normal outlet flow at Rice Creek is 42 cfs (L. Andrews, Wis. Dep. Nat. Resour., pers. comm.). Mean depth (20.5 ft) is relatively deep and clear compared with other study lakes (Table 1). Muskellunge have been stocked routinely but less frequently than in other

study lakes (Table 2). Predominant fish species in addition to muskellunge included walleye, yellow perch, white sucker, redhorse, rock bass, and grass pickerel. Cisco were more common in Big Lake than in other study lakes (Table 3).

Growth and mean length-at-age were above average (Tables 5, 6), presumably due to a forage base of white suckers and cisco. The size- and age-structure of muskellunge in Big Lake were above average (Tables 4, 7). Thus this lake is one which many believe has greater trophy potential for anglers. The muskellunge was the most sought after species in Big Lake (Table 11). Muskellunge anglers seemed to be more experienced and to have higher expectations regarding size of fish than for most other study lakes. Catch rates of both sublegal- and legal-sized fish and exploitation rates were well below most other lakes (Tables 9, 12, 14), presumably due to the greater depth and water clarity (Hanson 1986). A key to retaining the desirable population characteristics present in Big Lake is to maintain exploitation rates at comparatively low levels.

## Big Arbor Vitae Lake

Big Arbor Vitae Lake, in Vilas County, is a 1,090-acre drainage lake located upstream from Little Arbor Vitae Lake. Water levels are stabilized by a low-head dam with an estimated discharge of approximately 5 cfs (L. Andrews, pers. comm.). Water quality is fertile, but the lake does not experience intensive algal blooms as does Little Arbor Vitae Lake. Muskellunge have been stocked routinely but less frequently than in some of the other study lakes (Table 2). Predominant fish species in addition to muskellunge included walleye, largemouth bass, yellow perch, black crappie, white sucker, bluegill, and rock bass. Northern pike were present in low numbers (Table 3).

The muskellunge fishery in Big Arbor Vitae Lake was similar to that of Little Arbor Vitae Lake, except that there was a greater abundance of larger and older fish in Big Arbor Vitae (Tables 4, 7). Total fishing pressure (69 hours/acre) exceeded all other study lakes (Table 9), and muskellunge was the most sought after species (Table 11). Management recommendations are to maintain the low abundance of northern pike and to monitor exploitation rates to prevent increased exploitation.

**Table 1.** Characteristics of individual study lakes.

Lake	Surface Acres	Maximum Depth (ft)	Mean Depth (ft)	Shoreline Development Factor	Total Alkalinity* (mg/L)	Secchi Disk (ft)	Color*	Turbidity* (NTU)
Mud/Callahan	586	18	6.7	2.9	40	8	20	0.6
Winter	676	22	8.9	3.4	56	5	120	1.8
Sissabagama	719	48	15.5	2.2	32	8	10	0.6
Little Arbor Vitae	534	32	11.3	1.8	50	3	5	2.0
Big McKenzie	1,185	71	18.7	1.5	70	10	5	1.2
Sand	928	50	21.1	1.2	34	11	25	1.2
Day	641	18	6.7	2.6	34	4	100	1.9
Big	835	61	20.5	2.3	56	13	15	0.9
Big Arbor Vitae	1,090	41	18.1	2.4	50	4	10	1.9
Mean**	826	43	15.1	2.2	47	7.3	36.3	1.4

\* Analysis by Wisconsin State Lab of Hygiene from a summer composite sample from 1 m from surface, mid-depth, and 1 m from bottom.

\*\* Does not include Mud/Callahan Lake.

**Table 2.** Number muskellunge stocked in study lakes from 1968 to 1982. Surface area in acres is given in parentheses.

Year	Mud Callahan (586)	Winter (676)	Sissabagama (719)	Little Arbor Vitae (534)	Big McKenzie (1,185)	Sand (928)	Day (641)	Big (835)	Big Arbor Vitae (1,090)
1982	2,000	722	500	1,100	780	721	320	0	0*
1981	0	480	530	400	425	565	0	0	2,000
1980	0	680*	550	1,206	1,150	1,000	320*	1,712	1,000
1979	150	500*	500*	500	1,155	515*	0	0	0
1978	0	860	0	0	600	0	636	0	0
1977	0	700*	524	1,100	650*	50*	600*	1,005	1,929
1976	0	500*	1,228*	1,100	1,350*	1,000*	1,900	600	0
1975	0	624	260	1,100	547	611	128	0	0
1974	0	1,023	276	1,100	1,150	0	1,250	0	300
1973	0	400	718	1,100	1,147	0	600	300*	1,198
1972	0	250	0*	1,200	300*	0	423	0	2,100 <sup>b</sup>
1971	0	250	350*	548	350*	0	0*	0	500
1970	0	200	774	0	1,000*	0	0*	0	0
1969	0	75	414	800	0	0	—	2,000*	600*
1968	0	45	250	0	0	0	—	0	0

\* Additionally, fry and/or fingerlings < 8 inches total length were stocked.

**Table 3.** Relative fish species composition and abundance in study lakes.\*

Lake	Walleye	Northern Pike	Largemouth Bass	Smallmouth Bass	Yellow Perch	Bluegill	Black Crappie	White Sucker	Redhorse	Cisco	Rock Bass	Pumpkinseed	Hybrid Muskellunge	Grass Pickerel	Bowfin	Longnose Gar
Mud/Callahan	P	N	C	R	C	C	A	P	R	N	P	P	N	N	N	N
Winter	P	R	C	N	A	A	A	P	A	N	P	P	N	N	N	N
Sissabagama	A	R	P	P	C	C	C	C	R	N	C	C	N	N	N	R
Little Arbor Vitae	A	R	P	R	A	P	C	C	R	N	P	P	R	R	P	N
Big McKenzie	A	C	P	R	C	C	C	A	R	R	P	P	R	N	P	N
Sand	A	A	P	P	A	C	C	C	R	N	P	P	P	N	N	R
Day	N	N	P	N	A	R	A	R	P	N	N	C	N	N	N	N
Big	C	P	P	P	C	P	P	C	C	P	C	P	R	C	R	N
Big Arbor Vitae	A	P	C	P	A	C	C	C	P	N	C	P	R	R	P	N

\* Based on pooled subjective opinions of researchers and fishery managers. Minnow species not included. Relative abundance indicated by: A = abundant, C = common, P = present, R = rare, and N = not present.

**Table 4.** Total length frequency distribution (%) of pooled fyke-net data from 2 consecutive springs for male and female muskellunge.

Length (inches)	Overall Mean*	Mud/Callahan 1979-80	Winter 1979-80	Big Sissabagama 1980-81	Little Arbor Vitae 1980-81	Big McKenzie 1981-82	Sand 1981-82	Day 1981-82	Big 1981-82	Big Arbor Vitae 1981-82
<b>Males</b>										
≤ 21.0	0.2	1.2	0.5	0.7	0.4	0.0	0.0	0.0	0.0	0.0
21.0-23.9	2.6	21.0	2.0	6.2	2.3	4.8	2.2	1.3	0.7	1.4
24.0-26.9	18.8	59.7	17.9	28.1	19.5	23.7	17.6	13.3	19.7	10.2
27.0-29.9	38.0	17.6	39.8	35.6	51.4	30.1	34.1	36.9	30.9	45.4
30.0-32.9	25.6	0.2	26.0	20.5	21.8	25.8	20.9	38.2	20.4	31.5
33.0-35.9	9.8	0.2	6.6	7.5	3.9	9.1	16.5	9.9	15.8	9.2
36.0-38.9	4.3	0.0	6.6	1.4	0.8	3.8	7.7	0.4	11.2	2.4
39.0-41.9	0.7	0.0	0.5	0.0	0.0	2.7	1.1	0.0	1.3	0.0
42.0-44.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45.0-47.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
≥ 48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sample Size	(1,556*)	(561)	(196)	(146)	(257)	(186)	(91)	(233)	(152)	(295)
<b>Females</b>										
≤ 21.0	0.7	0.0	1.2	2.1	0.0	0.0	0.0	0.0	2.0	0.0
21.0-23.9	0.1	8.8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
24.0-26.9	3.5	52.7	4.8	8.3	4.8	0.0	5.3	1.9	2.0	1.2
27.0-29.9	10.0	33.7	10.7	8.3	19.0	4.8	7.9	20.2	2.0	7.1
30.0-32.9	21.9	3.4	21.4	20.8	28.6	15.9	21.1	37.5	10.0	20.0
33.0-35.9	21.7	0.6	39.3	31.3	8.3	12.7	21.1	21.2	20.0	20.0
36.0-38.9	16.8	0.0	8.3	10.4	10.7	20.6	28.9	9.6	28.0	17.6
39.0-41.9	14.4	0.0	4.8	14.6	16.7	22.2	7.9	6.7	22.0	20.0
42.0-44.9	7.4	0.3	7.1	2.1	7.1	17.5	0.0	1.9	12.0	11.8
45.0-47.9	3.1	0.6	2.4	0.0	3.6	6.3	7.9	0.0	2.0	2.4
≥ 48.0	0.4	1.2	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0
Sample Size	(556*)	(353)	(84)	(48)	(84)	(63)	(38)	(104)	(50)	(85)

\* Does not include Mud/Callahan Lake.

**Table 5.** Mean total length (inches) of muskellunge at each age for 9 Wisconsin lakes.

Lake	Age (years)											
	3	4	5	6	7	8	9	10	11	12	13	14
<b>Males</b>												
Mud/Callahan	20.9	22.7	23.0	24.9	25.8	26.9	28.4	26.0	29.0	–	–	–
Winter	23.7	27.0	29.2	31.5	33.9	34.5	36.9	37.0	37.2	38.0	–	–
Sissabagama	21.1	25.2	27.9	28.6	29.4	32.4	35.0	37.5	38.0	–	–	–
Little Arbor Vitae	20.4	25.4	27.7	29.5	30.7	31.3	35.5	–	–	–	–	–
Big McKenzie	23.6	26.3	29.1	32.0	34.8	35.9	37.7	38.6	40.8	–	–	–
Sand	–	25.7	28.4	31.1	33.4	34.6	35.8	37.0	38.9	40.0	37.8	–
Day	–	25.2	27.2	28.8	29.9	30.5	31.0	31.9	35.0	–	–	–
Big	23.1	25.7	28.6	31.0	33.3	34.5	36.1	36.2	35.7	38.7	39.5	–
Big Arbor Vitae	–	26.5	28.4	30.0	31.4	32.6	32.9	34.6	36.3	36.0	–	–
Mean*	22.4	25.9	28.3	30.3	32.1	33.3	35.1	36.1	37.4	38.2	38.7	–
<b>Females</b>												
Mud/Callahan	–	23.1	25.0	25.7	26.5	27.8	29.6	–	–	45.0	45.2	–
Winter	–	28.5	31.5	34.0	37.1	36.7	41.3	43.0	43.4	–	44.5	–
Sissabagama	–	27.0	28.3	29.0	33.1	35.0	37.5	39.0	48.0	45.3	–	–
Little Arbor Vitae	–	26.8	28.7	31.2	32.6	36.7	40.4	41.9	44.8	48.5	47.8	–
Big McKenzie	–	–	30.8	35.2	38.4	40.0	40.1	43.2	44.4	45.0	–	–
Sand	–	–	28.4	33.4	37.5	37.9	39.5	37.8	–	46.6	47.0	–
Day	–	–	29.9	30.8	29.8	31.9	33.7	35.2	38.6	42.1	–	–
Big	–	24.6	31.6	33.1	36.6	37.9	39.4	40.8	42.6	42.8	43.1	–
Big Arbor Vitae	–	–	30.1	31.6	33.9	36.1	38.2	40.7	41.7	42.8	45.5	47.0
Mean*	–	26.7	29.9	32.3	34.9	36.5	38.8	40.2	43.4	44.7	45.6	47.0

\* Does not include Mud/Callahan Lake.

**Table 6.** Total length-age and weight-length relationships for study lakes and coefficient of determination ( $R^2$ ).\*

Lake	Sex	Age (x) - Length (y)			Length (x) - Weight (y)		
		a	b	$R^2$	a	b	$R^2$
Mud/Callahan	M	1.20	0.25	0.44	-3.38	2.82	0.78
	F	1.16	0.32	0.38	-3.03	2.57	0.64
Winter	M	1.22	0.36	0.72	-4.21	3.41	0.92
	F	1.20	0.43	0.80	-4.38	3.54	0.96
Sissabagama	M	1.19	0.34	0.55	-4.15	3.36	0.88
	F	1.08	0.52	0.65	-4.04	3.30	0.96
Little Arbor Vitae	M	1.20	0.34	0.59	–	–	–
	F	1.06	0.56	0.83	–	–	–
Big McKenzie	M	1.14	0.46	0.81	-4.22	3.40	0.91
	F	1.18	0.45	0.80	-4.64	3.69	0.93
Sand	M	1.17	0.40	0.83	-4.25	3.41	0.94
	F	1.10	0.53	0.79	-4.77	3.75	0.97
Day	M	1.27	0.24	0.45	-3.99	3.26	0.89
	F	1.28	0.27	0.30	-4.22	3.43	0.93
Big	M	1.19	0.37	0.83	-4.57	3.64	0.91
	F	1.23	0.38	0.79	-4.79	3.78	0.91
Big Arbor Vitae**	M	1.25	0.29	0.66	-3.19	2.75	0.96
	F	1.17	0.43	0.81	-4.16	3.39	0.97
Mean <sup>a</sup>	M	1.21	0.35	0.58	-4.08	3.32	0.98
	F	1.16	0.45	0.58	-4.43	3.56	0.99

\* Length (inches); weight (lb); all equations are of the form:  $\log Y = a + b \log X$ .

\*\*Weight-length relationship calculated from 1983 data only.

<sup>a</sup> Does not include Mud/Callahan Lake; calculated using estimated lengths and weights predicted from each lake's equations.

**Table 7.** Age frequency distributions (%) from pooled spring fyke-net catch of sexually mature muskellunge from study lakes.

Age (yrs)	Overall Mean*		Mud/Callahan		Lake Winter		Big Sissabagama		Little Arbor Vitae		McKenzie		Big Sand		Day		Big		Big Arbor Vitae	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
3	1.1	0.0	0.9	0.0	2.6	0.0	1.4	0.0	0.8	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
4	17.9	2.6	5.6	1.1	28.9	14.6	18.6	4.2	12.3	1.2	32.2	0.0	17.8	0.0	2.7	0.0	17.4	2.0	13.4	0.0
5	32.4	16.7	13.4	11.5	42.3	25.6	23.4	10.4	34.0	23.7	35.5	20.6	37.8	21.1	15.1	11.5	35.6	4.1	35.3	16.5
6	21.0	19.6	36.8	31.0	15.5	41.5	27.6	8.3	32.0	17.5	15.8	12.7	21.1	26.3	20.4	18.3	13.4	20.4	21.9	8.2
7	10.3	17.8	28.9	36.5	3.1	3.7	15.9	31.3	13.8	18.8	6.0	23.8	7.8	28.9	18.2	10.6	8.1	12.2	9.6	12.9
8	7.4	15.8	11.4	14.7	1.0	1.2	9.7	22.9	6.3	11.2	2.7	15.9	4.4	7.9	16.9	16.3	7.4	28.6	10.6	22.4
9	4.9	11.0	2.5	4.3	2.6	2.4	2.1	8.3	0.8	15.0	2.7	7.9	4.4	5.3	15.1	19.2	6.7	14.3	5.1	15.3
10	3.0	8.8	0.2	0.0	1.0	3.7	0.7	10.4	0.0	7.5	1.1	11.1	3.3	2.6	9.3	18.3	6.0	4.1	2.7	12.9
11	1.4	3.8	0.2	0.0	1.5	4.9	0.7	2.1	0.0	2.5	0.5	6.3	1.1	0.0	2.2	4.8	4.0	4.1	1.0	5.9
12	0.4	2.1	0.0	0.6	1.5	0.0	0.0	2.1	0.0	1.2	0.0	1.6	1.1	5.3	0.0	1.0	0.0	2.0	0.3	3.5
13	0.1	1.8	0.0	0.3	0.0	1.2	0.0	0.0	0.0	1.2	0.0	0.0	1.1	2.6	0.0	0.0	0.7	8.2	0.0	1.2
14	0.0	0.4	0.0	0.0	0.0	1.2	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	1.2
Sample Size	(1,531*)	(549*)	(551)	(348)	(194)	(82)	(145)	(48)	(253)	(80)	(183)	(63)	(90)	(38)	(225)	(104)	(149)	(49)	(292)	(85)

\* Does not include Mud/Callahan Lake.

**Table 8.** Population abundance, standing stock, and relative stock density of legal-sized muskellunge as well as catostomid density rankings.

Lake	Population Estimate	95% CI	Population Estimate/Acre	Lb/Acre	Relative Stock Density (fyke net)	Relative Stock Density (population estimate)
Mud/Callahan	15	10-45	0.03	0.2	25.0	26.7
Winter	331	200-714	0.49	5.5	39.9	36.0
Sissabagama	116	78-218	0.16	1.8	43.7	44.8
Little Arbor Vitae	264	183-521	0.49	5.4	31.0	46.2
Big McKenzie	198	156-296	0.17	2.1	49.5	59.6
Sand	88	67-148	0.09	1.0	46.9	44.3
Day	394	276-720	0.61	6.0	21.3	19.8
Big	208	160-313	0.25	3.1	61.8	58.2
Big Arbor Vitae	411	292-691	0.38	3.9	35.1	38.9
Mean*	251	–	0.33	3.6	41.2	43.5

\* Does not include Mud/Callahan Lake.

**Table 9.** Estimates of angler use and catch rates of muskellunge from creel survey data.

Lake	Year	Total Hours/Acre	Total Angler Trips	Muskellunge Hours/Acre	Catch/ Hour*	Catch/ Hour**	Legal Harvest/Hour
Mud/Callahan	1979	35.7	5,517	28.3	0.063	0.002	0.002
Winter	1979	42.7	7,410	29.2	0.050	0.015	0.013
Sissabagama	1980	50.5	12,918	13.4	0.051	0.018	0.009
Little Arbor Vitae	1980	63.3	11,736	21.9	0.028	0.010	0.008
Big McKenzie	1981	33.5	9,506	5.8	0.044	0.012	0.005
Sand	1981	25.5	9,490	4.0	0.028	0.010	0.010
Day	1981	26.1	3,813	18.2	0.046	0.025	0.014
Big	1981	31.2	7,674	12.2	0.014	0.006	0.004
Big Arbor Vitae	1982	69.2	31,288	18.0	0.047	0.011	0.008
Mean <sup>a</sup>	–	42.8	11,729	15.3	0.038	0.013	0.009

\* Specific catch rate of all sizes of muskellunge caught.

\*\* Specific catch rate of only legal size muskellunge caught.

<sup>a</sup> Does not include Mud/Callahan Lake.

**Table 10.** *Percentage of season total by month for total angling pressure, muskellunge angling pressure, total catch (all sizes), and harvest of muskellunge from creel survey estimates.*

Lake	Percentage Season Total by Month						
	May	Jun	Jul	Aug	Sep	Oct	Nov
<b>Total Angling Pressure</b>							
Mud/Callahan	7.7	17.4	31.9	28.0	9.5	5.4	0.1
Winter	13.8	24.1	33.0	16.0	10.2	2.8	0.1
Sissabagama	19.5	22.5	22.2	18.8	11.5	5.0	0.4
Little Arbor Vitae	34.4	15.9	16.7	14.2	9.6	8.6	0.6
Day	13.2	20.2	24.6	22.2	14.4	5.0	0.5
Big	18.7	21.6	22.0	14.4	15.3	7.2	0.9
Big McKenzie	21.1	25.7	23.4	16.8	11.0	1.7	0.3
Sand	13.4	18.5	26.2	21.9	13.4	6.4	0.2
Big Arbor Vitae	20.2	24.1	27.1	15.6	8.9	4.2	–
Mean	18.0	21.1	25.2	18.7	11.6	5.1	0.4
<b>Muskellunge Angling Pressure</b>							
Mud/Callahan	4.0	14.0	33.2	28.5	11.9	8.4	0.1
Winter	8.9	27.4	33.3	15.2	11.6	3.5	0.1
Sissabagama	13.7	20.0	21.6	19.8	13.7	10.3	1.0
Little Arbor Vitae	12.5	20.4	24.9	18.6	12.0	10.5	1.2
Day	8.0	21.2	20.6	25.7	17.8	6.0	0.7
Big	5.8	21.9	22.8	19.5	15.8	12.1	2.1
Big McKenzie	10.8	14.5	24.4	19.4	24.9	4.7	1.3
Sand	3.1	12.4	11.7	20.4	33.4	18.8	0.1
Big Arbor Vitae	4.9	21.8	28.6	19.9	15.3	9.5	–
Mean	8.0	18.3	24.6	20.8	17.4	9.3	0.8
<b>Total Catch</b>							
Mud/Callahan	9.9	22.8	24.2	20.6	13.5	8.7	0.2
Winter	12.7	31.8	33.0	12.0	7.1	3.4	0
Sissabagama	18.6	15.8	10.5	11.7	22.3	19.4	1.6
Little Arbor Vitae	27.2	27.6	15.7	12.6	7.1	9.4	0.4
Day	3.8	23.6	15.7	26.4	16.0	14.5	0
Big	21.4	20.0	8.6	24.3	8.6	14.3	2.9
Big McKenzie	14.1	15.2	8.7	12.0	38.0	8.7	3.3
Sand	9.3	9.3	14.7	16.0	25.3	25.3	0
Big Arbor Vitae	14.0	29.5	11.6	13.5	13.0	18.4	–
Mean	14.6	21.7	15.9	16.6	16.8	13.6	1.0
<b>Harvest</b>							
Mud/Callahan	5.3	52.6	13.2	0	7.9	15.8	0
Winter	7.4	22.1	52.9	7.4	5.9	4.4	0
Sissabagama	2.3	20.5	11.4	6.8	22.7	34.1	2.3
Little Arbor Vitae	19.4	23.6	9.7	15.3	11.1	20.8	0
Day	0	15.8	25.3	29.5	21.1	8.4	0
Big	30.0	30.0	5.0	15.0	0	15.0	5.0
Big McKenzie	30.8	23.1	0	15.4	23.1	7.7	0
Sand	9.1	0	9.1	13.6	31.8	36.4	0
Big Arbor Vitae	17.4	30.0	21.3	13.9	11.3	6.1	0
Mean	13.5	24.7	16.0	13.4	15.3	17.4	0.9



**Table 11.** The percentage of angler trips designated for each species from study lakes.

Lake	Muskellunge	Walleye	Bass*	Northern Pike	Panfish	Anything
Mud/Callahan	74.1	0.5	17.9	—	4.7	2.9
Winter	67.0	0.5	5.1	—	21.7	5.7
Sissabagama	29.5	44.7	1.2	—	14.8	10.4
Little Arbor Vitae	38.5	27.1	1.4	—	22.3	10.7
Big McKenzie	11.8	26.6	1.8	4.9	29.7	25.1
Sand	17.6	56.4	0.1	1.2	18.3	6.4
Day	67.3	—	2.5	—	24.3	5.9
Big	40.9	28.8	0.7	0.3	6.5	19.7
Big Arbor Vitae	33.2	26.1	2.5	—	24.5	13.7

\* Includes both largemouth and smallmouth bass.

**Table 12.** Angler catch and harvest of muskellunge from creel survey estimates and voluntary registration.

Lake	Creel Survey Projections				Voluntary Registration	
	Catch/Acre*	Legal Catch/Acre**	Legal Harvest/Acre	Muskellunge Released (%)	Legal Catch/Acre	Harvest/Acre
Mud/Callahan	2.09	0.07 <sup>a</sup>	0.06	10.3	0.05	0.04
Winter	1.82	0.51 <sup>a</sup>	0.44	11.4	0.33	0.29
Sissabagama	1.17	0.41	0.21	50.0	0.22	0.13
Little Arbor Vitae	0.99	0.36	0.28	21.6	0.32	0.30
Big McKenzie	0.37	0.13	0.05	58.0	0.01	0.01
Sand	0.23	0.07	0.07	4.5	0.05	0.05
Day	0.98	0.52	0.29	43.7	0.09	0.08
Big	0.24	0.11	0.07	38.2	0.07	0.04
Big Arbor Vitae	1.36	0.29	0.22	25.7	0.02	0.01
Mean <sup>b</sup>	0.90	0.30	0.20	31.6	0.14	0.08

\* Includes all sizes of muskellunge.

\*\* Includes only legal size muskellunge.

<sup>a</sup> Not available from 1979 creel census records; estimated by multiplying harvest estimate from creel census times the ration of legal-sized catch to harvest from voluntary registration.

<sup>b</sup> Does not include Mud/Callahan Lake.

**Table 13.** Length frequency distribution (%) of angler catch of muskellunge from creel survey observations in study lakes.

Length (inches)	Overall Mean*	Mud/Callahan	Winter	Sissabagama	Little Arbor Vitae	Big McKenzie	Sand	Day	Big	Big Arbor Vitae
< 30.0	62.4	96.5	64.4	71.0	66.6	63.3	61.0	43.4	54.4	75.4
30.0-31.9	13.4	3.0	17.8	11.5	21.8	8.5	8.7	25.0	4.3	9.9
32.0-33.9	9.6	0.5	7.6	10.1	4.6	8.5	13.0	14.2	10.9	7.9
34.0-35.9	4.3	0	4.4	4.0	3.7	8.5	4.3	6.7	0	2.6
36.0-37.9	5.0	0	2.5	2.2	1.9	2.8	8.7	5.8	13.0	3.1
38.0-39.9	2.2	0	0.7	0.8	0	2.8	0	3.3	8.7	1.0
40.0-41.9	1.0	0	1.1	0	0	4.2	0	0.8	2.2	0
42.0-43.9	0.7	0	0.4	0.4	0.9	1.4	0	0	2.2	0
44.0-45.9	1.3	0	0.7	0	0	0	4.3	0.8	4.3	0
46.0-47.9	0.1	0	0.4	0	0.5	0	0	0	0	0
Sample Size**	(1,168)	(371)	(275)	(226)	(216)	(71)	(23)	(120)	(46)	(191)

\* Does not include Mud/Callahan Lake.

\*\*N = the number of fish recorded by census clerks.

**Table 14.** Exploitation rates of muskellunge from study lakes, based on fish actually harvested compared with the exploitation rate that would have resulted if all fish caught and released had been harvested.

Lake	Exploitation Rate					
	Possible			Actual		
	Volunteer Registration	Creel Survey	All Sources	Volunteer Registration	Creel Survey	All Sources
Mud/Callahan	30.0	43.1	40.0	30.0	43.1	40.0
Winter	36.0	43.1	44.0	34.0	38.8	42.0
Sissabagama	21.2	23.1	36.5	17.3	23.1	32.7
Little Arbor Vitae	35.0	24.7	38.1	32.0	19.6	35.1
Day	6.9	19.3	16.7	6.9	19.3	15.3
Sand	20.5	7.2	25.6	20.5	7.2	25.6
Big	—*	14.9	24.0	—*	14.9	18.7
Big McKenzie	5.0	31.5	21.2	5.0	17.5	13.8
Big Arbor Vitae	7.2	7.9	27.6	5.9	7.2	24.3
Mean**	18.8	21.5	29.2	17.4	18.4	25.9

\* Not available.

\*\* Does not include Mud/Callahan Lake.

**Table 15.** Population abundance (95% confidence intervals in parenthesis) and exploitation rates of muskellunge from Sand Lake as reported by Johnson (1981) compared with the present study.

Year	Abundance		Exploitation Rate	
	≥ 20 inches*	≥ 30 inches **	Original*	Revised**
1972	173 (140-241)	92 (69-115)	2.9	16.4
1973	186 (130-281)	110 (82-138)	2.1	7.3
1974	— (-)	134 <sup>a</sup> (67-202)	—	26.2
1976	151 (116-237)	85 (57-120)	2.1	17.1
1977	188 (135-325)	64 (42-87)	4.0	14.0
1978	—	—	—	18.2
1981 <sup>b</sup>	—	88 (67-148)	—	25.6

\* Presented as reported in Johnson (1981).

\*\* Recalculated following methods described in this manuscript using raw data from Johnson (1981).

<sup>a</sup> Used 1976 netting as the recapture period.

<sup>b</sup> Data from present study.

**Appendix.** Scientific names of pertinent species.

<b>Common Name</b>	<b>Scientific Name</b>
Longnose gar	<i>Lepisosteus osseus</i>
Bowfin	<i>Amia calva</i>
White sucker	<i>Catostomus commersoni</i>
Redhorse	<i>Moxostoma</i> sp.
Grass pickerel	<i>Esox americanus vermiculatus</i>
Northern pike	<i>Esox lucius</i>
Muskellunge	<i>Esox masquinongy</i>
Hybrid muskellunge	<i>Esox lucius</i> x <i>E. masquinongy</i>
Cisco	<i>Coregonus artedii</i>
Rock bass	<i>Ambloplites rupestris</i>
Pumpkinseed	<i>Lepomis gibbosus</i>
Bluegill	<i>Lepomis macrochirus</i>
Smallmouth bass	<i>Micropterus dolomieu</i>
Largemouth bass	<i>Micropterus salmoides</i>
Black crappie	<i>Pomoxis nigromaculatus</i>
Yellow perch	<i>Perca flavescens</i>
Walleye	<i>Stizostedion vitreum</i>

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