WALLEYE

Project Component Termination Report for the Period
June 1, 1990 to August 31, 1993

NCRAC FUNDING LEVEL: $151,657 (June 1, 1990 to August 31, 1993)

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Iowa Department of Natural Resources (DNR)	Spirit Lake State Fish Hatchery	Iowa
Kansas Department of Wildlife and Parks	Milford State Fish Hatchery	Kansas
Minnesota DNR	Devil's Track State Fish Hatchery	Minnesota
Ohio DNR	London State Fish Hatchery	Ohio
U.S. Fish & Wildlife Service	Garrison Dam National Fish Hatchery	North Dakota
U.S. Fish & Wildlife Service	Genoa National Fish Hatchery	Wisconsin

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REASON FOR TERMINATION

The objectives for this work on Walleye were completed.

PROJECT OBJECTIVES

(1) Genetically analyze selected walleye populations for potential use as brood stock.

(a) Population genetics (baseline information on genetic composition of various walleye populations).

(b) Quantitative genetics (comparison of phenotypic characteristics of progeny from selected walleye brood stock).

(2) Measure genetic parameters required for efficient selection on fry and fingerling traits, using pedigreed families.

PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1A

Genetic analyses were conducted by Southern Illinois University-Carbondale (SIUC) investigators on four walleye populations that were potential candidates for providing brood stock from which fish could be taken for future selective breeding experiments. These populations came from: (1) the Mississippi River near Genoa, Wisconsin, (2) Spirit Lake, Iowa, (3) Milford, Kansas, and (4) London, Ohio. SIUC researchers developed methodologies to identify biochemical traits that would be useful for genetic analysis. Initially, a single population of walleye was screened for allozyme variation in a large number of enzyme systems using different tissues and buffer systems to maximize the number of loci, and identify polymorphic loci. A total of 39 enzyme systems were surveyed in 53 walleye fingerlings from Spirit Lake, Iowa. Six tissues were screened from each fish (eye, gill, heart, liver, kidney, muscle) and four buffer systems were used for starch gel electrophoresis. Seventy loci, of which 30 are polymorphic, were identified. Fourteen of the 21 polymorphic loci were significantly polymorphic, that is there was <95% frequency of the most common allele. Prior to this work, only 10 polymorphic loci were identified in walleye populations, of which only five were significantly polymorphic. Mean heterozygosity per locus for the Spirit Lake walleye was 0.070, somewhat higher than the value of 0.050 obtained when 39 loci were examined in a previous study of allozyme variation in walleye populations.

Fry (21-day-old) reared at Iowa State University (ISU) from eggs obtained from hatcheries at Milford, Kansas; Genoa, Wisconsin; and London, Ohio were examined, but the fry were too small to take specific tissues for allozyme analysis. Thus, it is recommended that fry not be used for future genetic analyses. Fingerling fish at least 50 mm (2.0 in) total length (TL) seem to be the earliest stage on which comprehensive walleye allozyme analyses can be conducted.

Total DNA samples were extracted from 40 fish, but not including fish from the Ohio stock, and processed for allozyme analysis to determine the extent of mitochondrial DNA (mtDNA) variation within and among stocks. Together, the mtDNA and allozyme data provide baseline information on genetic composition and variability of walleye populations that were being evaluated for potential use as brood stock. These data would be fundamental for development of any future selective breeding programs. The data showed that the Mississippi River walleye from Genoa, Wisconsin exhibited a high level of genetic diversity, which would make it useful for selective breeding. Therefore, this population was selected for development of pedigreed families in Objective 2.

OBJECTIVE 1B

Concurrent to the development of biochemical methods to distinguish fish stocks, SIUC and ISU were evaluating the cultural performance of progeny from several sources of walleye stocks from the North Central Region (NCR) to find stocks that have superior growth rates and improved feed efficiency to enhance the feasibility of commercial culture. The findings can also serve to identify stocks useful for brood stock selection. SIUC carried out evaluations using a tandem extensive-intensive (pond/tank) rearing system whereas ISU reared walleye from hatch in intensive (tank) culture conditions entirely on formulated feed.

SIUC obtained eyed-eggs from Genoa, Wisconsin (Mississippi River); London, Ohio (semi-domestic); Lake Wallenpaupack, Pennsylvania; and Lake Shishibogama in northern Wisconsin. After incubation, newly hatched fry were stocked into fertilized ponds near the SIUC campus. Fingerling walleye (30-50 mm [1.2-2.0 in] TL) were harvested from the ponds then placed in 1.8-m (5.9-ft) diameter tanks and evaluated on their trainability to accept commercially prepared diets. In 1992, ISU obtained eyed-eggs from six stocks in the NCR: (1) London State Fish Hatchery, Ohio (Ohio stock); (2) Milford State Fish Hatchery (Kansas stock); (3) Genoa National Fish Hatchery, near Genoa, Wisconsin (Mississippi River stock); (4) Spirit Lake Fish Hatchery (Iowa stock); (5) Garrison Dam National Fish Hatchery, Riverdale, North Dakota (North Dakota stock); and (6) Devil's Track State Fish Hatchery, Minnesota (Minnesota stock). The Ohio stock, considered the only domesticated stock of walleye, were progeny of a third generation captive stock that has been reared at the hatchery. The eggs were hatched and the fry reared at ISU in an intensive culture environment on formulated feed.

Stock differences in performance of walleye were observed in both pond and tank culture environments. In the tandem pond/tank culture studies at SIUC, about 86% of the pond-reared fingerlings from the Mississippi River stock from Genoa, Wisconsin accepted commercially prepared diets, a higher feed acceptance than stocks from northern Wisconsin or Pennsylvania. Researchers from ISU observed substantial stock differences in regard to fish size at hatching, survival, and cannibalism of tank-reared walleye. Cannibalism was highest in the Minnesota stock and lowest in a semi-domesticated stock from the London Ohio hatchery. These findings suggest that the serious problem of cannibalism may be reduced by domestication.

OBJECTIVE 2

The study was a cooperative project between the University of Minnesota (UM) and ISU to prepare, culture, and evaluate pedigreed families of walleye. The families were founded from the same source population collected from the Mississippi River near Genoa, Wisconsin. A balanced, nested mating design of full- and half-sibling families was used, where each sire was mated to three dams. This mating design is desirable because: (1) data from half- and full-siblings allow precise estimation of necessary genetic parameters using data from only the parent generation of families, and (2) individual and family data allow application of combined selection on reproducing adults of this same parent generation. ISU raised 12 families and UM raised a different set of 12 families.

Trait heritabilities were estimated using 12 families of fry raised at ISU and growth related heritabilities of fingerlings raised at UM. Hatching length, gas bladder inflation, and cannibalism had sire heritabilities of 0.47 to 0.83, and growth related heritabilities ranged from 0.30 to 0.74 for length, and 0.41-0.93 for weight. Potential response to selection increases as heritability increases from 0 to 1. The finding suggests a strong heritability for growth, that cannibalism may be reduced through selective breeding, and that selection for faster growth should not increase cannibalism.

IMPACTS

OBJECTIVE 1A

Techniques were developed to discriminate walleye populations on the basis of biochemical traits. The baseline information collected on genetic composition and variability of walleye stocks in the region can be used to recognize and maintain unique strains for aquaculture. However, it is only possible to conduct such programs with maximum efficiency, while minimizing the effects of inbreeding, if there are good baseline data on genetic variability, such as collected in this study. The Mississippi River walleye stock from near Genoa, Wisconsin exhibited a high level of genetic variability. Such data of genetic diversity has been used for identifying suitable stocks for a

selective breeding program begun in Objective 2 of this project and carried forward in the fifth Walleye project. Because the genetic markers are passed from generation to generation, biochemical genetics is a powerful tool for recognition of differences among strains should they be developed by selective breeding.

OBJECTIVE 1B

The stock evaluation studies provided baseline information that would be needed to choose a source of brood stock for development of a captive domesticated brood stock for the NCR.

OBJECTIVE 2

Major elements of a selective breeding program were carried out: a pedigreed captive population was established by UM; UM and ISU collaborated to obtain estimates of heritability for important performance traits in indoor rearing conditions in both laboratory and production facilities; and plans and a written agreement for future collaboration between UM researchers and Aurora-Aqua, Inc., a Minnesota-based aquaculture company, were completed. Variations in performance were obtained between family groups of walleye from the same population. High heritabilities were calculated that indicate traits for fast growth and reduced cannibalism. Gains can be expected for many generations of continuous selection in the same direction on a given trait. The findings demonstrate that pedigreed family lines can be used to advantage in selective breeding programs for walleye. These findings suggest that efficient selection of walleye will successfully yield fish that have a low incidence of cannibalism and a faster growth rate, thus allowing commercial producers to rear fish to market size in a shorter time with reduced operating costs.

Walleye fingerlings reared at ISU were transferred to pond sites in northeast Iowa for use in a USDA-sponsored net pen research project carried out by a non-profit organization, Resource Conservation and Development for Northeast Iowa, Inc. of Postville, Iowa.

RECOMMENDED FOLLOW-UP ACTIVITIES

Additional biochemical genetics data needs to be generated to identify other stocks of walleye that could be suitable for a selective breeding program in the NCR.

Follow-up projects on brood stock selection and selective breeding should utilize stocks which have been shown to have higher performance characteristics. The work that has been done provides guidance on culture methods and measures of performance for future studies.

However, to undertake a successful selective walleye breeding program, will require a long-term funding commitment to carry out the work. It takes nearly three years for female walleye to reach sexual maturity and it will require many years of combined effort by a team with both genetic and fish culture expertise to carry out such a program.

PUBLICATIONS, MANUSCRIPTS, AND PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded Walleye activities.

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVERSITY	INDUSTRY	OTHER	OTHER	TOTAL	

				FEDERAL			
1990-91	$58,614	$24,898				$24,898	$83,512
1991-92	$53,043	$25,931				$25,931	$78,974
1992-93	$40,000	$29,828				$29,828	$69,828
TOTAL	$151,657	$80,657				$80,657	$232,314