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An Evaluation of the Tiger Muskellunge Stocking Program in Michigan

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AN EVALUATION OF THE TIGER MUSKELLUNGE STOCKING PROGRAM IN MICHIGAN[1]

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[1]Contribution from Dingell-Johnson Project F-35-R, Michigan

Abstract

In Michigan, the hybrid tiger muskellunge is utilized as a relatively easy to catch, trophy-sized esocid. In 1982, about 16,112 Michigan anglers harvested 13,447 tiger muskellunge, one for every 10 angler days of fishing.

A change from extensive to intensive hatchery rearing techniques in 1976 resulted in a five-fold increase in annual fingerling production and a 50% increase in managed tiger muskellunge lakes, but a considerable decrease in fingerling survival and angling quality. Subsequently, it was found that extensively reared fingerlings stocked at about 8 inches in early July had 4 to 16 times higher survival than intensively reared fingerlings stocked at 6 to 7 inches in early August. Attempts to enhance survival of intensively reared fingerlings by early or late stocking were not successful.

Four factors important to survival of stocked fingerlings were time of stocking, size at stocking, predator density, and density of small soft-rayed forage fishes.

Management recommendations include a return to extensive fingerling rearing techniques. Returns from 30,000 extensively reared fingerlings will equal those from 200,000 intensively reared fingerlings, the current program level. But, if intensive rearing techniques continue, fingerling stocking rate should be increased 600% in lakes with good populations of tiger muskellunge. Stocking of tiger muskellunge should cease in lakes with demonstrated poor fingerling survival. The fish populations and angling quality in managed lakes should be monitored more closely. Fishing regulations should be modified to reflect the image of the tiger muskellunge as a trophy fish.

Introduction

When a natural or man-made cross occurs between a northern pike, Esox lucius, and a muskellunge, Esox masquinongy, the resulting hybrid progeny are called tiger muskellunge. Naturally occurring tiger muskellunge were first reported in Illinois in 1927 (Crossman and Buss 1965) and are fairly common in areas of the United States and Canada where the natural range of both parental species overlap. Tiger muskellunge were first produced in hatcheries in Minnesota (Eddy 1944) and Wisconsin (Black and Williamson 1947) in 1939. No morphological differences were noted between tiger muskellunge produced from muskellunge males and pike females, and those produced from muskellunge females and pike males. Tiger muskellunge fry and fingerlings were hardier and often grew faster during their first year than either muskellunge or pike. The eggs produced by adult female tiger muskies normally did not ripen and the testes of adult males were usually incapable of producing sperm (Black and Williamson 1947), thus, tiger muskellunge were essentially sterile.

In 1955, the Michigan Department of Conservation (now Natural Resources) began a program of experimental introduction of purebred muskellunge (northern or Wisconsin type) into selected inland lakes (Williams 1959). One of the purposes of the introductions was to create more trophy fishing opportunities for Michigan anglers. By the mid-1960's the program had met with some success, but survival of most introductory stocks was low, as was angling success for the hard to catch muskellunge (McClay 1981). Since tiger muskellunge were reputed to be hard fighters and easier to catch than purebred muskellunge, in 1966 the Michigan Department of Natural Resources began to produce and stock tiger muskellunge as a trophy fish.

Between 1966 and 1975, annual production of tiger muskellunge fingerlings was variable, ranging from 3,528

fingerlings in 1968 to over 49,000 in 1970 and 1971 (McClay 1981). Of the 236,149 tiger muskellunge produced during the 10-year period, all but a few thousand were raised in ponds on diets of minnows (extensive culture). From 1976 through 1983 all of Michigan's tiger muskellunge were raised in tanks or troughs on pelleted food (intensive culture). Because intensive culture was cheaper and did not require the use of ponds, the average annual production of tiger muskellunge fingerlings increased to 139,018 fingerlings, about six times the mean annual production during the years of extensive culture. The usual cross in Michigan has been northern pike male x northern muskellunge female but recently, with a shortage of muskellunge females, the cross has been reversed. Some purebred muskellunge fingerlings were also cultured in 1966-83. Many of these muskellunge fingerlings were planted in lakes that provided brood stock for the tiger muskellunge program.

The great increase in the tiger musky program prompted a series of studies to evaluate its results. Summarized in the report are: (1) statewide estimates of the number of tiger muskellunge anglers and the annual harvest of tiger muskellunge; (2) ratings for all lakes stocked with tiger muskellunge as to relative density of the tiger muskellunge population and sportfishing quality; (3) measurements, at intensively studied lakes, of survival, growth, and angler harvest of tiger muskellunge in relation to stocking rate, size of fingerlings, and lake type; and (4) changes in population structure, fishing pressure, and angler harvest of important indigenous fishes.

Methods

The 1977 mail survey of anglers, conducted by the (then) Office of Surveys and Statistical Services, MDNR, included a special request that muskellunge anglers record the waters they fished, the number of days fished at each

location, and their catch of legal-size muskellunge and tiger muskellunge at each location. The survey provided estimates of angler harvest, by district, of tiger muskellunge and the two kinds of purebred muskellunge native to Michigan, northern muskellunge, and Great Lakes muskellunge.

Because some of the mail survey estimates of fishes harvested were obviously excessive (a common occurrence in mail surveys involving relatively scarce fishes), a method of obtaining more reasonable estimates had to be devised. I decided that each district fisheries biologist should be given the mail survey catch estimates for his district and asked to either okay the estimates or provide counter estimates. In 1982, the identical procedure was used to provide a second estimate of fishing effort and harvest of muskellunge in Michigan.

In December 1977, each district fisheries biologist also was asked to evaluate every water in his district that was stocked with tiger muskellunge since 1966. For each water, data were requested on years stocked, number and size of fingerlings stocked, survival and growth by year class, quality of the tiger muskellunge fishery, and any known effects of the tiger muskellunge on indigenous fish populations or fishing quality. In December 1982, a second evaluation was obtained, this time covering waters that were stocked from 1976 through 1981.

From 1977 through 1982, four lakes that were being stocked annually with fingerling tiger muskellunge were subjected to intensive examination. A stratified intensive creel census was conducted on Round Lake, Van Buren County, from 1977 through 1980, and on Osterhout Lake, Allegan County, in 1978 and 1979. Generally the census was conducted from May 15 (opening day of the sportfishing season for tiger muskellunge) to the end of August and consisted of 40 hours of on-site census per week. In 1981, Round Lake muskellunge fishermen were contacted before and

during the fishing season and asked to record in a diary their angling effort and catch of tiger muskellunge.

Electrofishing gear (220-v, ac boom shocker) or trap nets were used to attempt population estimates of tiger muskellunge in Round Lake in fall 1977 and spring 1978, and in Osterhout Lake in spring 1978. In spring 1982, an estimate was made of the total predator fish population (largemouth bass, Micropterus salmoides, and tiger muskellunge) in Round Lake.

A test of the relative survival of small, early-stock (June-July) fingerlings and normal-stock (July-August) fingerlings was made in Round Lake and Osterhout Lake in 1978 and 1979, and in Dumont Lake, Allegan County, in 1979. In this test the annual planting of fingerlings for each lake was divided equally into early-stock and normal-stock fingerlings. A similar test of the relative survival of minnow-reared and pellet-reared fingerlings was made in Osterhout Lake in 1980, in Round Lake and Dumont Lake in 1980 and 1981, and in Long Lake, St. Joseph County, in 1981. A third test, involving normal-stock and late-stock fingerlings, was attempted in Round and Dumont Lake in 1982. In these tests, electrofishing gear was used to determine the relative survival of the various plantings.

In summer 1979, a series of water analyses and an intensive survey of aquatic plants were completed on Round Lake and Osterhout Lake. On each lake six standard water analyses were made at irregular intervals in July and August. Maps of each lake were divided into 164-feet (50-meter) square grid sections. At each grid intersection the vegetation was analyzed in a 10-inch (0.25-meter) square area by visual observations from a boat or by scuba gear, or collected with a grappling hook. Estimates were made of the total lake bottom with vegetation and the percent of vegetation found at various depths, the density of the total vegetative cover, and the density and distribution of each aquatic plant species.

Results

The results section is divided into an analysis of questionnaires sent to anglers and district fisheries biologists and into an analysis of the intensive studies conducted at four lakes.

Questionnaires

Angling effort and harvest.--In Wisconsin, the nation's premier "musky" state, an estimated 219,000 anglers fish for muskellunge (mainly the northern variety) and harvest an estimated 69,000 fish annually (Klingbiel 1981). In Michigan, the 1977 mail survey estimated that 52,060 anglers fished for muskellunge (all varieties). Previously, presumably less accurate surveys estimated 27,200 muskellunge anglers in 1975 and 24,510 in 1976 -- an average of only 48.7% of the 1977 estimate (G. C. Jamsen, personal communication).

The mail survey estimates of angler catch by district are shown in Table 1 for tiger, northern, and Great Lakes muskellunge. Some of the catch estimates were obviously excessive. Therefore, each district fisheries biologist was informed of the survey catch estimates for his district and asked to provide counter estimates if necessary (Table 1). The total 1977 catch of tiger muskellunge in Michigan estimated by district biologists was 9,866 fish, only 48.1% of the mail survey estimate of 20,520 fish. Thus, there was reason to suspect that in the mail survey both the total number of muskellunge anglers and the total catch of tiger muskellunge were overestimated by about 50%. Therefore, I estimate that 25,000 muskellunge anglers harvested 10,000 tiger muskellunge in 1977.

Based on available growth data, the vast majority of tiger muskellunge harvested in 1977 were stocked as fry or minnow-reared fingerlings in 1973, 1974, or 1975. The annual statewide planting during those 3 years averaged

17,653 fry and 21,210 fingerlings, or a total of 38,863 fish (Table 2). An annual harvest of 10,000 fish therefore represented a return to the angler of 25.7% of the average annual plant of fry and fingerlings combined, or 47.1% of the average annual fingerling plant.

In 1982, the statewide harvest of tiger muskellunge estsimated by district biologist was 13,477, or 48.9% of the harvest estimated by the mail survey (Table 3). Thus, for both surveys, the biologists' estimate was about 50% of the mail survey estimate. The majority of tiger muskellunge harvested in 1982 were stocked as pellet-reared fingerlings in 1977-79. The mean annual planting in those years was 124,715 fingerlings. (Based on available growth data, most pellet-reared tiger muskellunge required 1 year longer than minnow-reared muskellunge to reach harvestable size which is why the 1977 through 1979 year classes, rather than 1978 through 1980, were chosen to determine the mean annual plant.)

Although the estimated statewide harvest of tiger muskellunge in 1982 was 36% higher than in 1977, the percentage of stocked fingerlings that were harvested dropped from 47.1% to 10.8%, a ratio of 4.36 to 1 (Tables 1, 2, and 3). For fry and fingerlings combined the return rate dropped from 25.7% to 7.7%, a ratio of 3.34 to 1. The increase in total harvest and the decrease in percent harvest coincided with the changeover from extensive to intensive hatchery culture of fingerlings.

Since the mail survey overestimated the total catch by about 50%, the estimates of fishing effort and total anglers were probably high. Therefore, the total fishing effort and angler counts for each district were modified to correspond with the revised harvest figures proposed by the district biologists (Table 3). The modified total estimates by region and statewide seemed much more realistic than the mail survey estimates.

An estimated 25,150 anglers fished for muskellunge in Michigan in 1982 (Table 4). About 64% of the anglers fished mainly for tiger muskies, 22% fished mainly for Great Lakes muskies, and 14% fished mainly for northern muskies. The average tiger muskellunge angler fished 8.28 days and harvested 0.83 fish for an average of 0.10 fish per angler day. By comparison, northern muskellunge anglers averaged 6.83 days and harvested 0.60 fish (0.09 fish per angler day), while anglers for Great Lakes muskellunge averaged 8.33 days and 0.54 fish (0.07 fish per angler day). Overall, the average muskellunge angler fished 8.09 days and harvested 0.74 muskellunge (0.08 muskellunge per angler day).

Lake evaluations by district personnel.--Through 1977, 95 inland lakes and impoundments had been stocked at least once with tiger muskellunge fry or fingerlings (Table 5). As of December 1977, 76 of these lakes were still being managed for tiger muskellunge -- 17 in Region I, 14 in Region II, and 45 in Region III. Only six lakes had been stocked with fry, all as initial plants. All 76 managed lakes had received at least one fingerling plant.

Fishing quality for tiger muskellunge was judged to be good to excellent in 17 lakes, fair in 17 lakes, and poor or non-existent in 6 lakes. Fishing quality was not yet established in 36 lakes, 32 of which had received their initial plant of fingerlings in 1976 and 1977.

Observations (by DNR fisheries personnel) or reports (by fishermen) on fishing pressure or fish populations were obtained for 20 of 63 tiger muskellunge lakes planted before 1976 and for 1 of 32 new lakes planted first in 1976 and 1977 (Table 6). An increase in total fishing pressure occurred on two lakes but no other data on fishing pressure were reported. There was a report of scarred largemouth bass (one lake) and a claim by anglers that "muskies are eating all the big bluegills" (one lake). However, tiger muskellunge appear not to have affected the numbers or size

of panfish (12 lakes) or largemouth bass (5 lakes). At four lakes, tiger muskellunge reportedly competed with northern pike, but at one lake a spearing ban following muskellunge plants reportedly enhanced the northern pike population. Overall, there was no evidence that tiger muskellunge had any important effect on other fish species, except that they may compete with other predatory fishes.

In 1982, there were 114 managed tiger muskellunge lakes, a 50% increase over 1977 (Table 7). The increase was 88% in Region I (15 lakes), 100% in Region II (14 lakes), and 20% in Region III (9 lakes). District I showed the greatest increase, 220% (11 lakes). Only districts 9 and 12 were managing fewer lakes for tiger muskellunge than in 1977. The statewide increase in managed lakes is a reflection of the increase in hatchery production of fingerling tiger muskellunge from an annual mean of 21,210 in 1973-75 to 124,715 in 1977-79. The fingerling stocking rate also increased from 3.57 per acre in 1973-75 to 4.02 per acre in 1977-79.

However, the quality of the program has declined. There were more good or excellent tiger muskellunge lakes in 1982 than in 1977 (23 versus 17), but the percentage of lakes with this rating has declined (31.5% versus 42.5%) (Table 8). Also, the numbers (26 versus 6) and percentage (35.6% versus 15%) of poor lakes has increased.

In 1982, district biologists provided information of fish populations and angling characteristics for 36 lakes with fair or better angling for tiger muskellunge (Table 9). In four lakes, tiger muskellunge were harvested at sublegal size, sometimes because they were misidentified as northern pike. Tiger muskellunge emigrated to some extent from six lakes. Angling for muskellunge was better in 1970-75 than in 1976-81 for four of five lakes that contained tiger muskellunge during both periods.

Changes in indigenous fish populations that were coincident with the development of tiger muskellunge

populations were reported for only eight lakes. Populations of indigenous predatory fishes reputedly increased in two lakes and decreased in one lake. Panfish or other forage fish populations improved in three lakes and deteriorated in three lakes. In 18 other lakes tiger muskellunge had no noticeable effect on indigenous fishes.

Intensive studies

Lake descriptions.--The four study lakes are relatively similar in size (168-215 acres) and maximum depth (30-51 feet).

Round Lake, Van Buren County, and Osterhout Lake, Allegan County, which were studied more intensively, are limnologically very similar. Surface area is 187 acres for Round Lake and 168 acres for Osterhout Lake. Maximum depth is 35 feet in Round Lake and 30 feet in Osterhout Lake. Secchi disk readings averaged 8-9 feet in both lakes during summer 1979. Surface methyl orange alkalinity varied from 74 to 82 ppm in Osterhout Lake and from 32 to 42 ppm in Round Lake (Tables 10 and 11). Both lakes stratified in the summer of 1979 with low oxygen conditions intermittently occurring at depths greater than 15 feet.

Essentially 98% of the vegetation in both lakes occurred at depths of 0 to 10 feet (Table 12). Weed cover was more dense and extensive in Osterhout Lake (Table 13). Chara and Nitella predominated in both lakes (Table 14). Potomogetons were common in Osterhout Lake but sparse in Round Lake.

Round Lake had been chemically treated in 1971 to eradicate a fish population that included carp, Cyprinus carpio, and several species of slow-growing panfish. In 1972 and 1973, the lake was stocked with largemouth bass and hybrid sunfish (redear sunfish, Lepomis microlophus x green sunfish, Lepomis cyanellus) (Table 15). By 1974 a large population of bluegills, Lepomis macrochirus, had

redeveloped in Round Lake. Tiger muskellunge fry were stocked in 1972; minnow-reared fingerlings in 1973, 1974, and 1975; and pellet-reared fingerlings in 1975, 1976, and 1977.

Osterhout Lake contained an assemblage of panfish, forage fish, and predatory fish typical of southern Michigan lakes, plus a remnant population of adult northern muskellunge from previous fingerling plantings. Bluegills were only moderately abundant but slow growing. Pumpkinseeds, Lepomis gibbosus, were fairly abundant and above average in growth. Other panfish were average in abundance but slightly below average in growth. Osterhout Lake contained an unusually high density of bullheads, Ictalurus sp.. Largemouth bass over 14 inches long were fairly numerous, and bass under 8 inches were abundant. However, 8- to 13-inch bass were scarce. Periodically, northern pike were moderately abundant. Osterhout Lake was stocked with minnow-reared tiger muskellunge fingerlings in 1972 and 1974 (Table 16). Pellet-reared fingerlings were stocked in 1976 and 1977.

Dumont Lake, Allegan County, covers 215 acres and has a maximum depth of 51 feet. The lake was slightly to moderately turbid, due mostly to the activity of a substantial population of carp, and aquatic vegetation was relatively scarce. Forage fishes included an abundance of alewife Alosa pseudoharengus, several species of minnows and suckers, and rather small numbers of panfish. Small to moderate populations of northern pike and largemouth bass, plus a few adult northern muskellunge, were present. Dumont Lake was stocked with minnow-reared tiger muskellunge in 1971, 1972, and 1974, and pellet-reared fingerlings in 1976 through 1978 (Table 17).

Long Lake, St. Joseph County, has an area of 211 acres and a maximum depth of 40 feet. During the study the water was clear and aquatic vegetation was dense in most shallow areas. The fish population was dominated by a slow-growing

population of bluegill and an unusually dense population of 12-inch and larger largemouth bass. Small forage fishes were noticeably scarce. Long Lake was stocked with tiger muskellunge fry in 1974 and with pellet-reared fingerlings in 1975, 1977, 1978, and 1980 (Table 18).

Creel census.--The 1977 intensive creel census for Round Lake estimated that 114 tiger muskellunge were harvested with all but one taken during the period from May 15 through June 30 (Table 19). Analysis of scales samples indicated that 22 (19%) of the creeled muskellunge were age II (1975 year class), 86 (75%) were age III (1974 year class), and 6 (5%) were age IV (1973 year class). Subsequent catch estimates were 150 tiger muskellunge in 1978, 259 in 1979 and 23 in 1980 (Tables 20-22). Unfortunately, the wide confidence limits on all of the harvest estimates substantially limits their reliability. The census data clearly showed the resurgence of the bluegill as the primary sport fish in Round Lake, with an estimated harvest of about 25,000 in both 1979 and 1980. By 1980 the hybrid sunfish had disappeared from the harvest but yellow perch (Perca flavescens) were being caught with rapidly increasing frequency.

From the creel census data for Osterhout Lake it was estimated (within wide confidence limits) that 136 tiger muskellunge were harvested in 1978 and 38 in 1979 (Tables 23 and 24). Bluegills were also the most harvested species on Osterhout Lake. Total angling effort, total harvest, and catch per effort at Osterhout Lake in 1978 and 1979 were considerably less than at Round Lake.

In 1981, at Round Lake, an attempt was made to obtain better and less expensive estimates of harvest by pre-season contact with as many tiger muskellunge anglers as possible. Each angler was asked to record total time spent angling for muskellunge and all fish harvested. Two angling clubs (Allegan Big 4 Anglers and Michigana Chapter of Muskies, Inc.) and a number of individual muskellunge anglers were

contacted and agreed to cooperate. The two clubs responded with relatively complete records for their members, but no information was received from individual anglers. Several of these anglers, contacted after the fishing season ended, stated that no reports were sent in because fishing was so poor. Members of the two angling clubs spent a total of 190 hours fishing for muskellunge on Round Lake. The total catch was one legal tiger muskellunge (which was released) and three sublegal muskellunge. Obviously, fishing for tiger muskellunge was not good at Round Lake in 1981.

Surveys and population estimates at Round Lake.--In fall 1977, trap nets and boom shocker were used to conduct a Schumacher-Eschmeyer-type population estimate of the tiger muskellunge in Round Lake. Seven muskellunge were collected in 42 trap net lifts and 103 muskellunge were taken in 13 nights of electrofishing. The data provided a surprisingly good estimate of the population of age-0, age-I, and age-II tiger muskellunge (Table 25).

It was feared that a significant number of the larger muskellunge might have suffered serious injury as a result of being shocked. To check on this possibility, sampling was resumed in spring 1978, again utilizing trap nets, which are very effective in capturing muskellunge at this time of year. In 30 net lifts in mid-April 1978, 50 muskellunge were captured, including 15 marked muskellunge that had been captured with electrofishing gear the previous fall. The proportion of marked fish was not found to be lower in the spring (15:50 or 1:3.3) than in the fall (110:473 or 1:4.3), suggesting that no significant delayed mortality of shocked fish had occurred. But, at least 10 (20%) of the muskellunge died in the trap nets, usually after becoming gilled in the leads.

Results of the fall 1977 and spring 1978 surveys were combined to narrow the confidence limits on the population estimates (Table 25). The survival of fingerlings stocked in 1976 and 1977 was considerably lower than for fingerlings

stocked in 1975. The 1974 year class also survived well, based on returns from the 1977 creel census (Table 19 and text). In addition, angler reports of good fishing in 1975 and 1976 were evidence of high survival of the first two plants of tiger muskies (1972 and 1973 year classes).

Trap netting revealed that bluegills were the most abundant species in Round Lake (Table 26), with an average of 269 per net lift. About 24% exceeded 6.0 inches in length. Largemouth bass were numerous (17 per net lift; 5% were 12.0 inches and larger). All bluegill and most largemouth bass age groups were growing slower than the state average rate.

At Osterhout Lake, a population estimate of tiger muskellunge was attempted April 25 - May 10, 1978, using a boom shocker. A total of 21 muskellunge were collected and marked, but no marked fish were recaptured. Included were one age-I (11.9 inches), four age-II (mean length 18.5 inches), and 16 age-IV (mean length 32.6 inches) fish. If the muskellunge were captured in proportion to their relative abundance, it must be assumed that, like their counterparts in Round Lake, the 1976 and 1977 year classes in Osterhout Lake did not survive well.

In spring 1982, a concerted effort was made to estimate the predator fish population in Round Lake (Table 27). The technique used was to obtain with electrofishing gear a Schumacher-Eschmeyer estimate of all largemouth bass 8 inches and larger, then use proportional catch ratios to estimate the population within each inch group. A direct estimate of tiger muskellunge was not feasible because of insufficient recaptures, therefore, the total tiger muskellunge population was estimated indirectly from the total bass population estimate and the bass/muskellunge capture ratio. Individual size groups of tiger muskellunge were estimated by using capture ratios within the muskellunge population.

The total predator population was estimated to consist of 3,067 largemouth bass, 8 inches and larger (16.4 per acre) and 394 tiger muskellunge, 11 inches and larger (2.1 per acre). The vast majority of the bass (78.6%) were 10 to 13 inches in length. Only four bass were over 15 inches long. Although none of the bass were aged, most were probably from the 1975-76 year classes, which were very abundant during the fall 1977 and spring 1978 surveys. These bass undoubtedly competed with the young tiger muskellunge for food and many of the bass were large enough to consume newly stocked fingerlings.

The population estimate for tiger muskellunge is not accurate for fish less than 13 inches long because many of those fish were too small to be captured in trap nets. Based on the population estimate of only 23 legal-size muskellunge, poor angling success would be predicted for fishermen on Round Lake in 1982.

Early-stock versus normal-stock study.--The hypothesis to be tested was: pellet-raised tiger muskies stocked as 3.5-inch fingerlings before June 7 ("early" stock) will survive at an equal or higher rate than 7-inch fingerlings stocked at the "normal" time (July 15 through August 31). The small fish could, of course, be produced at less cost.

Early and normal plantings were made in two lakes in 1978 and three lakes in 1979 (Table 28). Unfortunately in 1978 the fingerlings obtained from the usual Michigan cross (northern pike male x northern muskellunge female) did not attain 3.4 inches until relatively late, July 17. The normal (6.6-inch) fingerlings were stocked on August 17. In 1979, tiger muskellunge eggs were obtained from Ohio. They were the progeny of an Ohio muskellunge-northern pike cross. The early stock of "Ohio" fingerlings was planted on May 31 and the normal stock on July 26.

Relative survival for each stock of tiger muskellunge was measured at age 0 during the annual fall population estimates (Table 28). So few muskellunge survived that a

direct population estimate could be made for only one of the plants; however, the catch frequencies could be compared. In 1978, 15 nights of electrofishing at Round Lake produced 30 normal-stock fish but only one early-stock fish. At Osterhout Lake, only two age-0 fish (one of each stock) were collected in 14 nights. One night of electrofishing equaled one complete trip around each lake.

In 1979, eight nights of electrofishing at Round Lake produced three normal-stock and no early-stock muskies. No age-0 fish were captured at Osterhout Lake in four nights. On Dumont Lake, two normal-stock but no early-stock fish were taken in four nights.

Of the six tests, apparently only the 1978 normal stock at Round Lake resulted in relatively high survival (20%). In the remaining five tests survival of both plants was apparently so low that no significant difference in survival could be shown. It was concluded that early plants of 3.5-inch tiger muskellunge did not survive at a higher rate than normal plants of 7-inch muskellunge.

Minnow-reared versus pellet-reared study.--The hypothesis to be tested was: minnow-reared tiger muskellunge fingerlings stocked in July at 7.5 to 8 inches in length will survive at a higher rate than "normal", pellet-reared fingerlings stocked in August at 6 to 7 inches in length.

The test fish were stocked in Round and Dumont lakes in 1980 and 1981, in Osterhout Lake in 1980, and in Long Lake in 1981. For Round and Dumont lakes in fall 1980 and 1981, age-0 tiger muskellunge were collected and catch ratios were determined for minnow-reared and pellet-reared fish (Table 29). Schumacher-Eschmeyer population estimates were obtained for minnow-reared fish in Round Lake in 1980 and Dumont Lake in 1980 and 1981 (Table 30). The 1981 year class of minnow-reared fish in Round Lake was estimated in spring 1982 from the largemouth bass population estimate and the catch ratios as described previously. In each case the

equivalent population of pellet-reared muskellunge was estimated by using proportions based on catch ratios.

Survival of minnow-reared tiger muskellunge averaged 45.5% in Round Lake and 26.3% in Dumont Lake. Pellet-reared muskellunge survival averaged 5.5% in Round Lake and 3.4% in Dumont Lake. Mean survival ratio for all plants was 9.2 minnow-reared muskellunge for each pellet-reared muskellunge. The equivalent average catch ratio was 6.6 to 1 in favor of minnow-reared muskellunge (using fall catch ratio only), or 9.4 to 1 (using the spring 1982 catch data for Round Lake).

In fall 1980, seven electrofishing nights produced four minnow-reared and no pellet-reared age-0 tiger muskellunge at Osterhout Lake. In fall 1981, five nights of electrofishing produced two minnow-reared and no pellet-reared age-0 tiger muskellunge at Long Lake. Thus, the tested hypothesis was true on two study lakes and probably true on two other lakes.

Normal-stock versus late-stock study.--The hypothesis to be tested was: survival of pellet-reared tiger muskellunge fingerlings is enhanced if the fingerlings are stocked in fall (October) after the water temperature cools to 50 F or less.

It was proposed that Round and Dumont lakes be stocked in 1982 with complements of normal-stock (August) and late-stock (October) pellet-reared tiger muskellunge fingerlings. The proposed stocking density was increased to six times the norm so that enough fingerlings might survive to permit a meaningful population estimate.

On 5 August 1982, 2,400 normal-stock fingerling tiger muskellunge were put in Round Lake and 2,700 were put in Dumont Lake. Mean length of the fingerlings was 5.7 inches. However, the late-stock fingerlings, held in hatchery troughs, were decimated with disease and were not stocked. Thus, the hypothesis was not tested.

However, in fall 1982, a population estimate of the 1982 normal-stock tiger muskellunge was attempted at Round Lake, but in 14 nights of electrofishing only seven age-0 fish (mean length 11.5 inches) were captured. However, a rough, optimistic estimate of 55 fish was obtained by comparing this catch to that for the 1981 plant (7/23), and multiplying by the population estimate for the 1981 plant (182) which had been made in spring 1982 (Table 30). Thus, survival from the 1982 planting was about 2%, about what might be anticipated based on the relatively small size of the fingerlings and the poor survival of previous plants of normal-stock fingerlings.

Discussion

The value of stocked tiger muskellunge fingerlings in Michigan lies mainly in their potential to produce a fishery of relatively easy to catch trophy-sized esocids. Since its introduction to Michigan waters in 1966, the tiger muskellunge has become the most sought and most caught trophy esocid in Michigan. In 1982, an estimated 16,112 anglers spent 133,412 angler days harvesting 13,447 tiger muskellunge, compared with 5,480 anglers who harvested 2,978 Great Lakes muskellunge, and 3,558 anglers who harvested 2,124 northern muskellunge. Tiger muskellunge were somewhat easier to catch than other muskellunge. It took 10 days of fishing to catch a harvestable-size tiger muskellunge, 11 days to catch a northern muskellunge, and 14 days to catch a Great Lakes muskellunge.

A five-fold increase in hatchery production of tiger muskellunge fingerlings resulted from the change to intensive rearing techniques in 1976. This made possible a 50% gain in managed tiger muskellunge lakes (from 76 to 114) from 1977 to 1982.

The increase in the program led to increased concern among anglers that tiger muskellunge were having adverse

effects on indigenous fishes. However, observations by DNR personnel on lakes with established populations of tiger muskellunge showed that in the majority of lakes there was very little evidence that tiger muskellunge had any important effect on other fish species. Of course tiger muskellunge must eat and, like other predatory fishes, they tend to consume the largest possible available food items.

If, for example, bass and large bluegills dominate the list of available food fishes, then it is inevitable that large tiger muskellunge will consume some bass and large bluegills. However, most lakes that are dominated by populations of bass and panfish do not contain large numbers of tiger muskellunge. A typical tiger muskellunge "problem" lake might have a substantial population of minnows and suckers (which would provide adequate food for a large population of tiger muskellunge) and moderate but fast-growing populations of bass and panfish. In such a lake, the muskellunge could survive and grow well feeding on minnows and suckers but might consume enough harvestable-size bass and large panfish, incidentally, to significantly reduce those populations.

Although tiger muskellunge lakes increased in quantity from 1977 to 1982, they apparently decreased in average quality. Managed lakes with good or fair muskellunge angling decreased from 85% in 1977 to 64% in 1982, while lakes with poor to non-existent angling increased from 15 to 36%. The increase of 38 managed tiger muskellunge lakes resulted in a gain of only six lakes with good angling and seven lakes with fair angling, despite a three-fold increase in the mean number of fingerlings stocked per managed lake.

During the course of this study, concern developed in Michigan and other states over the relatively poor survival of intensively reared tiger muskellunge (Beyerle 1980 and 1981; Johnson 1978; Stein et al. 1981). Fortunately, in Michigan the first intensive study of a tiger muskellunge lake (Round) was conducted over a population that contained

both extensively and intensively reared fish. The obvious disparity in survival between the two groups of tiger muskellunge stimulated further investigations.

The magnitude of the disparity in survival to fall of age-0 fish was shown to range from 4:1 to as much as 16:1, always in favor of the extensively reared fingerlings. A check of hatchery records revealed two important differences between extensively and intensively reared tiger muskellunge. Fingerlings reared extensively on minnows were stocked about 1 month earlier (July) and were about 1 inch larger (7.5 to 8 inches), than fingerlings reared intensively on pelleted food (Beyerle 1981).

The time and size differential probably worked together to expose the extensively reared fingerlings to a greater abundance of edible-size (smaller) food items and reduced their chance of being eaten by predators.

Attempts to enhance survival of intensively reared fingerlings by early stocking were not successful. The late-stocking theory needs further testing. Survival of intensively reared fingerlings was strongly related to density of predators (largemouth bass) 12.0 inches and over in length and, probably, to the abundance of soft-rayed forage fishes (Beyerle 1984a and 1984b).

Four factors found to be important to survival of tiger muskellunge fingerlings were time of stocking, size at stocking, predator density, and density of small, soft-rayed forage fishes. Currently managers request 200,000 intensively reared fingerlings from the hatchery system. My studies demonstrated that equal survival to fall of age 0 could be had by rearing and stocking 30,000 extensively reared fingerlings. In addition, the survivors would average 2 to 4 inches larger, which would probably give them a further advantage.

Management Recommendations

Tiger muskellunge fingerlings should be grown to 8 inches and stocked into lakes by July 15. This goal can be accomplished by returning to extensive pond culture using minnows as forage. A possible alternate culture technique would involve rearing the fingerlings to about 3.5 inches in hatchery troughs on pelleted food, then continue rearing the fingerlings in troughs or raceways using minnows and/or surplus salmonids as forage.

If they have not already done so, managers should screen their tiger muskellunge lakes. Most lakes where survival has been less than good should be dropped from the planting schedule. Lakes that are dominated by slow-growing bluegills, or have few minnows, or that already have satisfactory populations of predators and forage fishes are poor prospects for tiger muskellunge. For lakes where survival of stocked fingerlings has been good or excellent, the stocking of larger fingerlings in July at the current stocking rate may be enough to change a "fair" lake into a "good" lake, or a "good" lake into an "excellent" lake. For other lakes with potential, the stocking rate may have increased to improve fishing.

If a decision is made to continue with the present intensive culture technique, then the fingerling stocking rate for "good" or "excellent" lakes should be increased by about 600% and all lakes no better than "fair" should be dropped from the program.

Fisheries managers should more closely monitor changes in populations and fisheries of all species at lakes being intensively managed for tiger muskellunge.

Fishing regulations should reflect the image of the tiger muskellunge as a trophy fish. Since they are relatively easy to catch and harvest, higher size limits (e.g., 36 inches) are appropriate and "no kill" regulations should be considered.

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Table 1. Angler catch, as estimated by mail survey (M) and district fisheries biologists (D), for muskellunge in Michigan, 1977.

District number	Muskellunge type					
	Tiger		Northern		Great Lakes	
	M	D	M	D	M	D
1	0	25	1,330	30	0	0
2	380	20	380	380	0	0
3	0	6	0	6	0	0
4	570	1,400	950	20	0	100
Total, Region I	950	1,451	2,660	436	0	100
5	1,900	500	0	0	2,090	250
6	570	570	190	0	0	20
7	0	0	0	0	0	30
8	2,280	1,500	760	75	0	0
Total, Region II	4,750	2,570	950	75	2,090	300
9	3,610	1,200	1,140	0	0	0
11	3,610	75	0	10	1,140	0
12	1,520	750	950	250	0	0
13	3,800	1,900	0	0	0	0
14	2,280	1,920	0	0	14,060	3,500
Total, Region III	14,820	5,845	2,090	260	15,200	3,500
Total, statewide	20,520	9,866	5,700	771	17,290	3,900

Table 2. Total number of tiger muskellunge stocked in Michigan from 1973 to 1975 and from 1977 to 1979.

	Muskellunge size		
Year	Fry	Fingerling	Total
1973	40,000	9,978	49,978
1974	12,960	31,762	44,722
1975	0	21,891	21,891
Total	52,960	63,631	116,591
Mean	17,653	21,210	38,863
1977	150,615	107,194	257,809
1978	0	128,542	128,542
1979	0	138,410	138,410
Total	150,615	374,146	524,761
Mean	50,205	124,715	174,920

Table 3. Angler catch, as estimated by mail survey (M) and district fisheries biologists (D), for muskellunge in Michigan, 1982.

District number	Muskellunge type					
	Tiger		Northern		Great Lakes	
	M	D	M	D	M	D
1	280	140	1,160	580	0	0
2	360	360	380	380	0	0
3	2,540	125	2,800	250	0	0
4	3,000	3,000	360	36	1,800	180
Total, Region I	6,180	3,625	4,700	1,246	1,800	180
5	2,980	2,980	0	0	760	760
6	6,300	2,520	0	20	0	20
7	3,020	600	0	0	0	18
8	1,440	150	0	0	0	0
Total, Region II	13,740	6,250	0	20	760	798
9	720	720	0	0	0	0
11	1,080	432	180	43	0	0
12	1,440	1,440	1,800	800	0	0
13	4,140	800	0	15	0	0
14	180	180	0	0	19,080	2,000
Total, Region III	7,560	3,572	1,980	858	19,080	2,000
Total, statewide	27,480	13,447	6,680	2,124	21,640	2,978

Table 4. Number of anglers and number of angler days of fishing pressure, as estimated by mail survey (M) and calculations based on harvest estimates by district fisheries biologists (D), for muskellunge in Michigan, 1982.

	Muskellunge type						
	Tiger		Northern		Great Lakes		Total
Location	M	D	M	D	M	D	D
Anglers							
Statewide	33,420	16,112	10,000	3,558	21,680	5,480	25,150
Angler Days							
Region I	38,180	22,395	27,260	7,227	23,600	2,360	31,982
Region II	95,980	43,659	2,160	229	28,400	29,820	73,708
Region III	142,560	67,358	38,880	16,848	128,700	13,491	97,697
Statewide	276,720	133,412	68,300	24,304	180,700	45,671	203,387

Table 5. Summary, by district, of inland lakes stocked through 1977 with tiger muskellunge fry or fingerlings, lakes presently being managed for tiger muskellunge, and estimated fishing quality in managed lakes.

	Total lakes		Estimated fishing quality			
District	Stocked	Presently being managed	Non-existent or poor	Fair	Good or excellent	Not established[a]
1	8	5	1	0	1	3
2	12	5	0	0	1	4
3	2	1	1	0	0	0
4	7	6	0	1	3	2
Total, Region I	29	17	2	1	5	9
5	6	5	0	1	2	2
6	4	4	0	1	2	1
7	5	4	0	0	0	4
8	2	1	0	0	1	0
Total, Region II	17	14	0	2	5	7
9	12	11	0	3	2	6
11	4	4	0	1	0	3
12	14	12	1	3	2	6
13	13	12	1	5	3	3
14	6	6	2	2	0	2
Total, Region III	49	45	4	14	7	20
Total, statewide	95	76	6	17	17	36
Percent		100	7.9	22.4	22.4	47.4

[a]Tiger muskellunge not yet legal size.

Table 6. Changes in fish and fishing at lakes stocked with tiger muskellunge as reported by district fisheries biologists.

	Number of lakes
Information available	21
Total fishing pressure	
Increase	2
Decrease	0
Panfish or other forage fish	
Increase in numbers	2
Decrease in numbers	3
No change in numbers	4
Increase in size	2
Decrease in size	2
No change in size	6
Tiger muskies prey on goldfish rather than panfish	1
Tiger muskies "eat all the bluegills"	1
Largemouth bass	
Increase in numbers	1
Decrease in numbers	1
No change in numbers	3
Report of scarred largemouth bass	1
Northern pike	
Tiger muskies compete with northern pike	4
Spearing ban since tiger musky plants have enhanced northern pike population	1
No information available	37
Lakes not evaluated (muskies not established)	35

Table 7. Summary, by district, of inland lakes stocked with tiger muskellunge fingerlings at least once from 1976 through 1981, lakes presently being managed for tiger muskies, and estimated fishing quality in managed lakes.

	Total lakes		Estimated fishing quality				
						Unknown	
District	Stocked	Presently being managed	Non-existent or poor	Fair	Good or excellent	Not established	No information
1	16	16	1	3	1	4	7
2	5	5	3	1	0	1	0
3	7	4	0	2	2	0	0
4	8	7	1	1	2	2	1
Total, Region I	36	32	5	7	5	7	8
5	10	10	3	1	5	1	0
6	6	6	1	0	2	1	2
7	8	8	3	2	0	2	1
8	5	4	0	2	0	2	0
Total, Region II	29	28	7	5	7	6	3
9	12	7	1	3	3	0	0
11	7	7	1	0	2	3	1
12	16	11	2	3	4	2	0
13	23	23	9	4	0	10	0
14	7	6	1	2	2	1	0
Total, Region III	65	54	14	12	11	16	1
Total, statewide (1982)	130	114	26	24	23	29	12
Percent		100	22.8	21.1	20.2	25.4	10.5

Table 8. A comparison of estimated angling quality for tiger muskellunge in lakes, 1977 versus 1982.

Year	Total lakes	Estimated angling quality		
		None or poor	Fair	Good or excellent
1977	40	6	17	17
		(15%)	(42.5%)	(42.5%)
1982	73	26	24	23
		(35.6%)	(32.9%)	(31.5%)

Table 9. Summary of available information on fishing or fish populations found by or reported to district fisheries biologists in lakes where angling quality for tiger muskellunge was fair or better during 1976-81.

Information available	Number of lakes			
	Region			
	I	II	III	Statewide
Tiger muskellunge population				
Well received by anglers	0	0	2	2
Not well received by anglers	0	0	2	2
Emigrating from lake	3	0	3	6
Harvested at sublegal size misidentified as northern pike	2	2	0	4
Many sublegals caught and released	0	0	1	1
Angling better than during 1970-75	0	0	1	1
Angling the same as during 1970-75	0	0	1	1
Angling worse than during 1970-75	0	4	0	4
Other predatory fishes				
Largemouth bass population decreased	0	0	1	1
Smallmouth bass fishery flourished	1	0	0	1
Bass fishing not effected	0	1	0	1
Good walleye fishery developed	0	1	0	1
Panfish and other forage fishes				
Panfishing declined	0	0	1	1
Yellow perch less abundant	1	1	0	2
Rock bass more abundant	0	1	0	1
Growth of panfish improved	0	1	0	1
Bluegills in better condition	0	0	1	1
Forage base decreased	1	0	0	1
Fishes other than tiger muskellunge				
No effect on other fishes	9	2	7	18

Table 10. Summary of physical and chemical data collected at Osterhout Lake, Allegan County, summer 1979.

Depth in feet	July		August				Mean
	20	30	3	13	24	29	
Temperature (F)							
0.0	75	77	75	73	73	72	75
6.6	75	77	75	73	73	72	75
13.1	73	75	75	73	70	70	73
19.7	68	68	70	72	68	68	68
26.2	63	61	--	64	--	--	63
B[a]	61	61	66	61	66	64	63
Oxygen (ppm)							
0.0	7.2	8.6	7.8	7.6	8.8	8.6	8.1
6.6	7.2	8.6	7.8	7.6	8.8	8.6	8.1
13.1	7.6	3.8	6.6	7.6	6.0	5.5	6.2
16.4	4.0	0.0	0.1	6.2	5.0	2.4	3.0
19.7	1.0	0.0	<0.1	6.2	4.6	1.7	2.2
26.2	0.8	0.0	--	0.0	--	--	0.1
B[a]	0.6	0.0	0.0	0.0	<0.1	<0.1	0.1
Surface MO alkalinity (ppm)							
	82	75	74	75	80	79	78
Secchi disk (feet)							
	9.2	7.9	8.9	7.5	8.9	7.9	8.5

[a] Bottom depth at the collection sites varied from 23.0 to 27.9 feet.

Table 11. Summary of physical and chemical data collected at Round Lake, Van Buren County, summer 1979.

Depth in feet	July		August				Mean
	23	31	6	14	24	29	
Temperature (F)							
0.0	79	77	77	72	72	72	75
6.6	79	77	77	73	72	72	75
13.1	77	77	75	72	72	72	73
19.7	72	72	72	72	70	72	72
B[a]	64	64	64	70	68	68	66
Oxygen (ppm)							
0.0	9.2	8.0	7.4	7.5	8.4	8.0	8.1
6.6	9.2	8.0	7.4	7.4	8.4	8.0	8.1
13.1	7.0	7.2	7.3	7.4	8.2	6.6	7.3
16.4	2.2	1.1	2.8	7.3	8.0	6.6	4.7
19.7	0.4	0.2	0.5	7.2	4.4	6.6	3.2
B[a]	0.3	<0.1	0.1	0.8	<0.1	0.5	0.3
Surface MO alkalinity (ppm)							
	42	35	38	32	34	34	36
Secchi disk (feet)							
	9.8	8.9	8.5	7.5	7.9	9.8	8.9

[a] Bottom depth at the collection sites varied from 23.6 to 24.6 feet.

Table 12. Relation between bottom depths and distribution of vegetation cover for Osterhout and Round lakes, 1979.

Bottom depth (feet)	Percent of total bottom area		Percent of bottom with vegetation		Percent of total vegetative area	
	Osterhout Lake	Round Lake	Osterhout Lake	Round Lake	Osterhout Lake	Round Lake
0-5	59.5	34.2	73.2	73.3	60.4	44.0
5-10	31.3	43.7	86.9	70.3	37.7	53.9
10-15	4.8	11.2	28.6	10.5	1.9	2.1
15+	4.4	10.9	0.0	0.0	0.0	0.0

Table 13. Estimated density of total vegetative cover in Osterhout and Round lakes, 1979.

Vegetation density[a]	Percent of total bottom area		Percent of total vegetative area	
	Osterhout Lake	Round Lake	Osterhout Lake	Round Lake
Very dense	38.8	6.5	53.8	11.4
Dense	4.8	9.1	6.6	16.1
Moderate	8.5	25.7	11.8	45.1
Sparse	20.1	15.6	27.8	27.5
Barren	27.9	43.1	0.0	0.0

[a] Very dense = bottom completely covered with plants.
Dense = 75-99% of bottom covered.
Moderate = 26-74% of bottom covered.
Sparse = 1-25% of bottom covered.
Barren = 0% of bottom covered.

Table 14. Density and distribution of aquatic plant species in Osterhout and Round lakes in summer 1979.

Species, and depth (feet)	Density[a]		Percent of area covered[b]		Percent of total vegetation in area	
	Osterhout Lake	Round Lake	Osterhout Lake	Round Lake	Osterhout Lake	Round Lake
Chara sp.						
0-5	M to D	M to D	22.3	12.1	30.5	16.5
5-10	S	M to D	5.6	13.5	6.5	19.2
10-15	---	---	---	---	---	---
Nitella sp.						
0-5	M to D	D	24.6	49.5	33.6	67.5
5-10	M	D	23.9	50.7	27.5	72.1
10-15	S	M	1.5	10.5	5.3	100.0
Potamogeton amplifolius						
0-5	S	---	2.3	---	3.1	---
5-10	S	---	4.4	---	5.0	---
10-15	S	---	4.2	---	14.7	---
P. crispus						
0-5	---	S	---	2.1	---	2.8
5-10	---	S	---	5.4	---	7.7
10-15	---	---	---	---	---	---
P. longiligulatus						
0-5	M to D	---	16.1	---	22.0	---
5-10	D	---	43.9	---	50.5	---
10-15	S	---	13.0	---	45.3	---
P. nodosus						
0-5	S	S	1.1	3.5	1.5	4.7
5-10	---	S	---	<0.1	---	<0.1
10-15	---	---	---	---	---	---
Vallisneria americana						
0-5	S	S	3.4	3.5	4.7	4.7
5-10	S to M	S	6.5	<0.1	7.5	<0.1
10-15	S	---	8.4	---	29.5	---

Species, and depth (feet)	Density[a]		Percent of area covered[b]		Percent of total vegetation in area	
	Osterhout Lake	Round Lake	Osterhout Lake	Round Lake	Osterhout Lake	Round Lake
Myriophyllum sp.						
0-5	S	---	<0.1	---	<0.1	---
5-10	S	---	2.6	---	3.0	---
10-15	S	---	1.5	---	5.3	---
Floating and emergent species including *Sagittaria* sp., *Eleocharis* sp., *Nuphar* sp., and *Nymphaea* sp.						
0-5	S to M	S	2.9	2.8	3.9	3.7
5-10	---	---	---	---	---	---
10-15	---	---	---	---	---	---

[a] Density is the relative abundance of the species only in locations where it grows, not within an area. S = sparse, M = moderate, and D = dense.

[b] Percent of area covered is a measure of distribution within an area.

Table 15. List of fishes (mostly age 0) stocked in Round Lake 1972-77.

Date	Species	Number stocked		Mean length (inches)	Culture method
		Total	per acre		
6/2/72	Tiger muskellunge	120,000		fry	---
6/27/72	Largemouth bass	383		6.6	---
8/25/72	Largemouth bass	19,500		3.8	---
9/21/72	Redear x green sunfish hybrid	97,000		0.8	---
7/9/73	Tiger muskellunge	777	4.2	8.8	minnows
7/31/73	Largemouth bass	20,000		---	---
9/19/73	Redear x green sunfish hybrid	20,124		---	---
9/3/74	Tiger muskellunge	282	1.5	11.2	minnows
7/31/75	Tiger muskellunge	442	2.4	8.0	minnows
8/25/75	Tiger muskellunge	300	1.6	5.4	pellets
7/12/76	Tiger muskellunge	800	4.3	6.1	pellets
7/21/77	Tiger muskellunge	800	4.3	7.3	pellets

Table 16. Tiger muskellunge fingerlings stocked in Osterhout Lake, 1972-77.

Date	Number stocked		Mean length (inches)	Culture method
	Total	per acre		
7/14/72	690	4.1	5.6	minnows
7/15/74	500	3.0	8.0	minnows
8/25/76	700	4.2	7.6	pellets
7/21/77	700	4.2	7.3	pellets

Table 17. Tiger muskellunge fingerlings stocked in Dumont Lake, 1971-78.

Date	Number stocked		Mean length (inches)	Culture method
	Total	per acre		
4/22/71	44	0.2	15.0[a]	minnows
10/8/71	48	0.2	14.0	minnows
8/11/72	900	4.2	9.1	minnows
5/15/75	700	3.2	8.0	minnows
5/14/76	900	4.2	6.3	pellets
5/21/77	900	4.2	7.3	pellets
8/23/78	900	4.2	6.4	pellets

[a]Age I.

Table 18. Tiger muskellunge stocked in Long Lake, 1974-80.

Date	Number stocked		Mean length (inches)	Culture method
	Total	per acre		
5/30/74	5,960	28.2	fry	---
8/28/75	952	4.5	7.1	pellets
5/21/77	2,000	9.5	7.3	pellets
8/23/78	2,000	9.5	6.4	pellets
8/13/80	2,000	9.5	6.7	pellets

Table 19. Estimated number of fish caught by species, angler hours, and angler trips at Round Lake, May 15 - November 5, 1977. Two standard errors in parentheses.

Species	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
Tiger muskellunge	30	83	1	0	0	0	0	114 (96)
Largemouth bass	5	133	28	98	132	3	0	399 (116)
Bluegill	374	1,057	1,090	331	123	110	0	3,085 (1,496)
Black crappie	0	0	7	5	0	1	0	13 (2)
Redear x green sunfish hybrid	2	32	1	14	8	9	0	66 (45)
Angler hours	476	1,639	1,176	717	608	86	1	4,703 (900)
Angler trips	141	487	155	322	158	23	1	1,287 (288)

Table 20. Estimated number of fish caught by species, angler hours, and angler trips at Round Lake, May 15 - August 25, 1978. Two standard errors in parentheses.

Species	Month				Total
	May	Jun	Jul	Aug	
Tiger muskellunge	34	92	18	6	150 (148)
Largemouth bass	179	251	106	23	559 (333)
Bluegill	2,308	2,291	2,026	3,386	10,011 (3,101)
Hybrid sunfish	172	0	134	0	306 (416)
Angler hours	3,930	4,585	3,878	2,066	14,459 (1,292)
Angler trips	1,371	1,301	1,175	599	4,446 (449)

Table 21. Estimated number of fish caught by species, angler hours, and angler trips at Round Lake, May 15 - September 3, 1979. Two standard errors in parentheses.

Species	Month					Total
	May	Jun	Jul	Aug	Sep	
Tiger muskellunge	3	29	144	83	0	259 (269)
Largemouth bass	6	57	48	0	0	111 (80)
Bluegill	2,888	8,640	8,067	6,059	334	25,988 (5,078)
Hybrid sunfish	145	79	19	0	0	243 (252)
Yellow perch	0	3	12	27	0	42 (48)
Angler hours	3,015	4,699	4,298	3,200	381	15,593 (1,235)
Angler trips	794	1,735	1,416	1,311	131	5,388 (514)

Table 22. Estimated number of fish caught by species, angler hours, and angler trips at Round Lake, May 15 - August 31, 1980. Two standard errors are in parentheses.

Species	Month				Total
	May	Jun	Jul	Aug	
Tiger muskellunge	13	0	0	10	23 (28)
Largemouth bass	0	47	63	67	177 (112)
Bluegill	4,474	12,189	5,409	4,290	26,362 (5,474)
Yellow perch	28	414	322	138	902 (403)
Angler hours	1,823	6,491	3,510	1,646	13,470 (1,289)
Angler trips	523	2,047	1,409	623	4,622 (480)

Table 23. Estimated number of fish caught by species, angler hours, and angler trips at Osterhout Lake, June 20 - August 26, 1978. Two standard errors in parentheses.

Species	Month			
	Jun	Jul	Aug	Total
Tiger muskellunge	113	23	0	136 (181)
Northern pike	0	0	12	12 (25)
Largemouth bass	85	114	114	313 (209)
Bluegill	106	1,090	1,449	2,645 (1,355)
Sunfish	86	46	226	358 (286)
Black crappie	0	21	0	21 (25)
Yellow perch	0	141	34	175 (157)
Angler hours	2,018	2,566	1,263	5,847 (1,353)
Angler trips	701	635	392	1,728 (400)

Table 24. Estimated number of fish caught by species, angler hours, and angler trips at Osterhout Lake, May 15 - August 23, 1979. Two standard errors in parentheses.

Species	Month				Total
	May	Jun	Jul	Aug	
Tiger muskellunge	30	8	0	0	38 (42)
Northern pike	14	0	0	0	14 (17)
Largemouth bass	11	14	31	16	72 (74)
Bluegill	486	1,816	815	176	3,293 (1,811)
Sunfish	335	1,357	17	66	1,775 (1,508)
Black crappie	0	47	260	4	311 (261)
Rock bass	0	10	22	0	32 (35)
Yellow perch	64	99	37	0	200 (143)
Bullhead	0	6	0	0	6 (13)
Angler hours	2,292	2,285	1,882	752	7,211 (962)
Angler trips	887	850	722	388	2,846 (454)

Table 25. Mean length and population estimates of tiger muskellunge in Round Lake, based on all 1977 data and on combined data for fall 1977 plus spring 1978.

Age and year class	Mean length in inches (number of fish)	Estimated number (95% confidence limits)		Percent survival[a]
		Fall 1977	Fall 1977 plus spring 1978	
0 (1977)	11.5 (28)	119 (65-665)	106 (60-467)	13.2
I (1976)	21.8 (36)	91 (40-00)	82 (56-147)	10.2
II (1975)	28.8 (72)	253 (152-768)	186 (142-271)	25.1
III (1974)	33.6 (9)	15 (7-00)	15 (8-115)	5.3
IV (1973)	37.0 (2)	--- ---	--- ---	---
V (1972)	29.6 (1)[b]	--- ---	--- ---	---

[a]Based on combined data from fall 1977, plus spring 1978.

[b]Deformed.

Table 26. Summary of catch and growth data for largemouth bass, bluegills, redear x green sunfish hybrids, and golden shiners taken with 42 trap net lifts at Round Lake, fall 1977.

Catch	Largemouth bass	Bluegill	Redear x green sunfish	Golden shiner
Total number	697	11,280	165	60
Number per lift	17	269	4	2
Percent catchable[a]	5	24	57	--
Size frequency (percent), by inches				
3.0-4.9	tr	22	13	0
5.0-6.9	24	78	77	50
7.0-8.9	61	tr	10	50
9.0-10.9	9	0	0	0
11.0-12.9	3	0	0	0
13.0 and larger	3	0	0	0
Growth in inches (state average in parentheses)[b]				
Age 0				
Mean length	4.7 (4.2)	1.4 (2.4)	--	--
Range	4.4-5.1	1.0-1.7	--	--
Sample size	4	34	--	--
Age I				
Mean length	6.9 (7.1)	2.6 (3.8)	--	--
Range	5.9-7.7	1.8-3.2	--	--
Sample size	43	21	--	--
Age II				
Mean length	8.0 (9.4)	3.8 (5.0)	5.0 (--)	--
Range	6.8-9.3	3.5-4.2	4.3-5.7	--
Sample size	36	19	11	--

Catch	Largemouth bass	Bluegill	Redear x green sunfish	Golden shiner
Growth in inches (state average in parentheses)[b]				
Age III				
Mean length	8.7 (11.6)	5.2 (5.9)	6.5 (--)	--
Range	7.9-9.6	3.9-6.7	4.4-7.4	--
Sample size	22	63	38	--
Age IV				
Mean length	11.6 (13.2)	6.0 (6.7)	6.1 (--)	--
Range	8.7-15.7	4.8-7.6	4.4-7.8	--
Sample size	22	54	30	--
Age V[c]				
Mean length	14.6 (14.7)	--	7.3 (--)	--
Range	10.4-19.0	--	--	--
Sample size	24	--	1	--

[a] Percent catchables are defined as largemouth bass greater than 12.0 inches, and bluegills and hybrid sunfish greater than 6.0 inches.

[b] State averages from Merna et al. (1981).
tr = less than 0.5%.

[c] One age-VI largemouth bass, 20.0 inches long was also taken.

Table 27. Population estimates of largemouth bass, tiger muskellunge, and total predatory fishes in Round Lake, spring 1982.

Inch group	Largemouth bass	Tiger muskellunge	Total	
			Number	per acre
8.0-8.9	285	0	285	1.52
9.0-9.9	235	0	235	1.26
10.0-10.9	864	0	864	4.62
11.0-11.9	1,138	4	1,142	6.11
12.0-12.9	409	8	417	2.23
13.0-13.9	93	0	93	0.50
14.0-14.9	39	12	51	0.27
15.0-15.9	0	35	35	0.19
16.0-16.9	0	77	77	0.41
17.0-17.9	0	62	62	0.33
18.0-18.9	0	15	15	0.08
19.0-19.9	0	42	42	0.22
20.0-20.9	4	27	31	0.17
21.0-21.9	0	23	23	0.12
22.0-22.9	0	23	23	0.12
23.0-23.9	0	23	23	0.12
24.0-24.9	0	12	12	0.06
25.0-29.9	0	8	8	0.04
30+	0	23	23	0.12
Total	3,067	394	3,461	18.51

Table 28. Relative survival and growth (mean length in inches) of early and normal plants of pellet-reared tiger muskellunge fingerlings based on fall electrofishing samples.

Lake, plant, and date stocked	Stocked		Sample in fall, age 0	
	Number	Length	Number[a]	Length
Round Lake				
Early, 7/18/78	400	3.4	1[b]	10.2
Normal, 8/17/78	400	6.6	30[c]	9.6
Early, 5/31/79	400	3.5	0	--
Normal, 7/26/79	400	6.2	3	10.7
Osterhout Lake				
Early, 7/18/78	350	3.4	1	8.9
Normal, 8/17/78	350	6.6	1	8.1
Early, 5/31/79	350	3.5	0	--
Normal, 7/26/79	350	6.2	0	--
Dumont Lake				
Early, 5/31/79	450	3.5	0	--
Normal, 7/26/79	450	6.2	2	11.9

[a] Number of fish caught once (exclusive of recaptures).

[b] The total population was estimated to be three (1/30 x 82). Thus survival was 0.8% from the plant of 400.

[c] The total population was estimated to be 82 (95% confidence limits of 48-270) by the mark-and-recapture method. Thus survival was 20.5% (95% confidence limits of 12.0-67.5%) from the plant of 400.

Table 29. Relative survival and growth (mean length in inches) of minnow-reared and pellet-reared plants of tiger muskellunge fingerlings based on fall electrofishing samples (5-20 nights of effort).

Lake, diet, and date stocked	Stocked		Sample in fall, age 0		Ratio M:P
	Number	Length	Number[a]	Length	
Round Lake					
Minnow, 7/18/80	400	7.5	51	13.8	
Pellet, 8/14/80	400	6.6	9	10.5	5.7:1
Minnow, 7/7/81	400	7.6	14	15.0	
Pellet, 8/13/81	400	6.3	3	10.5	4.7:1[b]
Osterhout Lake					
Minnow, 7/18/80	350	7.5	4	13.0	
Pellet, 8/14/80	350	6.6	0	---	---
Dumont Lake					
Minnow, 7/18/80	348	7.5	21	14.4	
Pellet, 8/14/80	450	6.6	4	10.9	6.8:1[c]
Minnow, 7/7/81	450	7.6	55	13.7	
Pellet, 8/13/81	450	6.3	6	10.4	9.2:1
Long Lake					
Minnow, 7/17/81[d]	385	7.8	2	11.2	
Pellet, 8/13/81[d]	500	6.3	0	---	---
Minnow, 7/17/81[a]	385	7.8	0	---	
Pellet, 8/13/81[e]	465	6.3	0	---	---

[a] Number of fish caught once (exclusive of recaptures).

[b] A ratio of 15.7:1 was obtained for a spring 1982 sample of 47 minnow-reared muskies (averaging 16.4 inches) and 3 pellet-reared muskies (averaging 11.9 inches).

[c] Adjusted for the difference in stocking rate.

[d] Muskies were stocked at the access site.

[e] Muskies were spot-planted in weedy areas.

Table 30. Estimated survival by Schumacher-Eschmeyer method (S), or catch ratio (C), of minnow-reared (M), and pellet-reared (P) tiger muskies in Round Lake and Dumont Lake.

Lake	Year class	Population estimate (95% confidence limits)	Date and method	Percent survival	Survival ratio M:P
Round	1980 (M)	182 (121-368)	Fall 1980 (S)	45.5	5.7:1
	(P)	32	(C)	8.0	
	1981 (M)	182	Spring 1982 (C)	45.5	15.2:1
	(P)	12	(C)	3.0	
Dumont	1980 (M)	97 (44-00)	Fall 1980 (S)	27.9	7.0:1
	(P)	18	(C)	4.0	
	1981 (M)	111 (87-156)	Fall 1981 (S)	24.7	9.1:1
	(P)	12	(C)	2.7	

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