Aquaculture for the Great Lakes Region

The bounty of the Nation's Dairyland goes beyond the traditional yield of cows and corn. Almost three decades ago, Wisconsin added fish to its portfolio of agricultural products.

Like dairy farmers before them, fish farmers found Wisconsin to be fertile ground for raising stock. Its abundant supply of freshwater has attracted more than 330 producers who are raising fish for food products, stocking, bait, and for-fee fishing. Today, the aquaculture industry in Wisconsin is growing by more than 10 percent a year and has an annual value of almost $9 million.

In the Great Lakes region, the commercial aquaculture business currently has a gross value of more than $76 million and produces more than 50 species of fish.

Nationally, aquaculture is the fastest growing segment of U.S. agriculture, with an annual value exceeding $1 billion.

The University of Wisconsin Sea Grant Institute has nurtured the growth of this burgeoning industry in the Great Lakes region since the early 1970s. With the help of Sea Grant funding, UW researchers have made important contributions to the field. They have created fish meal that satisfies the unique dietary requirements of fish; developed effective methods for controlling disease; produced faster-growing hybrids; and advanced domestication and intensive production of yellow perch, walleye, and other cool-climate fishes using a combination of biotechnology and basic husbandry techniques.

Supply and Demand Drives Value and Research

The ever-increasing demand for seafood can no longer be met by the world's dwindling fisheries. The existing market for yellow perch and walleye, for example, far exceeds the commercial catch rate. This imbalance has caused the price of these fishes to increase dramatically in recent years. Because of their high market potential, perch and walleye have been the focus of much of Wisconsin Sea Grant research. In fact, two of the first Wisconsin Sea Grant aquaculture projects were aimed at developing basic propagation and husbandry methods for these two fishes.

Many important developments came out of these early studies. Researchers devised methods for spawning and egg incubation, fingerling production and pond management, habituation of pond-reared fingerlings to formulated feeds and intensive culture conditions, and disease control and treatment.

The projects also identified the environmental conditions that need to be maintained for successful culture. Knowledge also was gained regarding growth and feeding rates, feed conversion efficiencies, and nutritional requirements.

Once the parameters for the commercial culture of perch and walleye were established, Sea Grant turned its attention to assessing the feasibility of raising these fishes using water-recycling systems. The Sea Grant studies generated a wealth of scientific, technical, and economic knowledge about water reuse systems.

Devising Solutions to Technical Problems

Sea Grant aquaculture research also focused on the identification and resolution of key scientific and technical issues constraining the development of commercial aquaculture in the Great Lakes region. One problem concerned the efficiency of public hatcheries that support the Great Lakes recreational fisheries. Sea Grant studies in this area have focused on fish nutrition, hormonal and genetic mechanisms controlling growth and reproduction, stress physiology, and pathology and disease.

Researchers found that Wisconsin has the perfect climate for raising other valuable coldwater fishes, such as salmon and trout. The state has an established commercial rainbow trout aquaculture industry, and a large percentage of public hatchery production in the region is devoted to this species.

In private or public situations, trout production costs are dominated by the cost of feed, which typically constitutes more than half the total cost of production. Sea Grant research uncovered the key nutritional requirements of trout and provided this information to feed manufacturers. The manufacturers were then able to create better and less costly feed.

Over the last decade, the application of the results of these studies on trout nutrition has been impressive. While feed conversion rates have increased, the amount of fish meal required in trout diets has declined. The net result is that the cost of trout diets to the farmer has not increased substantially over the years, in spite of inflation and rising commodity prices.

Building a Viable Industry

Sea Grant research identified several factors constraining the development of a major commercial aquaculture industry in the Great Lakes region and then aimed to overcome them.

Among these obstacles were growth and behavioral characteristics of coldwater fishes. Perch and walleye males grow more slowly and ultimately reach a smaller size than females, for example. Further, the growth rates of perch and walleye decline as they reach sexual maturation. In perch, this occurs well before the fish reach a marketable size. Added to this, reproductive development can reduce the percentage of edible flesh by as much as 35 percent. Finally, walleye are highly excitable under intensive culture conditions, resulting in slow growth rates and high incidences of disease and mortality.

To resolve these problems, UW Sea Grant aquaculture researchers conducted a series of investigations that focused on elucidating various endocrine and genetic mechanisms that control reproductive development and growth in perch and walleye. Once again, the investigations generated a wealth of basic scientific information that led to the development of practical solutions to many of these problems.

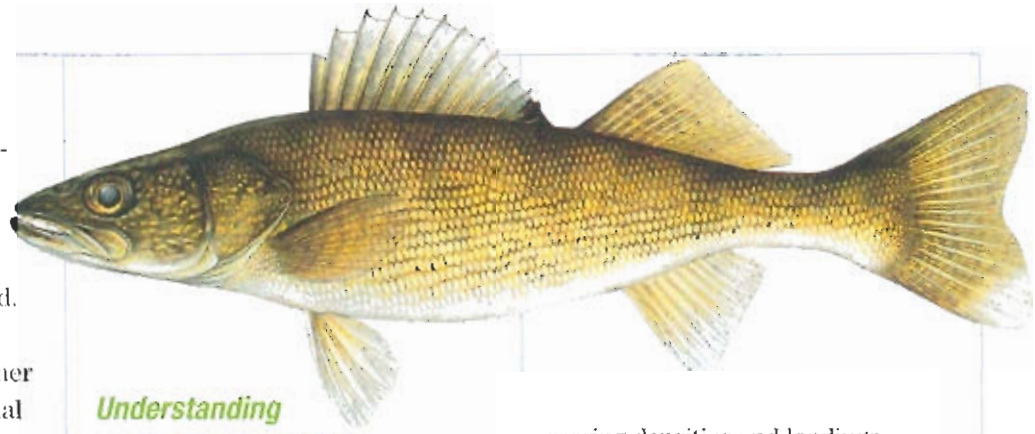
One area of study resulted in the development of methods for advancing the spawning season of walleye by almost two months, allowing walleye culturists to "jump-start" the growing season each year by producing larger, advanced fingerlings.

After investigating the factors that control sexual differentiation and timing, UW Sea Grant researchers developed methods for producing monosex female populations of perch and walleye. These methods rely on treating fingerling fish at a precise stage of development with an analog of the male hormone testosterone. Females treated in this manner produce viable spermatozoa upon reaching sexual maturity. If these sperm are used to fertilize normal eggs, the resultant offspring are 100 percent female.

One of the most important ramifications of this method is that only a small number of broodfish need to be treated with hormones. Largely because of this, the U.S. Food and Drug Administration granted UW Sea Grant researchers an experimental drug approval to test this method at six Midwestern perch farms. These researchers are now working closely with the national aquaculture drug coordinator to gain permanent approval for this method.

Methods of inducing sterility in perch and walleye also were

developed. By exposing newly fertilized eggs to heat or hydrostatic pressure shocks, sterile "triploid" fish (those containing three chromosome sets) have been produced. Later studies showed that triploids have significantly higher fillet yields and reduced gonadal development as compared with diploids. UW Sea Grant researchers are currently evaluating the commercial use of these triploid perch.



Growing Healthier Fish

Another important objective of Sea Grant research is understanding the mechanisms of certain fish diseases and evaluating potential methods for control. One project examined the impact of commonly encountered, chronic sub-acute stressors on the immune response of fish. Researchers evaluated a number of stressors, including ammonia and dissolved oxygen concentrations, high rearing densities and sub-optimal water temperatures. The results of these studies were used to define the levels of stressors that can make fish susceptible to disease.

Another project compared the immune responses of selected trout strains to the pathogen for bacterial kidney disease, a fatal disease organism in many salmonid populations. Results of this project included the development of highly specific analytical procedures and reagents, which are now available for use in state and federal fish health laboratories.

Understanding the Impact of Stress

Aquaculturists have long recognized the deleterious effects of physiological stress on the growth, health and survival of fish reared under intensive culture conditions. UW Sea Grant research currently focuses on the stress physiology of commercially important salmonids and cool-water fish. The goal of these studies is to develop and assess new technologies that will increase coldwater fish production and cost-effectiveness under the unique conditions of the Great Lakes region.

One of the first results of this work was the development of a method for measuring the hormone cortisol in fish. This diagnostic tool, used for evaluating stress in cultured fish, has been adopted by several research laboratories throughout the United States.

Sea Grant studies also suggest that liquid oxygen injection systems, if properly designed, can be used to rear rainbow and lake trout at higher densities than is currently practiced. These investigations also showed, however, that oxygen supersaturation can have severe negative impacts on fish growth and stress responses. Other studies have established a clear link between stress responses, and rearing densities and loadings. This information is helping trout farmers in the Great Lakes region maximize growth rates and production.The aquaculture of salmonids is a more established and mature industry than that of coolwater percids. Accordingly, the effects of many routine husbandry procedures on coolwater fish have not yet been elucidated. One recent finding in this regard is that different lighting conditions and disturbance levels markedly affect the growth and stress responses of perch.

Creating Stress-Resistant Breeds of Fish

While Sea Grant studies have contributed to increasing aquaculture production by identifying and eliminating sources of stress, it is impossible to eliminate some stressors under practical conditions. Many fish hatcheries in the Great Lakes region experience seasonal fluctuations in water temperature and quality, for example.

Recognizing this, UW Sea Grant scientists now are examining two alternative strategies for producing rainbow trout and yellow perch that are resistant to unavoidable aquaculture stressors. The first is a selective breeding

process whereby individual stress-resistant fish are identified and then crossbred to produce offspring that have increased tolerance to stressors. The second involves exposing fish to select environmental or biochemical treatments at early developmental stages. The production of stress-resistant fish by either approach is expected to increase the efficiency of private and public fish hatcheries throughout the region.

Another area of Sea Grant-funded research is evaluating the marked changes in the stress responses of salmonids as the fish mature sexually. Knowing that the hormone cortisol is directly responsible for the post-spawning death of semelparous salmonids, a better understanding of the relationship between stress responses and reproduction will be useful in developing methods to improve the quality of salmonid brood stock and eggs.

Nurturing the Environment — and a Business

After more than 30 years of Sea Grant-supported research, outreach, and education, a viable aquaculture industry has emerged in the Great Lakes region. The commercial production of yellow perch fingerlings and food-size fish has become a reality and is poised to undergo exponential growth in the coming years. Commercial success springs from the development of new technologies, which have reduced costs and increased reliability of production.

In part because of the availability of Sea Grant expertise, Wisconsin is now home to one of the largest and most advanced commercial recirculation aquaculture systems in North America. The St. Croix Aquaculture Facility, located in Danbury, Wisconsin, and owned by the St. Croix Band of Lake Superior Chippewa, recently opened its doors. The $25 million, state-of-the-art facility is expected to yield between 500,000 and 1 million yellow perch in its first year of operation.

The transfer of new knowledge also is achieved through conferences, such as the annual Wisconsin Aquaculture Conference, of which UW Sea Grant is a sponsor.

Aside from ensuring economic and technological success, Sea Grant is dedicated to nurturing an aquaculture industry that is environmentally sound and sustainable. To this end, Sea Grant researchers currently are developing a best management practices manual for aquaculture in Wisconsin and the Great Lakes region. The manual will be an invaluable resource for aquaculturists, helping them to operate facilities in the most environmentally friendly manner and assisting them in designing, locating and constructing new facilities. It also will assist regulatory agencies in developing policies that protect the environment while allowing the development and growth of the industry.

Further underscoring the importance of Wisconsin and the Great Lakes region for the aquaculture industry is the fact that the Third International Percid Fish Symposium will convene in Madison in 2003. The international scientific forum will focus on the current status of percid fishes, with a special focus on fish of the Great Lakes.

For more information, contact:

Fred Binkowski, Specialist
Aquaculture Advisory Services
UW Sea Grant
Great Lakes WATER Institute
600 E. Greenfield Ave.
Milwaukee, WI 53204-2944
Phone: (414) 382-1723
Fax: (414) 382-1705
Email: *sturgeon@csd.uwm.edu*

Jeffrey Malison, Director
Aquaculture Program
UW-Madison
Babcock Hall, Room 123
1605 Linden Dr.
Madison, WI 53706
Phone: (608) 263-1242
Fax: (608) 262-6872
Email: *jmalison@facstaff.wisc.edu*

To find out more about UW Sea Grant aquaculture projects, visit *http://seagrant.wisc.edu/outreach/aquaculture/*.

Or, visit the North Central Regional Aquaculture Center Web site at *http://aquanic.org*.

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