

# **ANNUAL PROGRESS REPORT**

## **EVALUATION OF GROWTH AND SURVIVAL OF DIFFERENT GENETIC STOCKS OF MUSKELLUNGE: IMPLICATIONS FOR STOCKING PROGRAMS IN ILLINOIS AND THE MIDWEST**

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**EXECUTIVE SUMMARY:** Muskellunge are an important sportsfish that are commonly stocked throughout Illinois and much of the Midwestern United States. In Illinois, as in many other states, the demand for these fishes far exceeds the supply. Stocking has become the primary management tool for establishing and maintaining muskellunge populations. The high costs associated with producing these fishes create the need for efficient management practices. Previous research efforts have determined the size of fish and timing of stocking to maximize growth and survival. However, additional information on muskellunge stocking strategies is needed. Specifically, more biological data on different genetic stocks of muskellunge is needed to determine the best population to stock in a particular body of water to maximize growth and survival.

Morphological and geographic characteristics have suggested multiple distinct groups of muskellunge. More recently, genetic analysis identified several different genetic stocks of muskellunge (Ohio River Drainage, Upper Mississippi River Drainage, and the Great Lakes Drainage Stocks), each with multiple populations. Previous work with young-of-year from these populations found differences in growth and food consumption as a function of temperature. As a trophy species, anglers and managers are interested in using populations of fish that grow the fastest, live longest, and obtain a largest maximum size. Because muskellunge populations are either not naturally found or have been eliminated in many Illinois lakes and reservoirs, it is not clear which population to use in stocking efforts. The muskellunge population currently used as brood stock for the stocking program in Illinois is of an unknown origin and may be made up of several different populations. Muskellunge stocks from various populations may perform differently in Illinois waters in terms of growth and survival. Additional information is needed on differences in growth and survival among stocks in waters at varying latitudes in Illinois before management recommendations can be made on which stock is most appropriate. Determining which stock has the highest levels of growth and survival under the various conditions found in Illinois waters will increase stocking success and angler satisfaction. This study examines differences in growth and survival among different stocks of muskellunge in order to make recommendations regarding stocking in Illinois.

In this study, two jobs related to muskellunge stock evaluation are being conducted. Those jobs are (1) evaluation of growth and (2) evaluation of survival among stocks of muskellunge. In this first year of a long-term effort, we compare growth and survival of muskellunge from the Ohio River Drainage Stock (Kentucky's Cave Run Lake population) and Illinois' current population in Lake Mingo, Vermillion County, Illinois. Muskellunge fingerlings from the two populations were stocked into Lake Mingo at rates between 2.4 – 5.6 fish per hectare. Initial mortality, 0% for both populations, was assessed using three 3-m deep predator-free cages for 48-h. The Kentucky Cave Run Lake population had a two-fold faster relative growth rate than did the Illinois population. Catch-per-unit-effort suggests that the Cave Run Lake population of muskellunge also had better survival than the Illinois fish.

In pond experiments at the Sam Parr Biological Station, Kinmundy, we used three 0.4-ha ponds to evaluate growth and survival differences among muskellunge from the Ohio River Drainage Stock (Kentucky's Cave Run Lake population), Upper Mississippi River Drainage Stock (Minnesota's Leech Lake population), and the Illinois population. At draining in the spring, no Leech Lake muskellunge were recovered from any of the ponds. Both the Kentucky and Illinois muskellunge showed similar daily growth rates, but when they were standardized by starting weight (relative growth rate), the Kentucky muskellunge showed a three-fold faster growth rate compared to the Illinois muskellunge. Survival was variable among the populations.

The Leech Lake muskellunge had 0% survival by the April 2003 draining. The survival of the Illinois population was higher than the survival of the Cave Run Lake population.

Similar and additional populations will be evaluated for growth and survival differences in future years of the study. The results obtained from this year's and future stockings will be used to identify long-term growth and survival differences among genetic stocks of muskellunge and to develop guidelines for future stockings that maximize survival, growth, and angler satisfaction in impoundments throughout Illinois.

**Job 101.1.** Evaluating growth of different stocks of muskellunge.

**OBJECTIVE:** To determine differences in growth among various stocks and populations of muskellunge in Illinois waters.

**INTRODUCTION:** Differences in growth among genetically distinct muskellunge stocks and populations may be important in determining the most appropriate populations for use in management applications. Different stocks of muskellunge have evolved under different ecological conditions, and as a result, have likely acquired different performance characteristics. Koppleman and Philipp (1986) found that 9 populations of muskellunge were genetically grouped into stocks and could be related to major river drainages, suggesting the existence of separate stocks associated with major river drainages. It is likely that as muskellunge were isolated into major river drainages, they experienced different thermal histories. As these separate groups progressed through evolutionary time, natural selection acted on the groups, resulting in groups of fish that are genetically dissimilar, and likely physiologically and behaviorally different from one another (Altukhov 1981, MacLean and Evans 1981, Begg et al. 1999a, Begg and Waldman 1999). These physiological differences could affect growth rates at various temperatures and will affect the appropriateness of a population for developing various Illinois fisheries.

Numerous studies have used physiological and behavioral traits for both discriminating among stocks and for demonstrating adaptation of stocks to different environments. Swimbladder gas retention was shown to be significantly different among two populations of lake trout *Salvelinus namaycush* (Ihssen and Tait 1981) and MacLean et al. (1981) demonstrated that significant differences in survival existed between populations of lake trout. Growth, an ecologically and economically important characteristic of cultured recreational fishes, can be influenced by both the environment and genetics. Luey and Adelman (1984) found significant differences in growth among groups of rainbow smelt *Osmerus mordax* sampled from three zones in Lake Michigan. These findings were consistent with previous genetic evidence suggesting three distinct stocks of rainbow smelt. Similar relationships could exist for different stocks of muskellunge.

Previous work has compared food consumption, metabolism, and growth among populations of muskellunge (Clapp and Wahl 1996). These laboratory studies evaluated six populations of young-of-year (YOY) muskellunge (Kentucky's Cave Run Lake, Minnesota's Leech Lake, New York's Lake Chautauqua, Ohio's Clear Fork Lake, St. Lawrence River, and Wisconsin's Minocqua Chain) at varying temperatures (5 – 27.5°C). The populations investigated represented muskellunge from each of the three identified muskellunge stocks, the Ohio River Drainage Stock, the Upper Mississippi River Drainage Stock, and the Great Lakes Drainage Stock (Table 1). Differences in growth and food consumption of YOY among populations were observed at higher temperatures (15 – 27.5°C). However, no significant differences in metabolism were observed at any temperature. Although results of these laboratory experiments showed bioenergetic differences among populations of muskellunge, they could not be explained solely in terms of thermal adaptation or established genetic groupings.

In this study, we investigate population differentiation beyond the YOY stage to adult muskellunge in the field. Long-term growth of muskellunge will be evaluated in pond and lake experiments. Identifying growth differences among muskellunge populations at these scales is important in defining these populations and in determining the most appropriate populations for

specific management applications. Populations may vary in long-term growth, age-at-maturity, and maximum size. In this job, we began assessing variation in growth among different YOY muskellunge populations.

**PROCEDURES:** In the first year of the study, we began by comparing growth between two different stocks and populations of muskellunge in Lake Mingo, Vermillion County, Illinois. Choice of stocks was dependent on availability of fish from each of the populations. Future segments of the project will include additional stocks and populations. The Ohio River Drainage Stock (Kentucky's Cave Run Lake population) was obtained from the Minor E. Clark Fish Hatchery, Kentucky Department of Fish and Wildlife and the current Illinois population was obtained from the Jake Wolf Memorial Fish Hatchery, Illinois Department of Natural Resources. Attempts were made to stock as similar of sizes and condition of fish as possible. Subsamples of each stock were held in three 3-m deep predator-free cages (N=15/cage) for 48 hrs to monitor mortality associated with transport and stocking stress. Muskellunge from each population were stocked at rates between 2.4 – 5.6 fish per hectare. A subsample (N = 30 Ohio River Drainage Stock; N = 50 Illinois Stock) of each population was measured in length (nearest mm) and weighed (nearest g) prior to each stocking (Table 2). Each fish was given an identifying complete fin clip and freeze cauterization of the wound for later identification of the stock. To determine growth rates, nighttime pulse DC boat-electrofishing samples were performed from late March through early May 2003. Length and weight measurements were taken on all sampled muskellunge. Daily temperatures were recorded using a thermograph placed at 1-m depth to assess its role in influencing growth rates of different stocks and populations. These data were used to determine relative growth rates between the two stocks of muskellunge in Lake Mingo.

In addition to the evaluation of growth between muskellunge stocks in Lake Mingo, we also conducted a pond experiment to evaluate growth among stocks in a more controlled environment. Advantages of this approach include greater precision via increased sample sizes, individual fish growth measurements, and replication by means of using several ponds. Three 0.4-ha experimental ponds at the Sam Parr Biological Station were used for this experiment. Three stocks, the Ohio River Drainage Stock (Kentucky's Cave Run Lake population), the Upper Mississippi River Drainage Stock (Minnesota's Leech Lake population), and the Illinois population (obtained from the Jake Wolf Memorial Fish Hatchery, IDNR) were stocked into the experimental ponds between October 24 and November 20, 2002. Thirty-three individuals of both the Illinois and the Leech Lake populations, and sixteen of the Cave Run Lake population, were stocked into each of the three ponds (total N = 82 fish/pond). Immediately prior to stocking, each fish was anesthetized and implanted with a passive integrated transponder (PIT) tag in a similar manner as described by Harvey and Campbell (1989). Following the tagging, each fish was measured in length (nearest mm) and weighed (nearest g) and allowed to recover prior to being stocked into one of the ponds (Table 3). Hourly temperature readings were recorded using a thermograph placed at 1-m depth.

Experimental ponds were drained in early April 2003. Muskellunge were collected and identified by the PIT tag. All fish were measured in length (nearest mm) and weight (nearest g) and placed back into one of three 1-acre (0.4 ha) experimental ponds for future evaluations. These data were used to determine relative growth rates among the three genetic stocks of muskellunge in experimental ponds. Results of these lake and pond evaluations will provide insight as to the fastest growing population in Illinois.

**FINDINGS:** Two populations, Cave Run Lake and Illinois (Table 1), were stocked into Lake Mingo during the fall of 2002 (Table 2). Unequal numbers were stocked (Cave Run Lake N = 171, Illinois N = 400) due to limited availability of Kentucky muskellunge. Mean lengths of the two populations were similar, but mean weights were higher for the Illinois population than the Cave Run Lake population (Table 2). Three 3-m deep predator-free mortality cages were monitored for 48 hrs post-stocking to evaluate stocking mortality of each population. Both populations showed 0% mortality after the 48-hr monitoring period. The spring 2003 nighttime electrofishing sampling showed that both populations grew over the 6-mo period, however, the Kentucky Cave Run Lake population had a two-fold faster relative growth rate than did the Illinois population (Table 4).

Three populations, Cave Run Lake, Leech Lake, and Illinois were stocked in equal numbers into three 0.4-ha experimental ponds at the Sam Parr Biological Station (Table 1). Fewer Cave Run Lake muskellunge were stocked compared to the other two populations due to limited availability of Kentucky muskellunge. The initial mean lengths and weights were highest for Illinois fish, followed by Cave Run Lake fish and Leech Lake fish (Table 3). Ponds were visually monitored for 48-hrs post-stocking to assess mortality due to PIT tagging and handling. No short-term mortality was noted. At draining in April 2003, no Leech Lake muskellunge were recovered from any of the ponds. Illinois fish were still longer and heavier than Cave Run fish, but differences had declined (Table 4). Growth, mean daily growth (g/d) and mean relative daily growth rate (g/g/d), of the three populations varied substantially (Table 5). Both the Kentucky and Illinois muskellunge showed similar daily growth rates, but when they were standardized by starting weight (relative growth rate), the Kentucky muskellunge showed a three-fold faster growth rate compared to the Illinois muskellunge (Table 5).

**RECOMMENDATIONS:** Any long-term differences among muskellunge populations we observe in pond and impoundment experiments will have important implications for conservation of native muskellunge populations, as well as for introduction of muskellunge into waters where they do not naturally occur. When muskellunge are introduced in areas where they have not previously occurred, such as Illinois impoundments, knowledge of population differentiation will be useful in planning stocking programs. Growth differences we observed among YOY muskellunge during the first year of this study can influence initial survival; both by loss to predation (Wahl and Stein 1989) and loss due to over-winter mortality (Bevelhimer et al. 1985, Carline et al. 1986). We have found initial growth differences among populations of muskellunge that will need to continue to be monitored as fish grown into adults.

It is likely that the Cave Run Lake population is more closely adapted to the thermal conditions of the experimental ponds than are the unknown-origin Illinois population or the Leech Lake population. Initial impoundment results suggest the Kentucky muskellunge to have a two-fold growth advantage over the Illinois muskellunge, while the pond experiment showed the Kentucky muskellunge to have a three-fold growth advantage over the Illinois muskellunge.

Further annual monitoring of the Lake Mingo stocking will be conducted, in addition to additional introductions of the various stocks in Lake Mingo for the purpose of growth evaluation. In subsequent segments, a second lake will be added to the study to further investigate both the population differentiation in growth and to further explore the effects of varying latitudes on muskellunge growth differences. The three 0.4-ha experimental ponds will be drained in early October 2003 to evaluate growth of the muskellunge stocks in the experiment. In late October 2003, a second trial of the pond experiment will be initiated with the



same and additional populations. The results obtained from this year and future years will be used to identify differences among genetic stocks of muskellunge and to develop guidelines for future stockings that maximize growth in impoundments throughout Illinois.

**Job 101.2.** Evaluating survival of different stocks of muskellunge.

**OBJECTIVE:** To determine differences in survival among various stocks and populations of muskellunge in Illinois waters.

**INTRODUCTION:** In addition to growth, survival differences among genetically distinct muskellunge stocks and populations may be important in determining the most appropriate populations for use in management applications. Survival and other population characteristics are the consequence of life history modes to which stocks have evolved (Begg et al. 1999b). Physiological differences among stocks could affect survival rates at various temperatures and will affect the value of a population for stocking in various waters throughout Illinois.

Numerous studies have investigated differences in survival among stocks, however most of this work has been done with salmonids. Significant differences in survival were found between hatchery reared and wild steelhead trout *Salmo gairdneri* in stream and pond evaluations; however outcomes varied between systems (Reisenbichler and McIntyre 1977). Genetic origin has been shown to influence survival among stockings of lake trout *Salvelinus namaycush* in two lakes in Ontario (MacLean et al. 1981). In comparisons of survival of northern largemouth bass *Micropterus salmoides salmoides*, Florida largemouth bass *Micropterus salmoides floridanus*, and their F1 hybrids in central Illinois, the native northern largemouth bass was shown to have the highest survival rates (Philipp and Whitt 1991). Further work suggested significant survival differences between stocks of northern largemouth bass from two different river drainages within Illinois when both were stocked in northern and southern Illinois (Philipp and Claussen 1995). These studies suggest that geographic origin (stock) can have a substantial influence on survival in a given region.

Limited work has been done evaluating survival differences among muskellunge stocks and populations. In Minnesota, performance of four native muskellunge populations of the Mississippi River Drainage Stock showed similar survival, with the exception of the lower survival of the Shoepack population (Younk and Strand 1992). Performance differences were also evaluated among 5 local populations in Wisconsin and compared to the performance of the Leech Lake, Minnesota population (Margenau and Hanson 1996, Margenau and Hanson 1997). Short-term (<60 d) survival was higher for the Mud/Callahan Lake population compared to the other four Wisconsin populations (Margenau and Hanson 1996). The remaining four populations all expressed similar short-term survival. Results showed that the Leech Lake population could be introduced into Wisconsin lakes and survive, however, there was no distinct advantage over the Wisconsin lake muskellunge populations (Margenau and Hanson 1997). All of these studies examined survival among populations of muskellunge from one stock, the Upper Mississippi River Drainage Stock. There exists a need to evaluate the survival differences among the three genetic stocks of muskellunge, the Ohio River Drainage Stock, the Upper Mississippi River Drainage Stock, and the Great Lakes Drainage Stock (Table 1). Many muskellunge fisheries, including those in Illinois, are sustained by stockings of muskellunge into waters where the species has been extirpated or for new introductions. In these scenarios, it would be beneficial to know which stock and populations have the highest survival in the thermal regime of the region to be stocked.

In this study, we will investigate population and stock differentiation in terms of survival for muskellunge in the field. Long-term survival of muskellunge will be evaluated in pond and lake experiments. Identifying survival differences among muskellunge populations at these

scales is important in defining these populations and in determining the most appropriate populations for specific management applications. In this job, we began assessing variation in survival among different YOY muskellunge populations.

**PROCEDURES:** In the first year of the study, we began by comparing survival between two different stocks and populations of muskellunge in Lake Mingo, Vermillion County, Illinois. As described in Job 101.1, we stocked similar numbers and sizes of the Ohio River Drainage Stock (Kentucky's Cave Run Lake population) and the current Illinois population. Muskellunge were stocked at a large fingerling size (Table 2) to increase initial survival across all populations as determined in previous studies (Carline et al. 1986, Szendrey and Wahl 1996, McKeown et al. 1999). Stocked fish were also reared under as similar conditions and feeding regimes as possible so as to eliminate any indirect biases on survival or vulnerability to predation (Szendrey and Wahl 1995). Subsamples of each stock were held in three 3-m deep predator-free cages (N=15/cage) for 48 hrs to monitor mortality associated with transport and stocking stress. Muskellunge from each population were stocked at rates between 2.4 – 5.6 fish per hectare (Table 2). Each fish was given an identifying complete pelvic fin clip and freeze cauterization of the wound for later identification of the stock. Previous work has suggested that removal of any single paired fin is equally detrimental to short-term survival (3 mo) and the loss of a pelvic fin is less detrimental than loss of a pectoral fin over the long term (McNeil and Crossman 1979). To determine survival, nighttime pulse DC boat-electrofishing samples were performed from late March through early May 2003. Electrofishing catch-per-unit-effort (CPUE) was used to assess survival differences between the stocks.

In addition to the evaluation of survival differences between muskellunge stocks in Lake Mingo, we also conducted a pond experiment to evaluate survival among stocks in a more controlled environment. Advantages of this approach include the ability of obtaining a direct measurement of survival via pond draining. Three 0.4-ha experimental ponds at the Sam Parr Biological Station were used for this experiment. As described in Job 101.1, three stocks, the Ohio River Drainage Stock (Kentucky's Cave Run Lake population), the Upper Mississippi River Drainage Stock (Minnesota's Leech Lake population), and the Illinois population (obtained from the Jake Wolf Memorial Fish Hatchery, IDNR) were stocked into the experimental ponds between October 24 and November 20, 2002 (Table 7). Immediately prior to stocking, each fish was anesthetized and implanted with a passive integrated transponder (PIT) tag in a similar manner as described by Harvey and Campbell (1989). Hourly temperature readings were recorded using a thermograph placed at 1-m depth.

Experimental ponds were drained in early April 2003. Muskellunge were collected and population identified by the PIT tag. All surviving fish were placed back into one of three 1-acre (0.4 ha) experimental ponds for future evaluations. These data were used to determine survival among the three genetic stocks of muskellunge in experimental ponds. Results of these lake and pond evaluations will provide insight as to the best surviving population in Illinois.

**FINDINGS:** Two populations, Cave Run Lake and Illinois (Table 1), were stocked into Lake Mingo during the fall of 2002 (Table 2). Three 3-m deep predator-free mortality cages were monitored for 48 hrs post-stocking to evaluate stocking mortality of each population. Both populations showed 0% mortality after the 48-hr monitoring period. Spring nighttime electrofishing was used to determine CPUE for each sampling event (Table 6). Due to the unequal numbers of stocked fish, Cave Run Lake population CPUE was multiplied by an

adjustment factor to compare against the Illinois population CPUE (Table 6). Adjusted CPUE was highest for both populations in early March and decreased through early May as water temperatures warmed and fish likely moved offshore (Figure 1). The Cave Run Lake, Kentucky population had a consistently higher adjusted CPUE as compared to the Illinois population (Figure 1). This suggests that the Cave Run Lake population muskellunge had better survival than the Illinois fish.

Three populations, Cave Run Lake, Leech Lake, and Illinois were stocked in equal numbers into three 0.4-ha experimental ponds at the Sam Parr Biological Station (Table 1). Fewer Cave Run Lake muskellunge were stocked compared to the other two populations due to limited availability of Kentucky muskellunge (Table 7). Ponds were visually monitored for 48-hrs post-stocking to assess mortality due to PIT tagging and handling. No short-term mortality was noted. At draining in April 2003, no Leech Lake muskellunge were recovered from any of the ponds. Survival was calculated as a percentage of the number of fish of each population surviving at the time of pond draining compared to the initial number. The survival of the Illinois population was substantially higher than the survival of the Cave Run Lake population (Table 7).

**RECOMMENDATIONS:** Any long-term differences in survival among muskellunge populations will have important implications for conservation and stocking of muskellunge. Survival differences we observed among YOY muskellunge during the first year of this study can influence the success and cost-effectiveness of a muskellunge stocking program (Margenau 1992). We have found initial survival differences among populations of muskellunge that will need to continue to be monitored as fish grow to adults. Initial impoundment results suggest the Kentucky muskellunge have a survival advantage over the Illinois muskellunge; however, the pond experiment showed the Illinois muskellunge to have a survival advantage over the Kentucky muskellunge. Leech Lake muskellunge, the population least likely to be adapted to the thermal regime of Illinois, had no survival in the pond experiment.

Further annual monitoring of the Lake Mingo stocking will be conducted, in addition to additional introductions of the various stocks for the purpose of evaluation of survival differences among stocks. In subsequent segments, a second lake will be added to further investigate both the population differentiation in survival and to further explore the effects of varying latitudes on muskellunge survival. The experimental ponds will be drained each fall and spring to evaluate the survival of the muskellunge stocks. In late October 2003, a second trial of the pond experiment will be initiated with additional populations. The results obtained from future years will be used to identify long-term differences in survival among genetic stocks of muskellunge.

**Job 101.3. Analysis and reporting.**

**OBJECTIVE:** To prepare annual and final reports summarizing information and develop guidelines for proper selection of muskellunge populations for stocking in Illinois impoundments.

**PROCEDURES and FINDINGS:** Data collected in Jobs 101.1 – 101.2 were analyzed to begin developing guidelines for muskellunge regarding appropriate populations for stocking throughout Illinois. In future segments, recommendations will be made that will allow hatchery and management biologists to make decisions that will maximize benefits for the muskellunge program in Illinois.

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