

DEPARTMENT OF NATURAL RESOURCES

# RESEARCH

## COMPARISON OF MUSKELLUNGE (*Esox masquinongy*) POPULATIONS IN A STOCKED LAKE AND UNSTOCKED LAKE IN WISCONSIN, WITH NOTES ON THE OCCURRENCE OF NORTHERN PIKE (*Esox lucius*)

By  
Leon D. Johnson  
Bureau of Research, Spooner

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### ABSTRACT

Populations of muskellunge (*Esox masquinongy*) in Sand Lake, which has not been stocked with muskellunge for over 26 years, were compared with populations in Lac Court Oreilles, which has been stocked annually since 1933 with the exception of 5 experimental nonstocking years, 1966-70. Muskellunge caught in both lakes during the 1972-78 spawning runs were similar in maximum size, but Lac Court Oreilles had proportionately more large (over 45 inches) and more old (over age XV) individuals. Sand Lake had two to three times the estimated number of muskellunge/acre, but the population density in both lakes was low (1 fish/5-20 acres) as compared to some other Wisconsin lakes.

Stocking appeared necessary for maintenance of the muskellunge population at its present level in Lac Court Oreilles. Naturally reproduced fish did not increase in number during the 5-year nonstocking period; rather nonstocking produced a "hole" where reduced numbers of fish from these 5 year classes were recruited to the adult population. Absence of stocking was not the only factor producing weak year classes during the study. Low survival of the stocked 1958-60 year classes resulted in a similar "hole" in the population age structure. While it was obvious that stocking increased the numbers of adult muskellunge in Lac Court Oreilles samples, Sand Lake maintained a naturally reproducing population without stocking.

The invasion and subsequent establishment of large populations of northern pike (*Esox lucius*) appeared to be related to the observed decline in the muskellunge population in Lac Court Oreilles. The more recent invasion of northern pike into Sand Lake, however, has not shown a decreased muskellunge population within the period of this study.

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## INTRODUCTION

Stocking programs have become a central part of the Wisconsin muskellunge (Esox masquinongy) management strategy. Natural reproduction of muskellunge appears to be very low or nonexistent in many Wisconsin lakes. Fifty-one fall shocking surveys of 20 northern lakes from 1962 to 1979 failed to produce any naturally reproduced fingerlings (L. Johnson unpubl.). The above surveys were conducted in 12 native muskellunge lakes and 8 lakes outside of the native muskellunge range. All 20 lakes were stocked annually. The possibility existed that stocked muskellunge were replacing individuals that might have survived from natural reproduction in the absence of competition from hatchery-raised fish. If stocked muskellunge were simply replacing naturally reproduced fish, then reduced stocking rates would be in order.

The primary objectives of this study were to (1) compare muskellunge populations in two northern Wisconsin lakes each having native muskellunge; one of the two populations had a history of annual stocking and the other was maintained only by natural reproduction, and (2) determine the response of the population in the stocked lake to a 5 year nonstocking period. The study lakes were Lac Court Oreilles in Sawyer County, stocked annually since 1933 with the exception of the 5 experimental years, 1966-70, and Sand Lake in Sawyer County, which had not been stocked since 1952.

Historically, northern pike (Esox lucius) and muskellunge did not occur together in Wisconsin until the mid-1930's. It is often thought that as northern pike spreads into native muskellunge waters, the muskellunge populations will subsequently decline (Inskip 1980). A secondary objective of this study was to determine northern pike population size in the two study lakes and to evaluate the evidence for interspecific competition with muskellunge.

## DESCRIPTION OF STUDY LAKES

Sand Lake: T39N, R9W, Sawyer County. Sand Lake is a 928-acre soft water drainage lake with an inlet, Sissabagama Creek, and an outlet, Sand Creek, which flows into nearby Whitefish Lake (Fig. 1). The normal flow of the outlet is 3.7 cfs over a 2-ft headwater control structure. Maximum depth is 46 ft, methyl purple alkalinity is 34 mg/l, and the Secchi disc reading is approximately 11 ft. At least 85% of the shoreline is sand, with the remainder in coarse gravel and boulders. There are two prominent beds of Scirpus, one along the north shore and the other on a sand bar along the south shore.

Muskellunge are native to the lake. There are few bays, and spawning occurs along the entire shoreline. The most abundant fish species are walleye, Stizostedion vitreum vitreum and yellow perch, Perca flavescens. Other fish species include: white sucker, Catostomus commersonii; largemouth bass, Micropterus salmoides; smallmouth bass, Micropterus dolomieu; bluegill, Lepomis macrochirus; black crappie, Pomoxis nigromaculatus; rock bass, Ambloplites rupestris; pumpkinseed, Lepomis gibbosus; green sunfish, Lepomis cyanellus; red horse, Moxostoma sp.; longnose gar, Lepisosteus osseus; and many minnow species. The northern pike was not native to Sand Lake. It was first observed in 1972 and became abundant after 1976.

Lac Court Oreilles: T39, R40N, Sawyer County. Lac Court Oreilles is a soft water drainage lake of 5,038 acres (Fig. 1). There is an inlet from Grindstone and Whitefish Lakes, and an outlet into Little Court Oreilles Lake on the Coudery River. There are approximately 500 acres of bog wetlands and three commercial cranberry marshes adjacent to the lake. Three large bay areas appear suitable for muskellunge spawning but Musky Bay, which warms up

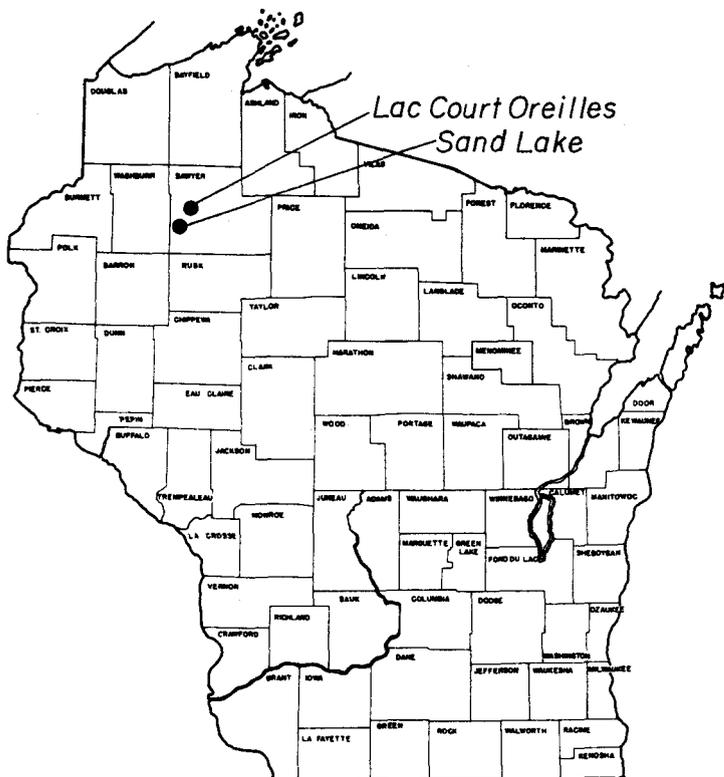


FIGURE 1. Location of study lakes in Sawyer County, Wisconsin.

earliest in the spring, provides the only significant spawning area. The maximum depth is 90 ft, methyl purple alkalinity is 45 mg/l, and the Secchi disc reading is 15 ft.

Lac Court Oreilles has a varied fish population of walleye, muskellunge, largemouth bass, smallmouth bass, bluegill, pumpkinseed, perch, black crappie, rock bass, longnose gar, white sucker, cisco (Coregonus sp.), three species of bullheads (yellow bullhead, Ictalurus natalis; black bullhead, Ictalurus melas; brown bullhead, Ictalurus nebulosus), and various minnow species. Northern pike were not native, but probably invaded from nearby lakes during years of high water. Northern pike were first observed in 1945 and increased in abundance after 1964. The lake trout Salvelinus namaycush was stocked in 1964 and 1967 but failed to become established.

#### METHODS

Muskellunge were caught in fyke nets during the spring spawning runs (late April-early May) in Musky Bay, Lac Court Oreilles from 1956 through 1978, and in nets placed around the shoreline of Sand Lake from 1972 through 1978, excluding 1975. Eight nets were placed in each lake. The nets were 2-inch stretch mesh with 5- x 6-ft frames, 5-ft hoops, and 65-100 ft leads.

In 1957 through 1961, eight additional nets were placed at other locations in Lac Court Oreilles to determine if muskellunge or northern pike used other locations for spawning. The few fish caught in two other bays and along the shoreline were either spent or had not yet spawned. Some were tagged and were subsequently caught in Musky Bay. After 1961, Musky Bay became the only sampling location.

Northern pike caught in the nets were measured and finclipped. Muskellunge

were weighed to the nearest one-quarter pound in a wet dip net on a 60-lb spring scale. The muskellunge were then transferred to a square-end tank containing about 4 inches of water where they were sexed and tagged, total length recorded, and scale samples taken. Sex was determined by the presence of eggs or milt or recorded as unknown. Unknown sex fish were excluded from the age and length frequency histograms.

All muskellunge captured in fyke nets in both Lac Court Oreilles and Sand Lake were marked with a 5-mm-wide numbered aluminum strap tag locked loosely around the preopercle (Johnson 1971). A hook-shaped tool, bent from a plastic-handled screw driver, was used to prepuncture the tagging site. Some necrosis of the tagging site was noted, but I observed no erosion of gills. No tag loss was detected during the study.

Muskellunge scale samples were taken from a key area immediately below the anterior insertion of the dorsal fin and midway to the lateral line. Repeated recapture of individual fish sometimes made it necessary to use both sides of the fish for scale collection in order to avoid collection of regenerated scales. The scales were impressed on cellulose acetate slides by means of a heated hydraulic press (Greenbank and O'Donnell 1948) and annuli were counted using a microscope. The age groups reported represent the number of completed growing seasons.

All 9- to 12-inch muskellunge fingerlings stocked in Lac Court Oreilles were marked with a ventral finclip. These became known-age stocked fish and could be distinguished from naturally reproduced adult fish. Exceptions would occur for the 1952-57 and 1971-78 year classes which may have contained survivors from fry and 2 1/4-inch fingerling stockings. Stocking was discontinued in Lac Court Oreilles in 1966-70 in order to determine if the naturally reproducing population would subsequently produce more adult fish. No muskellunge were stocked in Sand Lake.

Chapman's version of the Peterson method was used to estimate the number of muskellunge larger than 20 inches and northern pike above 15 inches in both lakes. Because the recapture data were obtained from the fyke net catch the following spring, population estimates were adjusted for the effect of recruitment (Ricker 1975).

Survival rates of the muskellunge were calculated using marking methods extending through three successive years (Ricker 1975). Exploitation rates were estimated from voluntary creel census records maintained at resorts and from tags returned by anglers.

## RESULTS

### Sand Lake

The annual fyke net catch of muskellunge in Sand Lake ranged from 51 to 77 fish (Table 1). The population estimates ranged from 151 to 188. This represented an estimated 0.16 to 0.20 muskellunge/acre or 1 muskellunge to 5-6 acres of water surface. Reported angler catches of muskellunge ranged from 6 to 12/season, resulting in a minimum estimated exploitation rate of 2.1-4.0%. Survival of muskellunge between spring 1972 and spring 1973 was 75%. Survival was lower, 42% between the springs of 1976 and 1977.

The size of the males ranged from 21 to 40 inches; females ranged from 26 to 47 inches. (Fig. 2). Mature males first entered the spawning run at 3 years and a few females were mature at 4 years (Fig. 3). The majority of males were mature at 4 or 5 years and most females were mature at 5 or 6 years. The oldest male was 13 years and the oldest female was 16 years.

TABLE 1. The muskellunge and northern pike populations sampled in Sand Lake in the spring of 1972 through 1978 (except 1975).

Year	Number Muskellunge Captured	Population Estimate	95% Confidence Interval	Number/Acre	Percent Exploitation	Percent Surviving to the Following Spring
1972	77	173	140-241	0.19	2.9	75
1973	73	186	130-281	0.20	2.1	--
1974	57	--	--	--	--	--
1975	--	--	--	--	--	--
1976	64	151	116-237	0.16	2.1	42
1977	65	188	135-325	0.20	4.0	--
1978	51	--	--	--	--	--

Year	Number Northern Pike Captured	Population Estimate	95% Confidence Interval	Number /Acre
1972	8	--	--	--
1973	8	--	--	--
1974	21	--	--	--
1975	--	--	--	--
1976	17	1471	--	--
1977	172	5700	4300-6600	6
1978	238	--	--	--

No northern pike were captured in Sand Lake during surveys in the 1950's (Wisconsin Department of Natural Resources unpubl.). A few individuals were caught in the fyke nets in 1972-76 (Table 1), but no population estimates could be made. There was a sudden increase in the numbers of northern pike caught in 1977 and 1978. However, the 1976 population estimate was based on only one recapture. The 1977 estimate, based on 6 recaptures, represented 6 northern pike/acre. Although northern pike populations were increasing at the end of the study, muskellunge populations remained the same (Fig. 4).

Natural hybrid muskellunge were observed for the first time in 1978. A total of 9 hybrids ranging in size from 15 to 27 inches were captured, but were not included in the population estimate. In addition, over fifty 12- to 14-inch northern pike were gilled in the net leads in 1978. No young muskellunge were gilled.

#### Lac Court Oreilles

The muskellunge population in Lac Court Oreilles was sampled during the spring spawning run from 1956 through 1978. Data for the years 1972-78 correspond to the same time interval that Sand Lake was studied. The annual fyke net catch of muskellunge during this interval ranged from 61 to 165 (Table 2). The population estimate ranged from a low of 244 to a high of 383. The

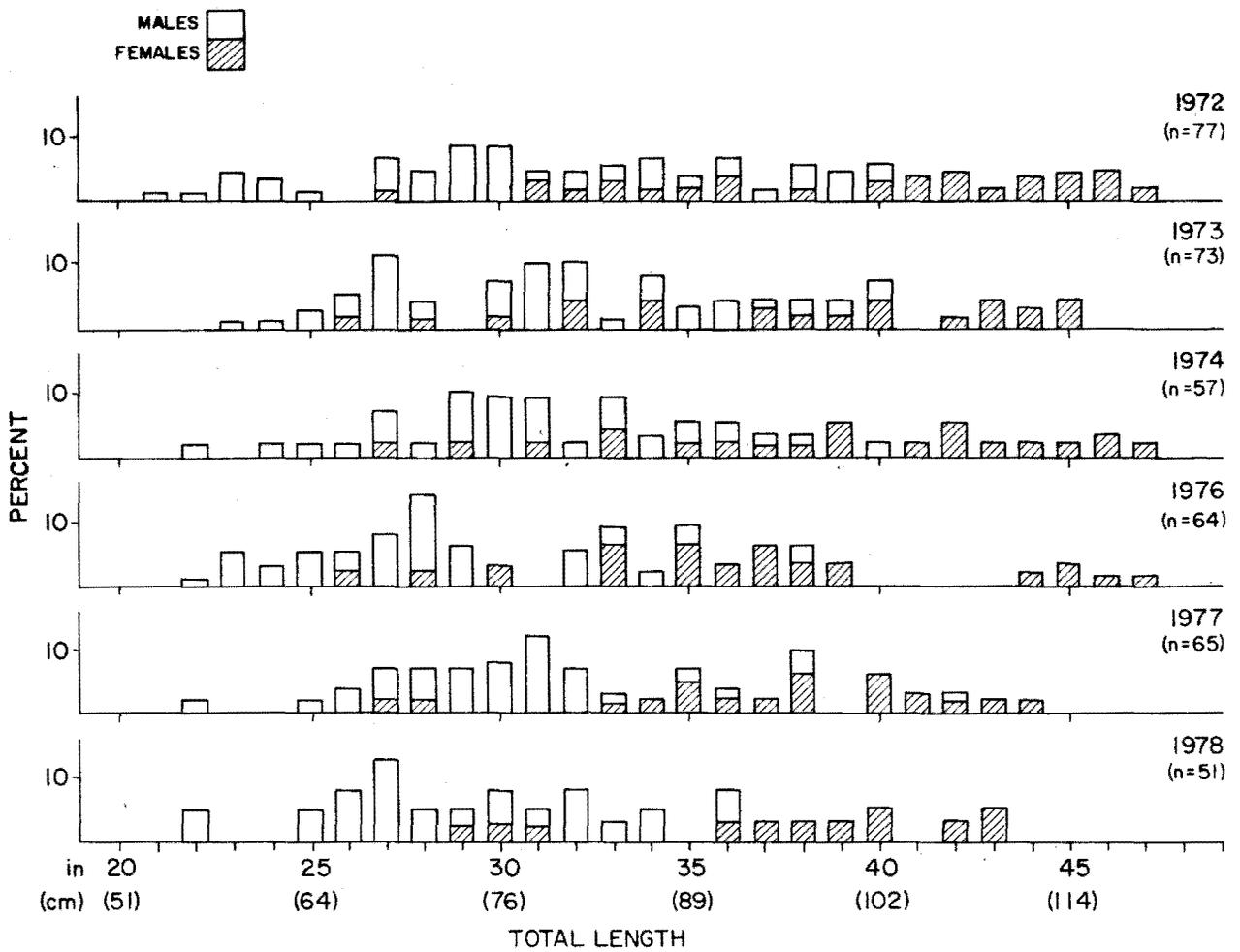


FIGURE 2. Length frequency distribution of male and female muskellunge caught in fyke nets in Sand Lake, 1972-78.

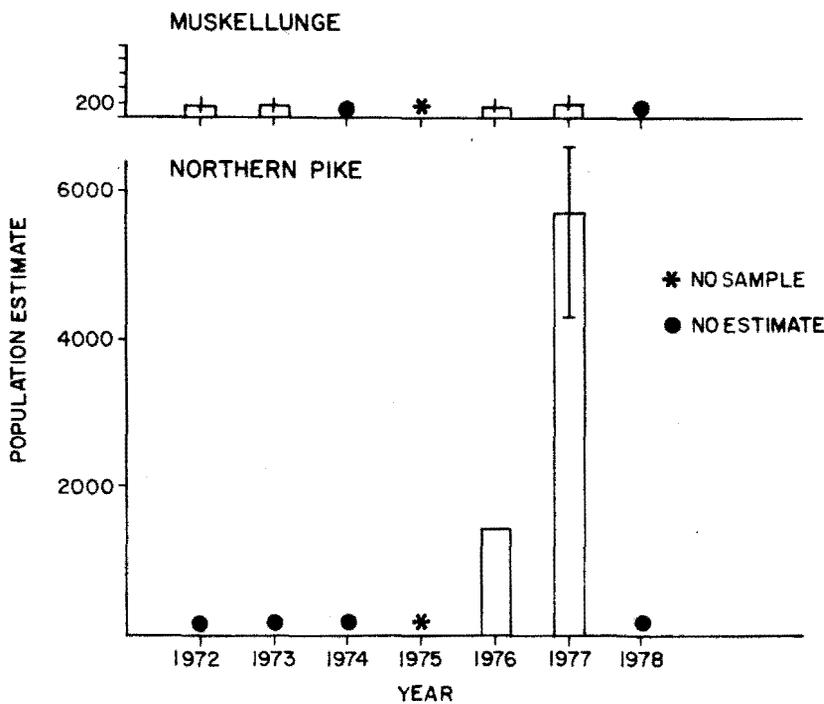


FIGURE 4. Population estimates and 95% C.I. for muskellunge and northern pike in Sand Lake, 1972-78.

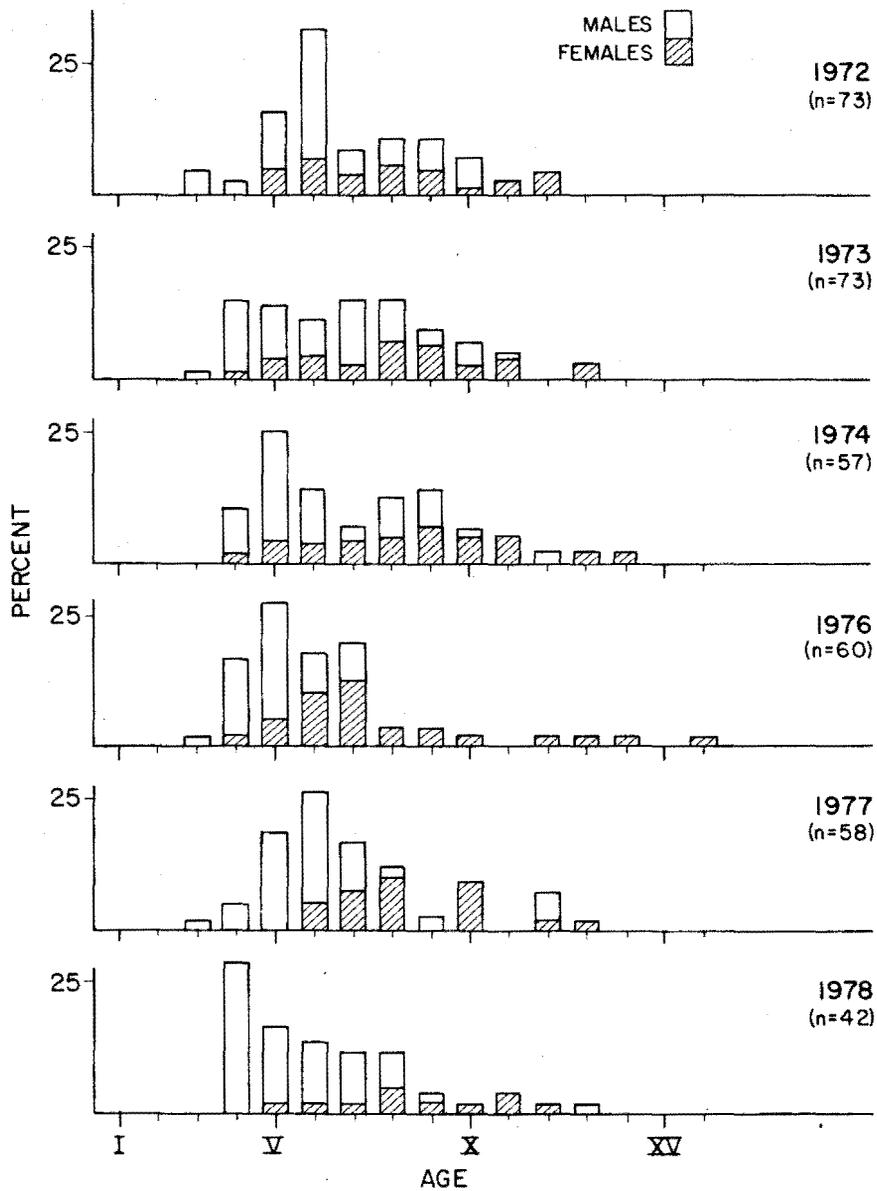


FIGURE 3. Age distribution of muskellunge caught in fyke nets in Sand Lake, 1972-78.

TABLE 2. The muskellunge and northern pike populations sampled in Lac Court Oreilles in the spring of 1960 through 1978. The years 1972-1978 correspond to the years that Sand Lake was also sampled.

Year	Number Muskellunge Captured	Population Estimate	95% Confidence Level	Number /Acre	Percent Exploitation	Percent surviving to the following spring	Percent Native
1960	221	1060	880-1222	0.21	3	52	79
1961	259	850	733-1015	0.17	5	61	49
1962	367	694	633-860	0.14	7	60	62
1963	248	590	552-725	0.12	3	56	47
1964	218	430	375-500	0.09	7	52	36
1965	188	515	437-695	0.10	4	55	43
1966	149	774	526-815	0.15	4	62	25
1967	222	556	475-695	0.11	6	57	18
1968	163	465	370-604	0.09	8	62	30
1969	193	722	568-965	0.14	8	44	30
1970	216	520	430-655	0.10	13	30	19
1971	172	528	420-720	0.10	11	69	22

1972	122	244	210-338	0.05	16	71	31
1973	61	281	179-508	0.06	20	66	28
1974	69	267	194-400	0.05	10	46	43
1975	101	368	281-532	0.08	10	40	37
1976	125	304	250-403	0.06	9	48	33
1977	111	383	292-529	0.08	9	--	16
1978	165	--	--	--	--	--	24

Year	Number Northern Pike Captured	Population Estimate	95% Confidence Interval	Number /Acre
1960	--	--	--	--
1961	1310	4200	4000-4800	0.83
1962	516	2060	1800-2300	0.41
1963	805	4300	3500-4300	0.85
1964	1241	5800	5200-6500	1.15
1965	675	4500	4000-5200	0.89
1966	907	5300	4600-5400	1.05
1967	1745	7800	7300-8300	1.55
1968	1937	6300	5700-6900	1.25
1969	2078	4900	4600-5300	0.97
1970	1726	9270	8200-9590	1.84
1971	1385	12620	9200-1385	2.50
1972	1522	16500	12700-22000	3.28
1973	2879	10700	8800-11400	2.12
1974	2260	17000	16000-19000	3.37
1975	2309	15000	13000-19000	2.97
1976	917	13000	13000-14700	2.58
1977	1083	14000	11000-18000	2.77
1978	2488	--	--	--

number/acre thus ranged from 0.05-0.08 muskellunge/acre or 1 muskellunge/13-20 acres. Estimates of angler exploitation based on the voluntary creel ranged from a high of 20% in 1973 to a low of 9% in 1976 and 1977. Survival from spring to spring ranged from 40 to 71%. The number of stocked muskellunge as a percent of the total number of muskellunge caught in the fyke nets varied from 57% in 1974 to 84% in 1977.

The size of the males ranged from 21 to 43 inches total length, and females ranged from 25 to 50 inches (Fig. 5). Some males entered the spawning run at 3 years, and in 1974, a few 3-year-old females were mature (Figure 6). Although the period of nonstocking affected the determination of the age of maturity for 1969-75, the 1966-68 and 1976-78 histograms indicate that, in general, males are mature at age 4 or 5 years and females at 5 or 6. The oldest male was 21 years and the oldest female was 26.

Stocking was discontinued in Lac Court Oreilles from 1966-70 in order to observe the response of the naturally reproducing population. The number of fish recovered from the year classes from this period was not larger than the number from natural reproduction in previous year classes (Fig. 7). This indicated that in the absence of competition with hatchery-raised fish, naturally produced fish did not increase in number.

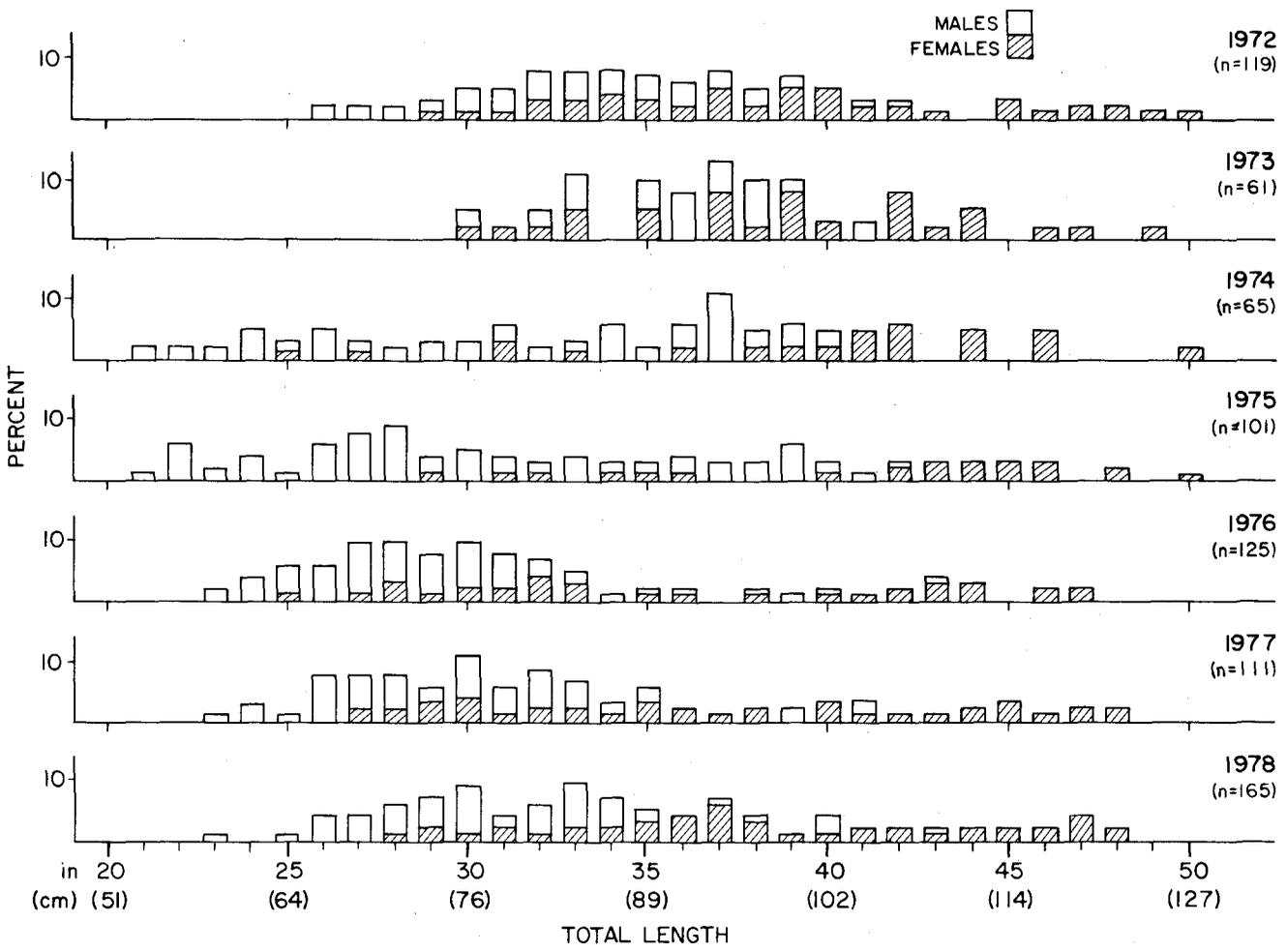


FIGURE 5. Length frequency distribution of male and female muskellunge caught in fyke nets in Lac Court Oreilles, 1972-78.

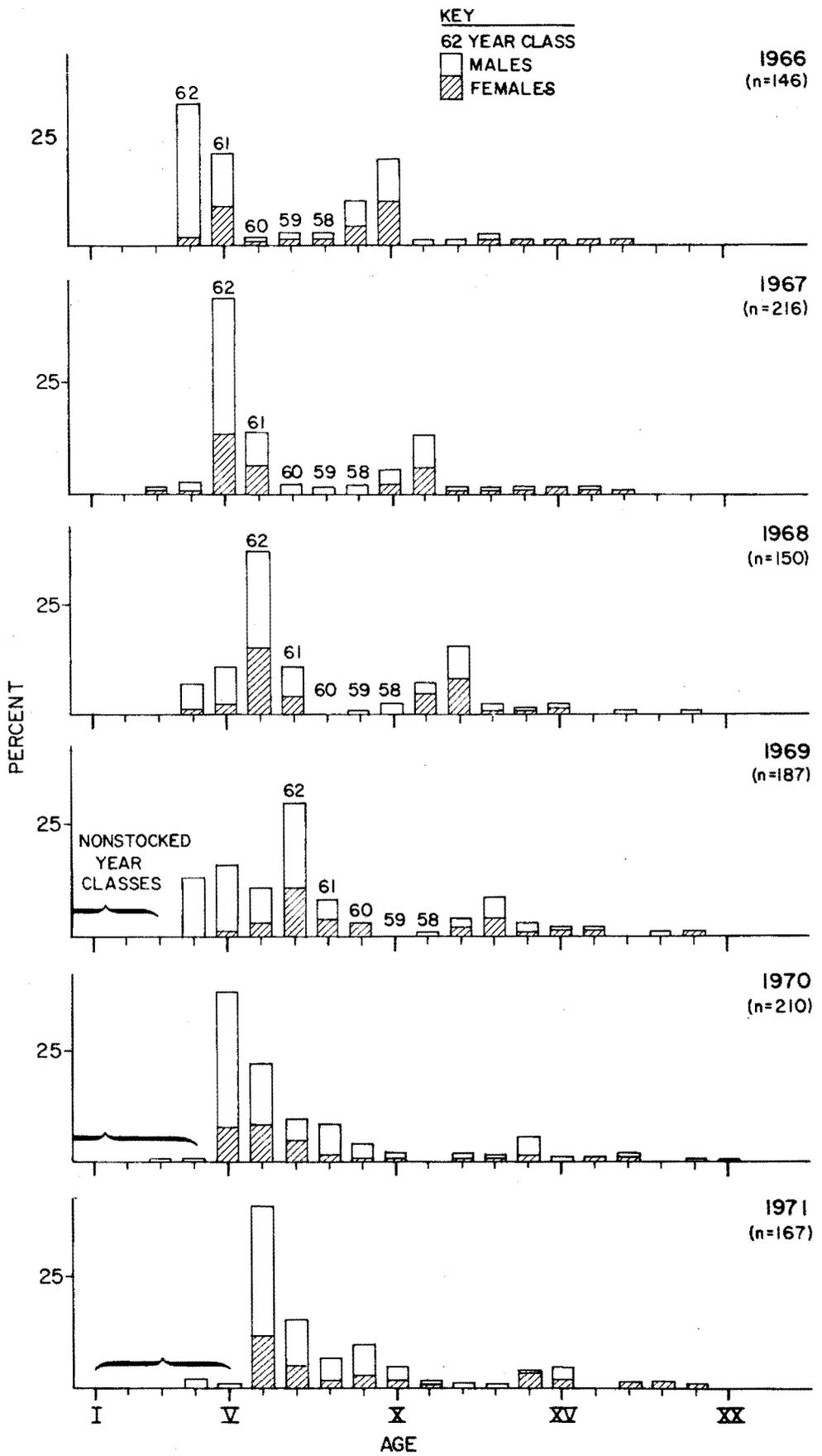


FIGURE 6. Agedistribution of muskellunge caught in fyke nets in Lac Court Oreilles, 1966-78.

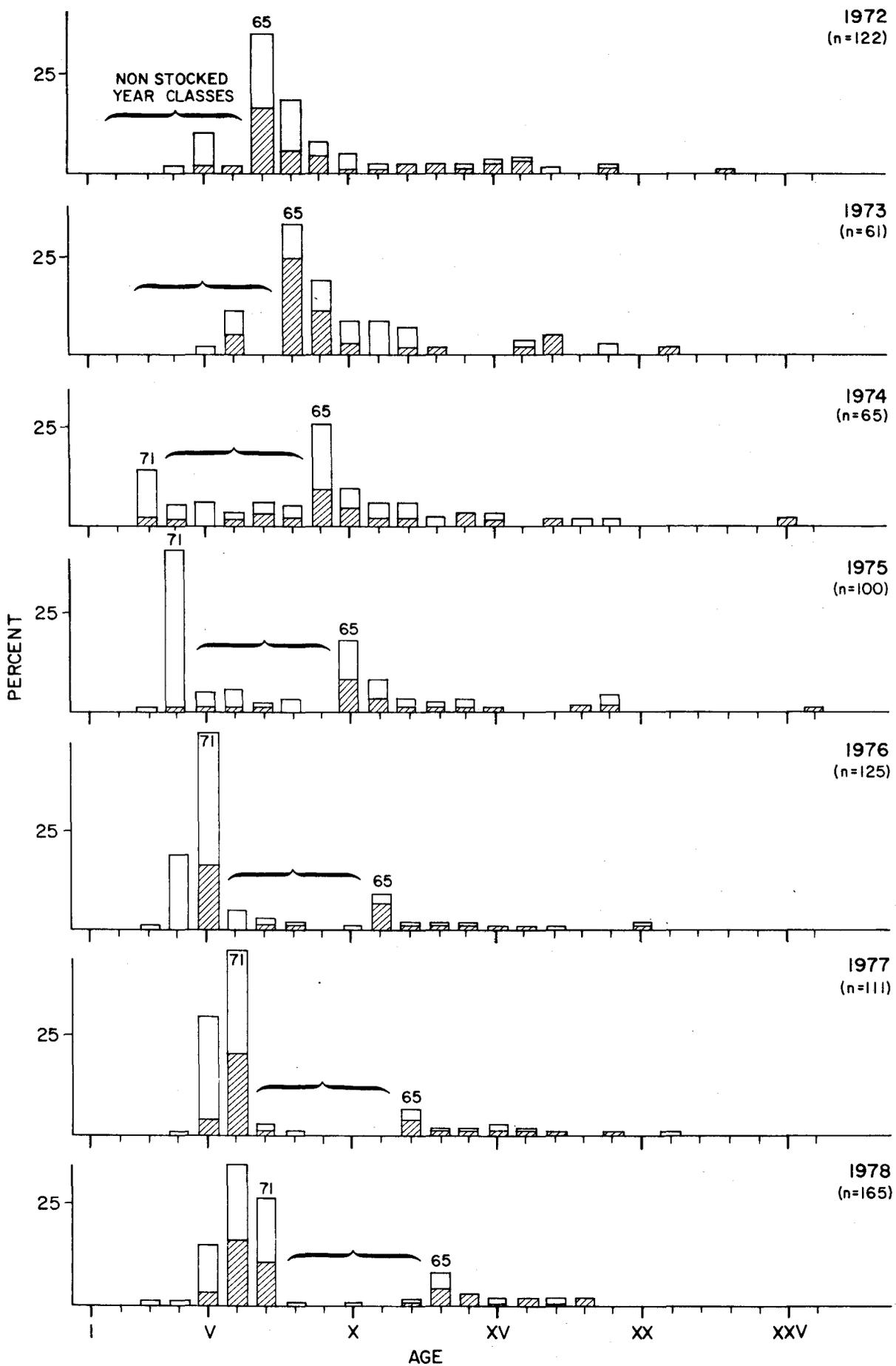


FIGURE 6 (Cont.)

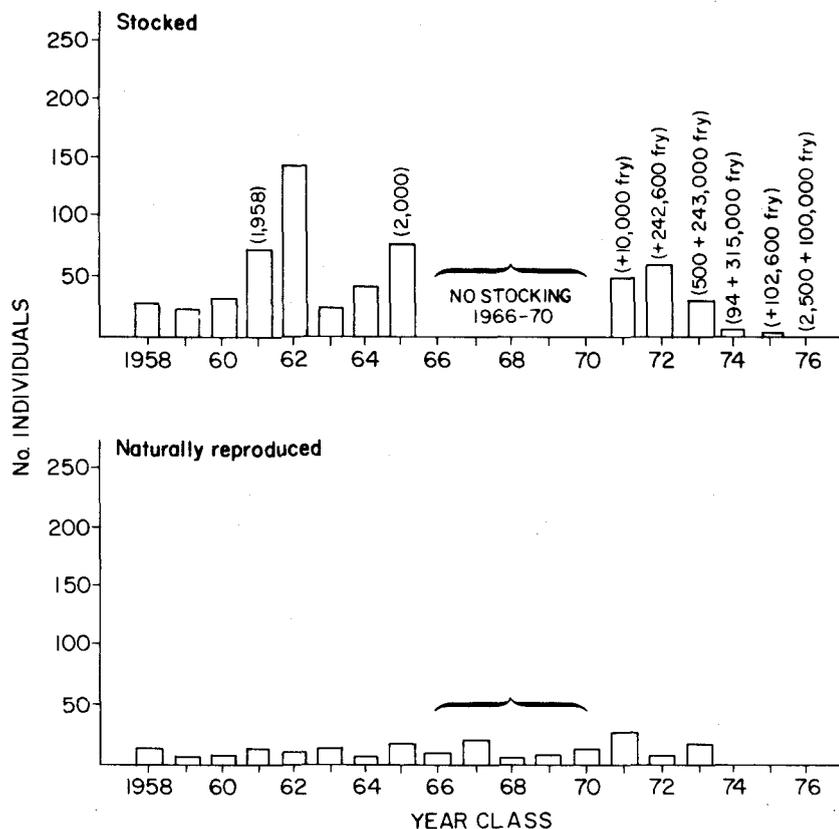


FIGURE 7. Number of individual muskellunge recovered from each year class from 1958 to 1978 in Lac Court Oreilles. Sampling ended in 1978.

This absence of stocked muskellunge and lack of corresponding increase in the naturally reproduced fish created a "hole" in the age structure of the population (Fig. 6). Age classes that would normally be well represented in the spawning run were conspicuously reduced, especially in the 1975-78 samples. Year classes immediately preceding and following the nonstocking period were strong. The 1965 year class dominated the spawning run at ages VII-IX in 1972-74 and was evident through age XIII in 1978. The first year class after stocking was resumed in 1971 was well represented in the spawning run at age III in 1974 through age VII in the last year of sampling, 1978.

Absence of stocking was not the only condition producing weak year classes over the entire sampling period. There was an earlier "hole" in the muskellunge age structure evident in the 1966-69 samples (Fig. 6). This represents reduced numbers of fish recovered from the 1958-60 year classes. Although 1,000 fingerlings/year were stocked during this time, relatively few were recruited to the adult population (Fig. 7). The low survival of these year classes presented an almost equivalent result to that of the nonstocking period; naturally reproduced muskellunge did not increase in number in response to the absence of stocked fish.

Although fyke net sampling continued through 1978, only a few 3- and 4-year-old muskellunge were captured in Lac Court Oreilles from the 1974-75

year classes (Fig. 7). Since muskellunge begin to enter the spawning run at ages III-V, I expected to catch more fish from the 1974 year class in the 1976-78 samples. This year class has suffered mortality or is late in maturing. It was too soon to capture many fish from the 1975-78 year classes.

Northern pike are present in Lac Court Oreilles although they were not native. A single fish was observed in 1945. Too few were caught to enable population estimates until 1961 when the estimate was 4,200 (Fig. 8). Each year thereafter there was a sizeable population which gradually increased to a high in 1974 of 17,000. The population has remained above an estimated 13,000 fish or approximately 3 northern pike/acre.

The muskellunge population declined over the 1956-77 period from an estimated high of over 1,000 fish to a low of under 300 (Fig. 8). This appeared to correlate with the increasing population of northern pike over the same period (Fig. 9). However, the years of lowest population estimates, 1971-78, are the same years during which the recruitment of adult spawners was low due to the period of no stocking.

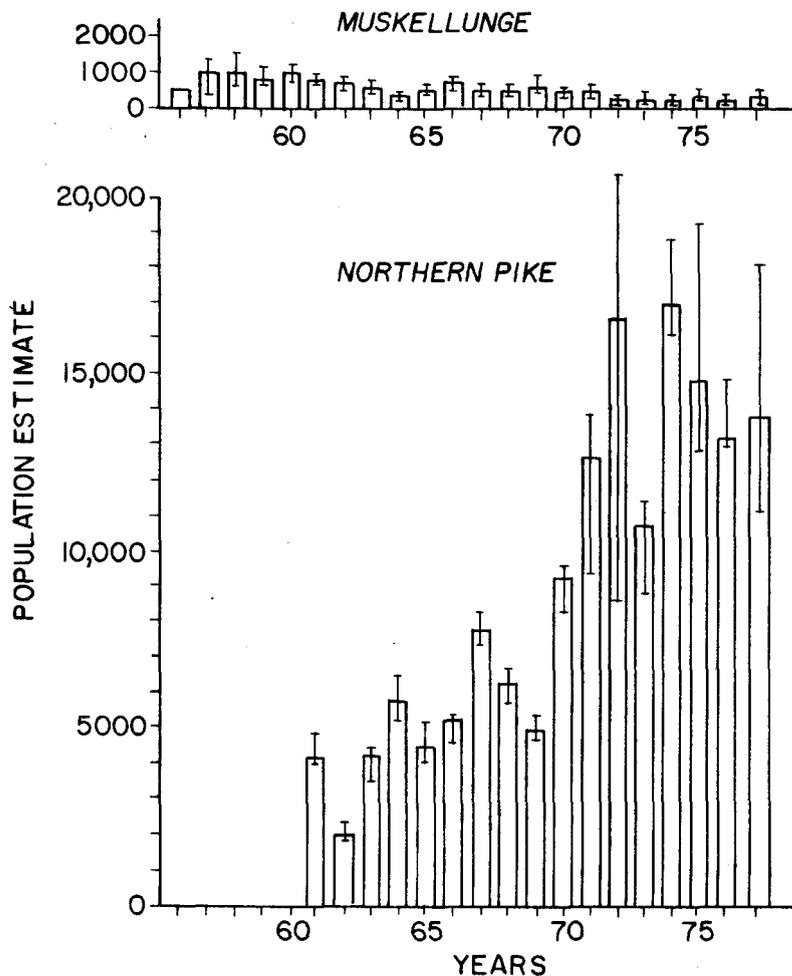


FIGURE 8. Population estimates and the 95% confidence limits for adult muskellunge and northern pike in Lac Court Oreilles, 1955-78.

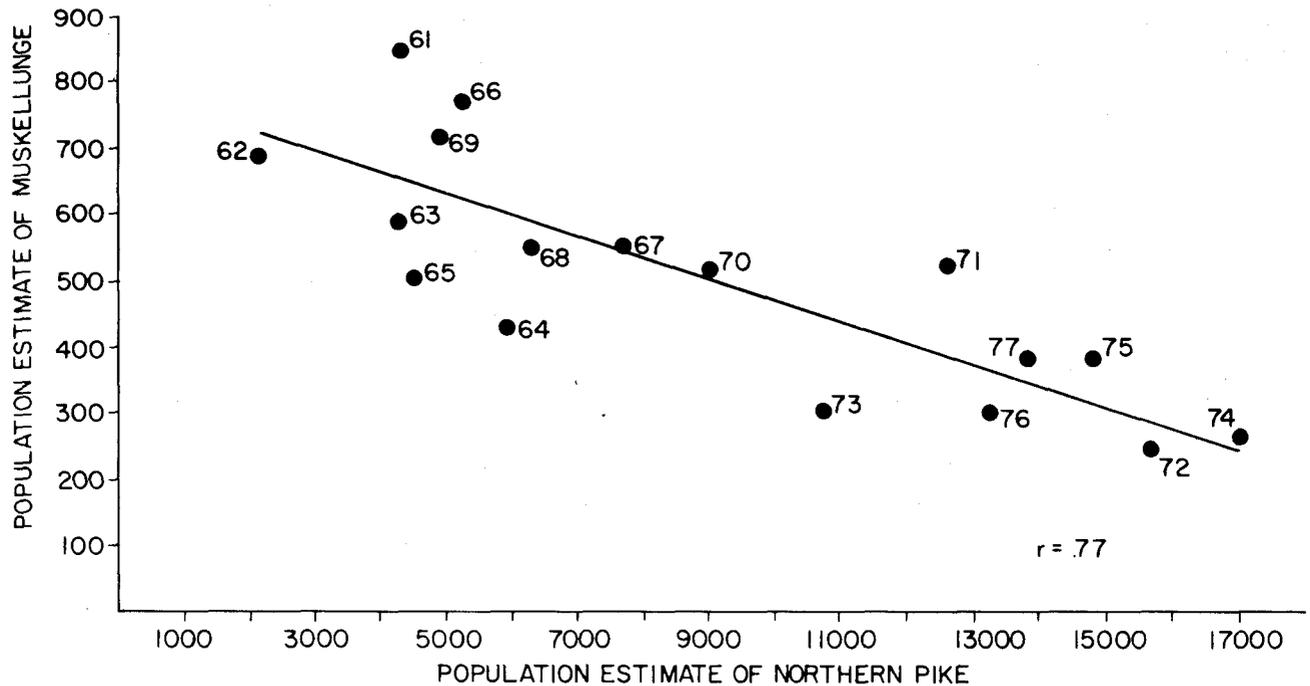


FIGURE 9. Correlation between population estimates of northern pike and population estimates of muskellunge in Lake Court Oreilles from 1961-1977.

## DISCUSSION

Muskellunge populations in Sand Lake and Lac Court Oreilles were similar in some respects. The maximum adult size was about the same, 40 and 43 inches for males in Sand Lake and Lac Court Oreilles, respectively, and 47 and 50 inches for females. However, the Lac Court Oreilles muskellunge population had proportionally more large (over 45 inches) and more old (over age XV) individuals. The oldest male in Lac Court Oreilles was 8 years older than the oldest male in Sand Lake, and the oldest female was 10 years older. Since the larger and older fish were present in Lac Court Oreilles before the nonstocking period, nonstocking was not the factor causing the size and age difference.

In spite of these differences between the two lakes, Sand Lake had two to three times the estimated number of muskellunge/acre, a lower exploitation rate, and a well-structured population maintained entirely by natural reproduction. I suspect that the lower angler catch in Sand Lake was due to the fact that fishing locations are diffuse while Lac Court Oreilles has numerous well-known sand and rock bars used by anglers. I have no data on angler compliance with the voluntary creel survey.

The muskellunge population densities were low in both lakes, 1 fish/5.0-20.0 acres, as compared to populations of 1 fish/1.1 to 5.2 acres found in 4 other Wisconsin lakes in earlier years (Table 3).

Stocking appears to be required for the maintenance of the Lac Court Oreilles muskellunge fishery at its present level. Stocked muskellunge outnumbered

TABLE 3. Estimates of number of acres that support one adult muskellunge in four northern Wisconsin lakes (Johnson, unpublished data) and in the two lake studies.

Lake, County	Year	1 Muskellunge/ No. Acres
Bone Lake, Polk Co.	1964	1.1
Mason-Evergreen, Sawyer Co.	1969	2.7
Big Spider Lake, Sawyer Co.	1964 and 1965	2.8
Lake Twenty-six, Burnett Co.	1970	5.2
Sand Lake	Present study	5.0- 6.0
Lac Court Oreilles	Present study	13.0-20.0

naturally reproduced fish in every year of the study. During the years of stocking, strong vs. weak year classes represented in the samples were related to the survival vs. mortality of the stocked fish and not to the number of naturally reproduced fish. During the nonstocking period, the hypothesis that stocked muskellunge were replacing naturally reproduced muskellunge was found to be invalid in Lac Court Oreilles. Naturally reproduced fish did not respond by increasing in number during the 5-year nonstocking period. This was observed in (1) an examination of the population age structure in which nonstocking produced a "hole" where reduced numbers of fish from these 5 year classes were recruited to the adult population, (2) evidence that the nearby naturally reproducing population in Sand Lake did not experience a series of weak year classes in the same 5 years, and (3) a tabulation of the cumulative number of fish recovered from each year class showing that numbers of naturally reproduced fish did not increase in the absence of competition from stocked fish. The representation of the latter (Fig. 7) is somewhat biased because each individual fish from the older year classes has had more chance of being caught. However, the fact that most muskellunge caught were less than 10 years old means that the nonstocking year classes (1966-70) had sufficient opportunity to be caught in the sampling period through 1978. Any definitive increase in naturally reproduced muskellunge should have shown up in this time period.

Presence or absence of stocking in Lac Court Oreilles has not been the only factor influencing year class strength; obviously, environmental factors and hatchery procedures are of primary importance. For example, even though the 1958-60 year classes received stocked fish, they produced a "hole" in the population age structure in the 1966-69 sampling years (Fig. 6 and 7). On the other hand, a very strong year class was produced in 1962 even through the stocking rate was half that of the also strong 1961 and 1965 year classes. If stocking had not been discontinued for 1966-70, we do not know whether or not stocked fingerlings would have survived or whether another "hole" in the age structure due to low survival might still have occurred.

The invasion of northern pike and the subsequent establishment of large populations in Lac Court Oreilles may be the most significant factor presently affecting the muskellunge fishery. Muskellunge population estimates decreased over the years that northern pike estimates were steadily rising. Although the lowest muskellunge estimates come from the years when the nonstocked year classes were producing few adult fish, the correlation between northern pike

and muskellunge population estimates is still somewhat convincing. Additional muskellunge population estimates in the 1980's, after the nonstocked year classes died out, would have been required to determine if muskellunge numbers would remain low in the face of northern pike invasion even after annual stocking was resumed.

Northern pike populations increased in Sand Lake more recently than in Lac Court Oreilles. Numbers caught were too small for population estimates until 1976-77. The muskellunge population has not decreased in Sand Lake, but I hypothesize that it will if northern pike abundance remains high.

Percent survival of muskellunge from one spring to the next decreased over the sampling period in both lakes. This reduction in survival may be related to competition with northern pike although I have no further evidence to substantiate the idea.

#### SUMMARY AND MANAGEMENT CONSIDERATIONS

The muskellunge populations in two northern Wisconsin lakes were compared during the 1972-78 spawning runs, Sand Lake had not been stocked with muskellunge over an interval of 26 years, whereas Lac Court Oreilles had a history of annual stocking. Sand Lake, despite its history of nonstocking, maintained a muskellunge population that was two to three times greater than Lac Court Oreilles. Although population density was lower in Lac Court Oreilles, there were more large (over 45 inches) and more old (over age XV) individuals than in Sand Lake.

Stocked muskellunge in Lac Court Oreilles did not replace naturally spawned muskellunge, but rather added to the numbers in the population. After 5 years of nonstocking, numbers of naturally reproduced fish did not increase. At the same time, the 5 resulting small year classes altered the age structure of the spawning population.

The stocking of a particular year class in Lac Court Oreilles did not guarantee the recruitment of that year class into the adult population. The survival of stocked fish from each year class was variable.

Sand Lake maintained a muskellunge population without stocking for over 26 years. On the other hand, Lac Court Oreilles seemed to require a stocking program for the maintenance of its muskellunge fishery at its present level. Although some natural reproduction did occur in the absence of stocking in Lac Court Oreilles, it was obvious that stocking substantially increased adult muskellunge numbers.

An increase in northern pike population estimates was correlated with a reduction in the muskellunge population estimates in Lac Court Oreilles. It was too soon after the northern pike invasion to observe the response in Sand Lake, but I predict a decrease if the northern pike remain abundant. I recommend that estimates of the muskellunge and northern pike populations in Sand Lake be made periodically during the next 10-year period to test that hypothesis.

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### About the Author

Leon Johnson's a fishery biologist with the Warm Water Research Group in the Bureau of Research, Spooner.

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Anne M. Forbes and Ruth L. Hine, Editors  
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