STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-81-R-8

Study No.: 230723 **Title:** Effects of exploitation and fisheries management on genetic diversity of fish stocks in inland and Great Lake waters of Michigan.

Period Covered: October 1, 2006 to September 30, 2007

Study Objectives: To use molecular markers and population genetics theory to investigate genetic stock relationships and status of indigenous fish species of importance in Michigan. We seek to estimate the degree of stock structure and the effects of past and proposed management on population and meta-population levels of genetic diversity.

Summary: Research is ongoing in each of several topical areas, all related to historical and contemporary factors affecting the genetic diversity of fisheries in Michigan waters. Studies involve numerous native species of economic importance that are intensively managed. This project seeks to provide information to better understand how recent management practices have impacted the genetic diversity of Michigan's fisheries. Review of available literature conclusively shows that historically, Michigan's fisheries were composed of taxonomically diverse fish assemblages. Most species were also genetically diverse, resulting from admixture events whereby fishes that were geographically isolated into glacial refugia mixed in the Great Lakes region, including Michigan, following the retreat of glacial ice. All available literature suggests that humans have left an indelible and mostly negative mark on the genetic architecture on Michigan's fishes. Management efforts have contributed to community and species declines in genetic diversity. Each job addresses issues of importance to fish species in Michigan.

Findings: Jobs 2–7 were scheduled for 2006-07, and progress is reported below.

Job 2. Title: Evaluation of Black Lake sturgeon.–

A. Mating system and effective population size.–We used microsatellite markers to determine parentage for a remnant population of lake sturgeon in the Laurentian Great Lakes basin. We observed that polygyny and polyandry were common with males and females mating with an average of 3.10 and 1.93 mates, respectively. Despite recent reductions in population size, we did not observe evidence of inbreeding. We also observed a considerable amount of variance in reproductive success among both males and females. On average, individuals whose offspring migrated downstream during a more constrained time period produced fewer offspring than those individuals whose offspring migrated downstream over a more protracted time period. While we did not observe a significant correlation between body size and reproductive success, we did observe a significant relationship between the number of mates an individual had and the number of offspring produced. Our results suggest that individuals increase their reproductive success by distributing their gametes among multiple mates and spawning during multiple or more protracted periods of time. Estimates of the effective number of breeders were 44% and 47% of the census number of breeders when Nb was estimated from parentage data and temporal changes in allele frequencies, respectively. Relatively low estimates of Nb reveal that estimates of the total number of spawning adults is not a good predictor of generational declines in levels of genetic diversity.

B. Contributions of lake sturgeon of hatchery origin to the adult Black Lake spawning population.–Over the period 2001 to 2007 estimates of the proportion of the adult male spawning population at Black Lake comprised of individuals of hatchery origin varied between 10.1 to 29.6% (Figure 1). Fish were identified to year classes that were released into Black Lake based on established length at age analyses conducted for the population. We have not observed females of hatchery origin spawning over the period of study. Using genetic determination of parentage, we estimate that 10.6% of the juveniles produced during 2001 were sired by hatchery males (30 of 283 genotyped juveniles). Analyses are ongoing for other year classes.

General trends toward increased representation of hatchery males in the spawning population and results from genetic analysis of juveniles in 2001 revealing contributions of hatchery adults to offspring recruited to the larval stage suggest that natural production may increasingly be influenced by gametes from hatchery fish. High reproductive success of male hatchery fish can be a problem when females of hatchery origin begin to spawn. Approximately two males and two females were used to produce cohorts in 1983, 1984, and 1987 (Michigan DNR, unpublished data). Accordingly, we anticipate that most hatchery individuals are related within year classes. Probabilities of matings by related hatchery fish will increase, potentially leading to higher incidence of inbred progeny. Given that inbreeding has been widely shown to be negatively related to fitness (i.e., lower survival and reproductive success) in other fish species, continued recruitment of hatchery fish into the adult spawning population is a concern. Empirical studies are recommended that document both trends in hatchery adult abundance, reproductive success, and fitness of progeny resulting from consanguous matings.

C. Projection of future effects of supplementation to the Black Lake population.–Few adults were used for brood fish during each of 3 years (1983, 1984, 1987). However, large numbers of offspring were released each year (>11,000 over 3 release years), greatly increasing the risk of inbreeding. Based on eight microsatellite markers, we estimate that levels of genetic diversity were similar among wild adult sturgeon and individuals that were likely produced by supportive breeding efforts. However, we observed a significant difference in allele frequencies between these two groups. Levels of relatedness were significantly greater in the group of individuals that were produced by supportive breeding efforts, greatly increasing the risk of inbreeding in this population.

We developed an individual based model that will project potential long-term effects of inbreeding in this remnant, isolated population. In absence of empirical data, we have parameterized the model using parameter estimates from the literature for other species. While supportive breeding efforts did increase population size, preliminary results from our model predicted that the level of inbreeding in this population will rapidly increase over a short period of time when the individuals produced by supportive breeding efforts mature. Analyses and reporting for this job will be completed over the coming year.

Job 3. Title: <u>Examine levels of walleye stock structure.</u>–Analyses of walleye genetics data from other researchers working with populations from Michigan have been analyzed and compared to data collected by Michigan State University and the Michigan DNR. Publication of the research conducted and reported during 2005 is ongoing. A publication for the Journal of Great Lakes Research is being prepared that details results of all data collected and reported on over the last several years.

Job 4. Title: <u>Determine hatchery impacts of steelhead and harvest rates.</u>–Analyses of data and preparation of publications of the research conducted are ongoing. Publications in the journals

Aquaculture and North American Journal of Fisheries Management are being prepared that details results of all data collected and reported on over the last several years.

Job 5. Title: Assess status of Lake Superior coaster brook trout.–A broodstock management plan was developed for the Lake Superior Basin Management Team of the Michigan Department of Natural Resources. A multi-stage plan was developed covering genetic issues related to (a) the number of fish to use for each year class, (b) the number of year classes to maintain, (c) the mating strategy for production and future broodstock year classes, (d) periodicity for replenishment of genetic diversity with infusion of gametes of wild fish, (e) assessment and monitoring protocols to follow generational changes in levels of genetic diversity in production and broodstock fish. Analyses of publication of the research on degree of stock structure and incidence of hatchery fish in natural stream-resident brook trout populations in rivers of southern Lake Superior are ongoing. Analyses of stream resident populations, including resident brook trout from the Salmon Trout River are necessary to assess genetic relationships between Salmon Trout River coasters and resident brook trout. A publication for the Journal of Great Lakes Research is being prepared that details results of all data collected and reported on over the last several years.

Job 6. Title: Collect and evaluate Esocid data and develop genetics hatchery management plan.–Data on spawning numbers, male and female gamete-take procedures, and restocking of hatchery fish into broodstock lakes developed for Northern musky are being tabulated to estimate temporal changes in broodstock genetic diversity. Recommendations will be forwarded based on data to direct future spawning and fish culture activities for Northern musky and for proposed broodstocks of Great Lakes musky.

I have reviewed and contributed a genetics section to the Management Plan for Muskellunge in Michigan. Analyses were conducted to assess the effects of alternative gamete take procedures suggested for the development of new Great Lakes musky broodstock lakes in Michigan. Simulations were conducted varying the numbers of adults spawned from source populations, how progeny were distributed across the broodstock lakes, and how subsequent cohorts from the broodstock lakes would be returned to the lakes to maintain population levels.

Analyses of data and preparation of a publication on research pertaining to probabilities of introgression of northern and Great Lakes musky is ongoing. We have surveyed the literature to determine historical ranges of northern and Great Lakes musky (Figure 2). We have also reviewed all Michigan Department of Natural Resources musky stocking records to identify drainages with connectivity to the Great Lakes and to native Great Lakes musky populations that may be at risk to genetic mixing with stocked northern musky.

We have genotyped musky from the Huron River in southeastern Michigan in the Lake Erie drainage. We found that northern musky and Great Lakes musky are genetically distinct and can be easily identified using microsatellite loci with >99% confidence. Based on genetic assignment tests we have identified the presence of northern musky downstream from a dam separating a reservoir stocked with northern musky from a river inhabited by Great Lakes musky. Data conclusively show that dams are permeable to movements by stocked fish. Findings of co-occurrence of musky from both northern and Great Lakes subspecies in the Huron River during the spawning season suggest that management policies regarding the location of stocking of non-native fish need to be re-evaluated.

Northern Pike were collected from two inland lakes that have been traditionally used as gamete sources for northern pike in Michigan (Gun Lake and Gull Lake). We were also provided putative

northern pike/musky hybrids from ponds behind the Wolf Lake Hatchery. Samples were used to determine whether introgression has occurred between northern pike and northern musky.

All individuals were characterized using microsatellite loci. The loci show fixed species-specific differences between northern pike and musky. Thus, all hybrids (F1, F2, and backcross) can be unambiguously identified. We found that several fish from Gun and Gull Lakes were hybrids. We found that the majority of fish sampled from the Wolf Lake ponds were hybrids. These fish were putatively retained from a year when the Michigan DNR obtained musky fingerlings from an outside source. The presence of large numbers of hybrids at the Wolf Lake hatchery suggests that the majority of supposed musky stocked in Michigan during this year were hybrids and not northern musky.

I have worked with members of the DNR Stocking Committee to develop a genetics policy for fish transfer. Additional recommendations will be proposed in a genetics section in the new DNR Esocid Management Plan.

Job 7. Title: Prepare final report and communicate results.–Findings of activities are communicated in this document and to Michigan DNR and regional fisheries biologists via oral communications at meetings, professional meetings, and written reports. A final report that summarizes results of all jobs is under preparation.

Prepared by: Kim T. Scribner
Date: September 30, 2007

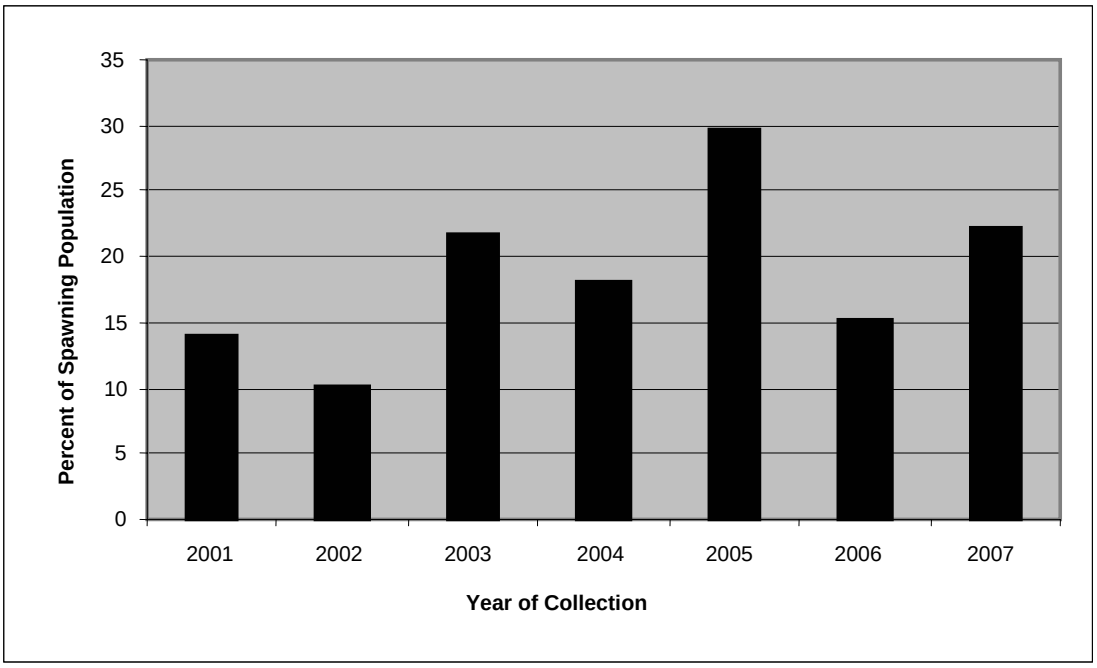

Figure 1.–Annual estimate of the proportion of the adult male spawning population originating from hatcheries. Estimates are based on individual total body length (cm) and established estimates of length-age relationships (Baker, unpublished data) that place individuals in year classes stocked into Black Lake during 1983, 1984, and 1987.

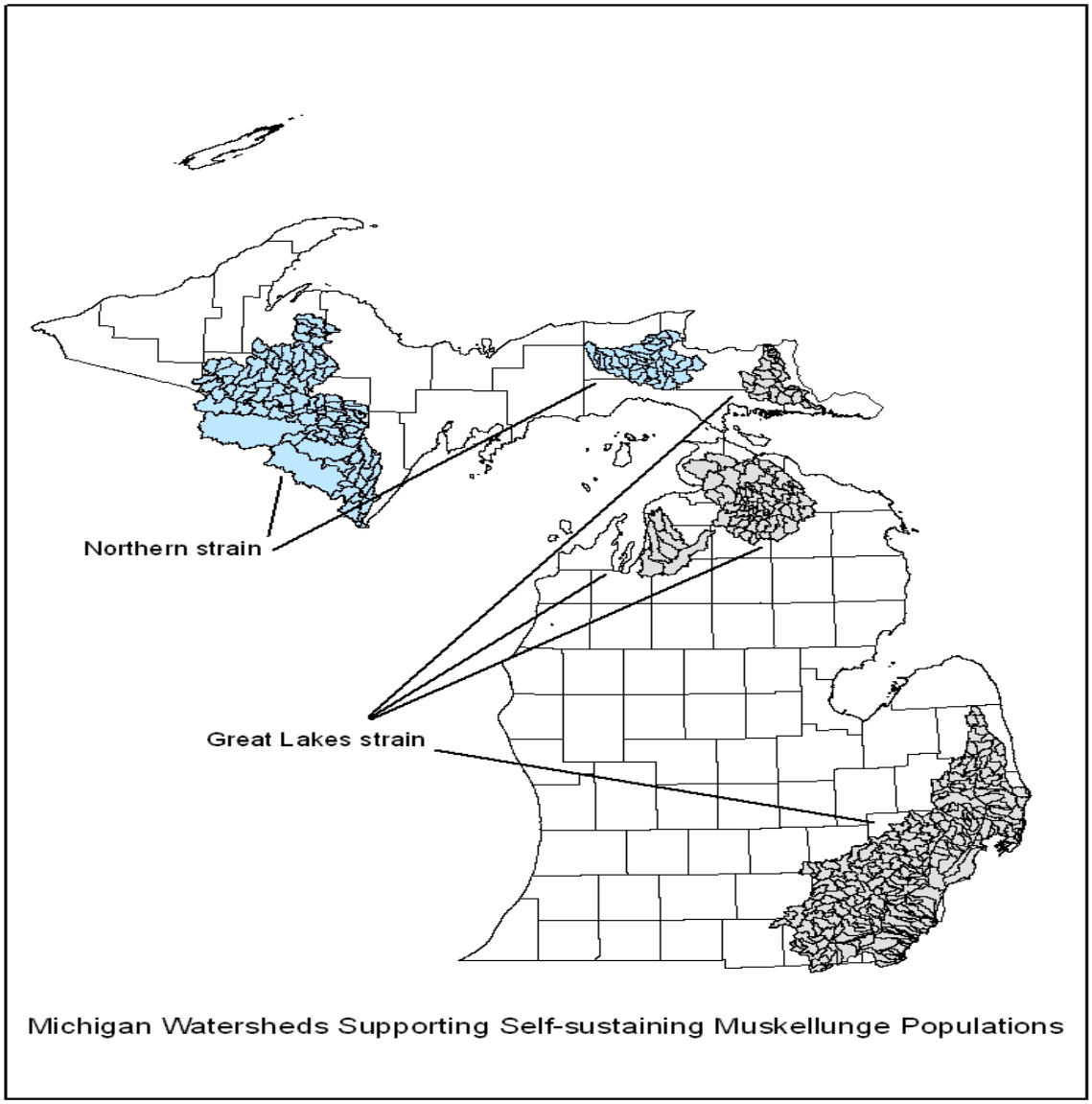

Figure 2.–Map showing the historical natural distribution of northern and Great Lakes musky in Michigan.