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**MICHIGAN DEPARTMENT OF NATURAL RESOURCES
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¹A contribution from Dingell-Johnson Project F-53-R, Michigan

ABSTRACT

This study of the muskellunge (*Esox masquinongy*) in Lake St. Clair covers the period of 1978-86 and was preceded by an earlier segment covering the years from 1969-76. Tag returns showed evidence of at least two distinct groups of muskellunge in Lake St. Clair. One group, which spawns in the north, disperses southward to inhabit the entire western side of the lake. This was also apparent in sport catch records which indicated that post-spawning muskellunge moved progressively southward throughout the summer season. Another group resides and apparently spawns in the southeastern (Ontario) part of the lake. Although these two stocks appear to be segregated, some muskellunge in the western area of Lake St. Clair were observed straying outside their normal home range.

The growth rate of muskellunge has not changed significantly since 1969 based on an analysis of length-at-age data. Length-weight regression did suggest that the fish may be getting heavier as compared to earlier years. However, this apparent increase is most likely due to the timing and size of the samples analyzed and the fact that the data collected were biased over time by a succession of minimum size limit increases which now extend lake wide.

The current regulations for Lake St. Clair muskellunge emphasize a trophy-size fishery. These regulations seem adequate at this time to ensure continuance of successful natural reproduction, good growth rates, and increases in the numbers and size of muskellunge available to anglers. However, further monitoring is necessary to maintain this world famous fishery at current levels.

INTRODUCTION

Williams (1948; 1961), Krumholz (1949), and Haas (1978) have all conducted studies of the muskellunge (*Esox masquinongy*) in Lake St. Clair. The attention given this species has been well justified since muskellunge angling in Lake St. Clair is world famous. The former world record muskellunge (28.35 kg) was taken there in 1940 (Williams 1961). The species has not showed the level of stress and dependency on supplemental stocking that has occurred in many other parts of its range (Dombeck et al. 1986; Inskip 1986).

Lake St. Clair is about midway in St. Clair-Detroit River system (SCDRS), connecting Lake Huron with Lake Erie. Surface area of Lake St. Clair is about 1,110 km² of which approximately 1/3 is United States-owned, with the balance Canadian-owned (Leach 1973). Average depth is 3.4 m and maximum natural depth is 6.4 m. The lake is bisected by a dredged, 8.2 m-deep navigation channel. Lake Huron is the source of 97% of Lake St. Clair's water (Derecki 1984).

The relatively eutrophic and productive environment of Lake St. Clair (Ryder 1965) supports a diverse fish community. In a 1983-85 trap-net survey encompassing the entire SCDRS, 57 species of fish were collected (Haas et al. 1985). Lake St. Clair has long been known for excellent sport fisheries for yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*) and smallmouth bass (*Micropterus dolomieu*), in addition to muskellunge.

Annual spring trap netting of muskellunge in Anchor Bay, Lake St. Clair began in 1969 and continued through 1985. Haas (1978) reported on data collected during 1969-76. This study covers the period 1978-86.

METHODS

Muskellunge for tagging and mean length at age analysis were obtained from trap nets set at the Anchor Bay station in Lake St. Clair (north area, Figure 1). These nylon-mesh nets had hearts and pots 1.8 m deep and leads 91.4 m long.

Muskellunge in good condition were tagged with vinyl tube dart tags with a nylon, single-barbed base. The tags were inserted and secured into the interneural process below the dorsal fin. Age determinations were obtained from scales imprinted on acetate plastic blanks. Some older, slow-growing males were impossible to age by the scale analysis method. Even the recommended aging technique utilizing the cleithral structure (Casselman 1978) or sections of the pectoral fin (Johnson 1971) did not provide valid age assessment.

Populations of muskellunge are characterized by their relatively low density. Consequently, obtaining adequate sample sizes is always a problem for the researcher or the manager. Fortunately, the Michigan-Ontario Muskie Club (MOMC) has provided annual

records of the registered catch of their members since 1968. This club contains the bulk of the most active Lake St. Clair muskellunge anglers.

Some MOMC members tagged and released their captured muskellunge from 1969–82. Beginning in 1983, the club began a catch-and-release program without the tagging program. This involved the participating members keeping a record of the total length and the catch localities of the fish that they released.

RESULTS

Tag recoveries

During the period 1977–85, a total of 338 muskellunge were tagged, including 234 fish by MOMC members and 104 fish by the Michigan Department of Natural Resources (MDNR). Club members tagged only four fish in 1982, which was their last year of tagging. A total of 79 muskellunge caught in the Anchor Bay trap nets were tagged. Since 1983, only 66 of these fish were tagged by the MDNR and 25 of these came from nets set in areas outside of Anchor Bay during the 1983–85 survey of the SCDRS.

The catch of muskellunge by the MDNR was greatly reduced because of a total conversion to shallower nets. In the 1969–76 study, extensive use was initially made of trap nets with 3.0 m-deep hearts and leads. These nets were large enough to extend to the water surface, which made them quite effective in intercepting and capturing muskellunge. The use of these deeper nets was totally abandoned after 1975 due to their high vulnerability to increasingly frequent and severe boat-inflicted damage. The smaller nets, while quite effective in capturing walleye and smallmouth bass for ongoing studies, virtually ended the muskellunge netting program.

There were too few tag returns (total of 18) to allow any conclusive interpretation of muskellunge distribution in the 1978–86 period. The last tag returns (2) were reported in 1985. The few returns came from fish tagged in the north and southwest areas of the lake (Figure 1). Fish tagged in the southwest part of the lake were either recaptured there or in the northern part of the lake. This distribution of returns agrees with the results of the 1969–76 study. However, in the 1977–86 study, two fish tagged in northern Lake St. Clair were recaptured in the southeast area of the lake. In the 1969–76 period, this movement was not observed. Haas' (1978) study, utilizing a larger sample size (50 tag returns), was able to show evidence of a substantial southward migration of muskellunge from Anchor Bay after the completion of spring spawning.

Analysis of the catch records of MOMC members for the 1977–86 period added evidence of the extensive southward movement of muskellunge. The north, southwest, and southeast areas of the lake provided 82% of the catch. The mean day of capture in these three areas

progressed from July 1, plus or minus 5 days, for the north area to July 30, plus or minus 4 days, for the southwest area and, finally, to August 25, plus or minus 4 days, for the southeast area (Table 1). The chronology of capture by area closely resembles the 1969-76 MOMC catch results when the mean day of capture was July 9, plus or minus 10 days, for the north, July 28, plus or minus 5 days, for the southwest and August 23, plus or minus 4 days, for the southeast area.

The diurnal distribution of the catch of 1,102 muskellunge registered by MOMC anglers was analyzed. A majority of the fish (62.0%) were caught between 1100 and 1700 hours, 28.8% were taken from 0600 to 1100 hours, and only 9.2% were caught after 1700 hours. This distribution of the catch does not show whether muskellunge were actually more vulnerable to angling during the hours of peak harvest or whether it was reflecting the period of most intense angling effort.

The tagging or handling techniques of MOMC members appeared, by their own observations, to have resulted in unusually high mortality (and was the reason for their abandoning all tagging after 1982). Only 9 (3.85%) of 234 muskellunge tagged by club members were recaptured. By contrast, 9 of the 104 fish tagged by MDNR were recovered for an 8.65% rate of return.

An estimated population of 16,902 adult and subadult muskellunge in Lake St. Clair was derived by dividing the 8.65% tag return rate into the combined MOMC angler and MDNR trap net catch of 1,462 fish for the period of 1978 through 1985 (the last year in which tag returns were reported).

Growth

The age of Lake St. Clair muskellunge could be determined from scale impressions with reasonable accuracy up to age 10. Fish older than 10 years could not be confidently aged by any method and were not used in the analysis. Johnson (1971) concluded from studies of Wisconsin muskellunge populations that the scale method was fairly accurate in assessing the ages of 1 through 9-year olds.

The ages of 257 muskellunge were determined from samples collected primarily at MOMC tournaments in 1978 and 1979 (Table 2). The mean age of males in this sample was 7.1 years and 7.6 years for females. Females grew faster and attained greater total lengths than males. Males greater than 1,027 mm long were rarely encountered. This has been universally observed in muskellunge populations including the earlier Lake St. Clair studies of Williams (1961) and Haas (1978).

The mean total length of muskellunge registered by MOMC members only varied 3 mm (1,087-1,090 mm) between the three major areas. Haas (1978) also found no significant difference in mean size of the sports catch by area for the 1973-76 period. He did find that, in

1968, the mean length of the fish was significantly greater in the north than in the southwest or southeast areas.

There was no indication that muskellunge of Lake St. Clair were currently undergoing any changing growth trend. Mean lengths-at-age were similar to the results obtained from fish collected in the 1969-76 period. Mean length at age of Lake St. Clair muskellunge generally exceeds that which has been reported for inland waters [e.g., lakes of western and central Ontario (Hourston 1952) or of Wisconsin (Johnson 1971)]. The growth rate most closely resembles that of another Great Lakes population which inhabits the St. Lawrence River.

Hanson's (1986) analyses of eight northern Wisconsin lakes revealed that muskellunge growth was correlated to the density of catostomids. The fast growth rate of Lake St. Clair muskellunge may also be related to the abundance of catostomids as a food source. Catostomids, consisting of several species of redhorse (*Moxostoma* spp.) and white suckers (*Catostomus commersoni*) together comprise one of the most abundant groups of fish in Lake St. Clair (Haas et al. 1985).

Regression calculations of 783 muskellunge caught by MOMC members between 1978 and 1986 were used to describe the length-weight relationship $\log (W) = 2.7318 \log (L) - 4.3711$ where (W) = weight in g and (L) = total length in mm. The length-weight relationship of 296 muskellunge caught in trap nets between 1969 and 1974 was $\log (W) = 3.0162 \log (L) - 5.2377$ (Haas 1978).

DISCUSSION

Haas (1978) concluded, on the basis of the distribution of tag returns, that there were at least two groups of muskellunge inhabiting Lake St. Clair. The group spawning in the north rapidly dispersed at the completion of spring spawning into a large summer range which includes all areas of the western half of Lake St. Clair. The other group spawned in southeastern Lake St. Clair and also utilized this area for its summer range. The returns of that period revealed no evidence of fish straying out of their home range.

Tag returns from the 1978-85 period affirmed the evidence of two discrete, spawning groups. There were, however, recapture of two fish in the southeast area that were tagged in the north area. This is viewed as representing the temporary straying of a few fish out of their home range. It is not seen as contradicting the conclusions of the earlier study.

Another tagging study also revealed the presence of two groups of smallmouth bass in Lake St. Clair with spawning grounds and summer ranges similar to the muskellunge (Bryant and Smith 1988). Discrete groups of muskellunge probably occur commonly in large bodies of water. Mooradian (1986) found evidence from tag returns of two or more groups of muskellunge inhabiting separate areas of Chautauqua Lake, New York. Six specific

muskellunge spawning areas were located in Leech Lake, Minnesota by means of radio-tagged adults (Strand 1986).

Analysis of MOMC angler catch records supported other evidence of a post-spawning southward movement of muskellunge. This was indicated by the fact that the mean day of capture occurred earlier in the northern than in the southern part of the lake. MOMC anglers, by virtue of their shared experience and unlimited mobility, are very knowledgeable of the distribution of muskellunge in Lake St. Clair. Therefore, the timing of the catches by area actually reflect seasonal changes in fish distribution. MOMC catch records from 1973 through 1976 and 1978 through 1986 have revealed no significant differences between the mean length of muskellunge caught in various areas of Lake St. Clair. However, Haas (1978) found the mean length of muskellunge in the 1968 sport catch was significantly greater in northern as compared to southern areas of the lake. He concluded that more restrictive size and season regulations (enacted in 1969) protected spawning muskellunge until they had dispersed from their spawning grounds in the north, resulting in a more even areal distribution of harvested fish after 1968.

The areal distribution of 390 muskellunge registered by MOMC anglers in the 1973-76 period was 16.1% from the north, 48.7% from the southwest, and 35.1% from the southeast area. This distribution shifted considerably, in the 1978-86 period when 25.1% of the angler catch sample of 906 fish was taken in the north, only 29.0% in the southwest, and 45.9% in the southeast area.

An estimate of the adult and subadult population of 16,902 fish was calculated by dividing the 8.65% return rate of MDNR-tagged fish into the total known catch of 1,462 fish. The total catch figure is undoubtedly low since it neither includes the unregistered catch of fish by MOMC anglers nor the catch of non-club member anglers. Hanson (1986) found that the harvest of legal-sized (762 mm) muskellunge in eight northern Wisconsin lakes ranged from 0.07 to 0.52 fish/acre and averaged 0.30 fish/acre. If it was assumed that the Lake St. Clair catch rate at least equaled the lowest Wisconsin catch rate of 0.07 fish/acre, the estimated muskellunge catch (fish larger than 762 mm) in Lake St. Clair would be about 19,200 fish. For comparison, a 1983-85 mark-and-recapture estimate of northern pike in the SCDRS was 27,444 fish (Haas et al. 1985).

The growth of muskellunge is characterized by pronounced sexual dimorphism (Scott and Crossman 1973). The several studies of muskellunge in Lake St. Clair have all shown that the females grow faster and attain greater maximum size than the males. Mean length-at-age data did not show any evidence of changing growth trends in the population since at least 1969. Length-weight regressions calculated by Haas (1978) and during this 1978-86 study indicate a trend towards heavier muskellunge. However, it is not certain that the trend is real since

significant weight changes could result, for example, from the unknown proportions of the pre- and post-spawning catches of fish.

The mean length and girth of muskellunge in the sport catch have both increased since 1980 (Table 3). The increase would be more in recent years except for the inclusion of records of some catch-and-release fish averaging a lesser size than fish registered in MOMC tournaments. The increased average size and weight of muskellunge in the angler catch is obviously in response to the progressively more restrictive regulations imposed by the State of Michigan as well as by the MOMC on its own members. State law has steadily increased the minimum size limit from 726 mm to 914 mm in 1976, to 965 mm in 1981, and to 1,016 mm in 1987. Similar minimum size limit changes by MOMC on their tournament entry fish have tended to precede the state regulation changes.

A further regulation benefitting muskellunge occurred in 1987 when Ontario substantially increased the minimum size limit of muskellunge in their waters to 1,016 mm from the former 762 mm. Lakewide uniformity of muskellunge angling regulations was realized in 1988 when Ontario lowered their daily catch limit from two to one fish.

The muskellunge in Lake St. Clair, unlike many populations elsewhere, does not presently show signs of stress. The population remains self-sustaining and supports a sport fishery of probably unequalled quality and quantity. Numbers of fish in the population and the mean and maximum lengths of fish caught by anglers should increase further as a result of the present fishing regulations and the continuation of the present excellent water quality environment.

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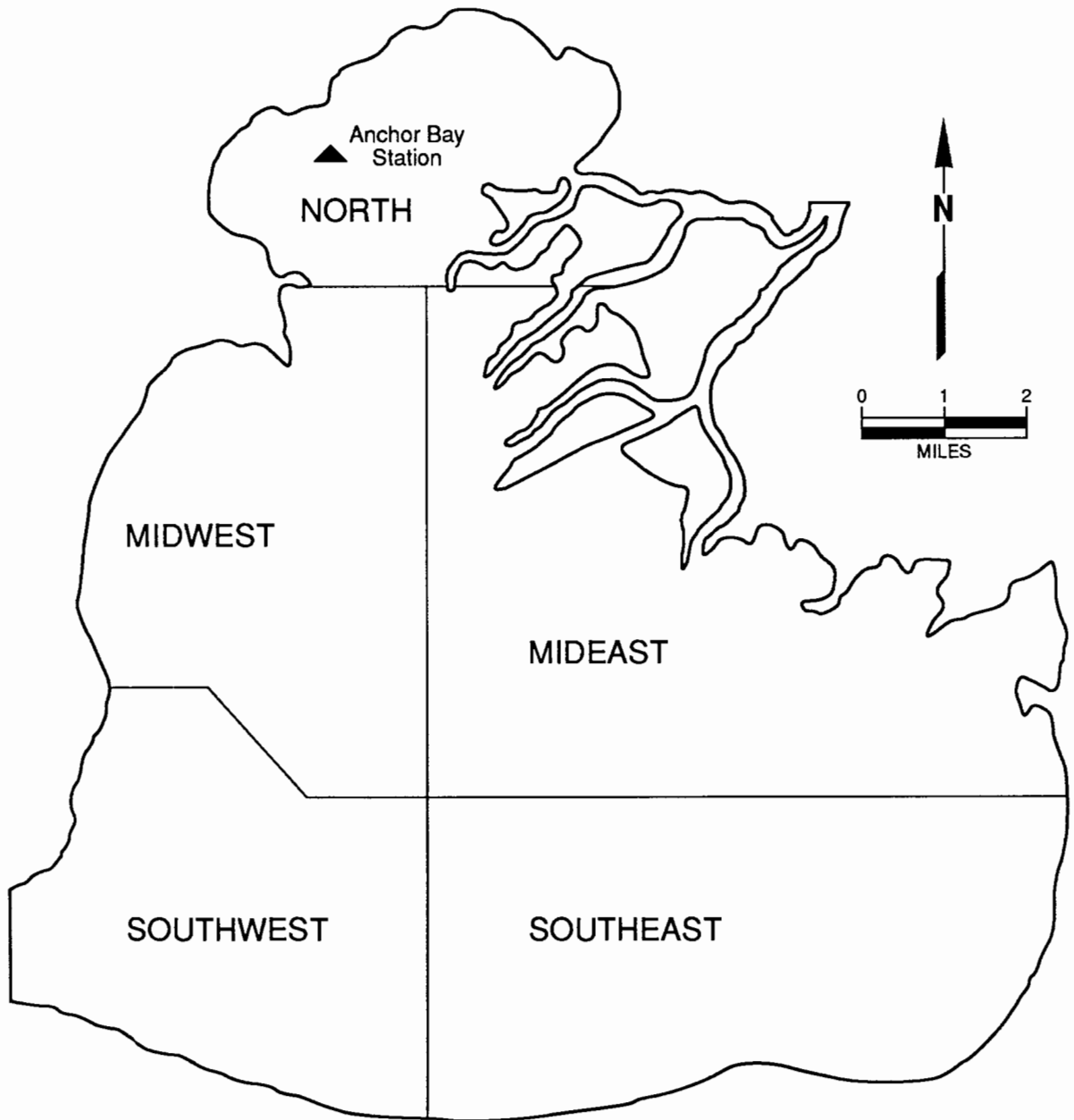


Figure 1. Map of Lake St. Clair showing the areas used to delineate the muskellunge sport fishery.

Table 1. Mean day of catch and mean total length (mm) of muskellunge captured in three areas of Lake St. Clair by Michigan-Ontario Muskie Club anglers during the period 1978-86. Confidence limits (95%) are in parentheses.

	Area		
	North	Southwest	Southeast
Number of fish	227	263	416
Mean total length	1,088 (12)	1,087 (10)	1,090 (8)
Mean day of capture	Jul 1 (5 days)	Jul 30 (4 days)	Aug 25 (4 days)

Table 2. Mean total length (mm) at age of muskellunge caught in Lake St. Clair during the period 1978-79. Confidence limits (95%) are in parentheses.

	Age group					
	5	6	7	8	9	10
Males						
Mean length	889 —	920 (23)	969 (26)	1,027 (35)	1,083 (58)	—
Number	1	17	32	19	2	—
Females						
Mean length	924 (31)	973 (24)	1,011 (43)	1,070 (38)	1,115 (17)	1,170 (40)
Number	2	19	49	54	17	8
Sexes combined						
Mean length	912 (30)	948 (35)	995 (43)	1,058 (43)	1,116 (48)	1,174 (38)
Number	3	38	89	87	30	10

Table 3. Mean total length (mm) and mean girth of muskellunge (mm) caught in Lake St. Clair by Michigan-Ontario Muskie Club members.

Year	Number caught	Mean length ± 95% confidence limits	Mean girth ± 95% confidence limits
1968 ¹	343	972 ± 15	—
1969	424	968 ± 28	—
1971	285	1,036 ± 12	—
1972	156	1,033 ± 25	—
1973	75	1,064 ± 27	—
1974	108	1,054 ± 20	—
1975	99	1,063 ± 20	—
1976	117	1,035 ± 18	—
1978	198	1,052 ± 14	410 ± 10
1979	151	1,063 ± 15	416 ± 8
1980	105	1,075 ± 15	410 ± 12
1981	119	1,093 ± 24	433 ± 9
1982	161	1,097 ± 12	423 ± 28
1983	87	1,106 ± 15	434 ± 28
1984	79	1,119 ± 16	457 ± 16
1985	106	1,112 ± 16	449 ± 12
1986	95	1,114 ± 16	455 ± 14

¹The 1968–76 data are from Haas (1978).

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