

ADVANCEMENT OF YELLOW PERCH AQUACULTURE

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Funding Request: \$150,000

Duration: 2 Years (September 1, 1993 - August 31, 1995)

Objectives:

1. To determine the commercial scale feasibility and improve on the best intensive tank and pond culture practices for the production of yellow perch fingerlings.
2. To determine the commercial scale feasibility of raising food-size yellow perch in flow-through raceways or tanks, open ponds, and large net-pens, comparing the best available formulated diets.

Proposed Budgets:

Institution	Principal Investigator(s)	Objective(s)	Year 1	Year 2	Total
University of Wisconsin-Milwaukee	Fred P. Binkowski	1	\$15,000	\$15,000	30,000
University of Wisconsin-Madison	Jeffrey A. Malison	1	\$23,000	\$23,000	46,000
University of Nebraska-Lincoln	Terrence B. Kayes	1 & 2	\$15,000	\$15,000	30,000
Ohio State University	Konrad Dabrowski James M. Ebeling	1	\$12,000	\$12,000	24,000
Purdue University	Paul B. Brown	2	\$10,000	\$10,000	20,000
TOTALS			75,000	75,000	150,000

Non-funded Collaborators:

Facility	Collaborator(s)
Alpine Farms/Glacier Springs Trout Hatchery, Wisconsin	John Hyink and John Wolf
Perch Research International, Inc., Bentley, Michigan	George Matousek
Coolwater Farms, Dousman, Wisconsin	Dave Northey
Pleasant Valley Fish Farm, McCook, Nebraska	William Hahle
Red Hook Fisheries, Inc., David City, Nebraska	David Gerhold
Aquatic Management, Inc., Lisbon, Ohio	Byron Bezdek
Freshwater Farms of Ohio, Inc., Urbana, Ohio	Dave Smith

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JUSTIFICATION

The yellow perch is a highly valued food fish having numerous biological characteristics that make it an excellent candidate for commercial aquaculture in the North Central Region (Calbert 1975). The market demand for yellow perch has always been high, reflecting a strong consumer preference for seafood products derived from this fish (Lesser 1978; Lesser and Vilstrup 1979). The basis for this demand is tied to long-standing uses in the region, such as Friday-night fish fries. Advantages to the fish processing and restaurant industries include the perch's firm flesh and low fat and phospholipid content. Such characteristics are conducive to products having a long shelf life, resistance to freezer damage and minimal problems with off-flavor and cooking odor (D.A. Stuibler, Fisheries and Seafood Processing Extension Specialist, University of Wisconsin-Madison, personal communication). Its delicate flavor and relative lack of cooking odor make the yellow perch a favorite among restaurateurs and homemakers.

In 1990-91, fresh yellow perch fillets retailed for \$17-25/kg (\$8-11/lb) in most markets. For many years, commercial harvests of yellow perch from the Great Lakes and Canada have failed to keep pace with market demands (Calbert 1975; Lesser and Vilstrup 1979). Increasingly, regulatory constraints designed primarily to protect recreational sport fishing are limiting commercial perch fishing in all Great Lakes waters, including Lakes Michigan and Erie, Green Bay and Saginaw Bay (e.g., Belonger 1986). The reduction of domestic supplies of yellow perch, together with the constant concern over microcontaminant levels in Great Lakes fish (Downs 1985; Smith 1988), has resulted in a tremendous growth of interest in the feasibility of yellow perch aquaculture (Calbert 1975; Downs and Smith 1983). Currently, an embryonic yellow perch industry is beginning to emerge in the North Central Region.

Early studies on perch conducted in the 1970s and 1980s demonstrated that this species has many biological characteristics recommending it for commercial culture (see review by Heidinger and Kayes 1986). Among them are its (1) ready acceptance of formulated feeds; (2) lack of aggressive behavior and cannibalism; and (3) relatively high tolerance of crowding, handling, and marginal water quality. Procedures for culturing yellow perch under laboratory conditions have been known for some time (Huh 1975; Kocurek 1979), as are methods of raising perch to a size and age at which, under natural photoperiod/temperature conditions, they can be successfully spawned (see Malison et al. 1986).

More recently (since 1989) the North Central Regional Aquaculture Center (NCRAC) has sponsored studies on yellow perch aquaculture which have focused in three primary directions. The first of these has compared the performance of selected wild stocks of yellow perch, including triploids, when reared under intensive culture conditions. Results to date have shown that offspring of stocks of perch from different geographical locales have temperature-dependent differences in survival, growth, and feed conversion. This information should allow producers to select the best-performing stock for a specific culture system.

A second line of NCRAC-funded research has compared intensive tank and pond culture systems as methods of producing perch fingerlings. The comparisons have shown that, with current technology, the survival of perch fry in ponds is higher than of those reared in tanks. These and other findings suggest that pond systems may be more cost-effective than tank systems for fingerling production. Tank systems, however, have several potential advantages over pond systems. First, assuming that strategies for inducing out-of-season spawning can be developed, tank systems could be used to produce fingerlings on a year-round basis, whereas pond systems are inherently seasonal. Second, raising large numbers of segregated groups of fingerlings (as would be needed, for example, in selective breeding programs) would be more easily accomplished in tanks than ponds.

The third line of NCRAC-funded research on yellow perch has evaluated flow-through and pond culture systems for grow-out. In these studies, key production characteristics, including optimum stocking densities, loading rates and water quality parameters, have been delineated for perch. Such information is essential for designing culture systems and estimating production capacities of existing facilities.

Because of budgetary constraints and the need for precise measurements, many of the previous studies were conducted on a small scale under laboratory conditions. Comparatively little of the knowledge gained has been field tested under practical conditions in a manner by which new findings can be readily transferred to the aquaculture industry. Some of the methods developed and evaluated, such as for intensive tank and pond fingerling production, have potential for great improvement.

To date, studies on perch nutrition and diet evaluations have been limited, despite the fact that fish feeds generally constitute over 50% of the production cost of most intensive fish culture operations. Furthermore, little or no information is available on the economics of various aspects of yellow perch aquaculture. With these facts in mind, the NCRAC has determined that the top priority areas for study are to conduct production-scale field trials and improve on current best practices of key aspects of perch aquaculture.

This proposal by the NCRAC Yellow Perch Work Group addresses critical problems and constraints currently facing the commercial culture of yellow perch. The project is ideally suited for a cooperative regional research effort and involves investigators with appropriate expertise from five different institutions in four states: Ohio State University (OSU), Purdue University, University of Nebraska-Lincoln (UN-L), University of Wisconsin-Madison (UW-Madison) and University of Wisconsin-Milwaukee (UW-Milwaukee). The principal goal of the project is to develop practical strategies for commercial yellow perch aquaculture under the diverse environmental conditions that exist in the North Central Region. Specifically, the aims of this project are to: (1) determine the commercial scale feasibility and improve on the best intensive tank and pond culture practices for the production of yellow perch fingerlings, and (2) determine the commercial scale feasibility of raising food-size yellow perch in flow-through raceways or tanks, open ponds, and large net-pens, comparing the best available formulated feeds. Detailed production data on the culture practices examined will be generated and provided to the NCRAC Economics and Marketing Work Group to develop production budgets and evaluate costs.

RELATED CURRENT AND PREVIOUS WORK

Intensive Tank and Pond Culture of Fingerling Yellow Perch (Objective 1)

Conceptually, there are two basic methods of producing yellow perch fingerlings for commercial aquaculture. One method is to raise the fish from fry to the fingerling stage entirely in tanks. Alternatively, fry can be stocked into ponds and raised to the fingerling stage, at which time they can be habituated to formulated feeds.

Until recently, attempts to culture large numbers of yellow perch from hatch through early-fry stages in tanks have not been successful. Perch fry at hatch are normally about 5 mm total length (TL) (see Heindinger and Kayes 1986). Mansuetti (1964) identified 13 mm TL as the minimum size at which perch accepted and survived on formulated feed. Best (1981) concluded that perch fry will accept conventional formulated starter diets only after reaching about 16 mm TL. In an earlier study, Hale and Carlson (1972) found that perch larvae could be reared in glass aquaria if copious quantities of lake zooplankton were provided for several weeks in advance of the introduction of a formulated diet. However, major limitations on extrapolating Hale and Carlson's (1972) results to intensive aquaculture are that their study involved few replications, small numbers of fish (50-200/treatment), and the need to collect and process large amounts of zooplankton from the wild.

Over the past 6 years, researchers at the UW-Milwaukee have developed and employed a system using live food for raising larval perch in tanks. This system uses batch cultures of "green tank water" (GTW) as an initial food until the perch are large enough to consume brine shrimp nauplii. Briefly, GTW is produced in 2.4 m-diameter tanks that are vigorously aerated and illuminated with high intensity metal-halide arc lights suspended approximately 0.5 to 1.0 m above the water surface. Cultures are initiated by fertilizing the tank water with dehydrated alfalfa meal and seeding the tanks with a small amount of a previous culture. Within 1 week at 18-23 °C, large numbers of large ciliate protozoa and rotifers bloom, and within 2-4 weeks rapidly reproducing populations of copepods with abundant nauplii and copepodites can be produced.

The GTW is regularly added as a food source to tanks containing newly hatched perch fry. The GTW is needed only for the first 4-6 days after hatch, after which perch are large enough to feed exclusively on brine shrimp nauplii. Beginning on Day 14, the brine shrimp are mixed with increasing amounts of finely chopped beef liver, and by Day 20 the fish are being fed only beef liver. Over the next 10 days a formulated starter feed (Biodiet Starter, Bioproducts, Inc., Warrenton, Oregon) is mixed with the ground liver in increasing proportions, and by Day 30 the perch are consuming 100% formulated feed.

Over the last several years, UW-Milwaukee researchers have successfully produced an average of 2,000-4,000 perch fingerlings per cubic meter of rearing space using this system. Significant problems, however, remain with the tank culture of perch fry. To date, the UW-Milwaukee procedure has been employed only in the laboratory on a small scale. Also, recently completed studies funded by NCRAC have shown that the survival of fry reared in ponds was dramatically higher than those reared in tanks. The high level of mortality of tank-reared fry was associated with cannibalism and a high incidence of spinal deformities and non-inflation of the swim bladder. About 50% of the total mortality occurred when the perch fry were fed brine shrimp nauplii exclusively, suggesting that they (and possibly the GTW organisms) are not nutritionally adequate.

Ultimately, the preferred method for rearing larval perch intensively in tanks would be to develop a formulated diet which is both accepted by the fry and nutritionally complete. Until recently, little was known about the nutritional requirements of larval perch. Two years ago, however, researchers at OSU began a series of studies to estimate the nutrient profiles of larval perch, as well as their natural live-food organisms, with the ultimate aim of using this information to develop and test larval perch diets. One notable finding was that perch larvae have much higher levels of docosahexaenoic (22:6w3) and eicosapentaenoic (20:5w3) fatty acids than *Daphnia*, one of their major natural foods. Other studies on several species of marine fish have recently

shown that fatty acid composition and the supplementation of diets with highly unsaturated fatty acids have important influences on the performance of intensively reared larvae (Koven et al. 1990; Dhert et al. 1990; Eda et al. 1990; Webster and Lovell 1990). The same may be true for yellow perch.

Although tank production systems for perch fry have certain potential benefits, rearing small fingerlings in ponds and then harvesting and habituating them to formulated feeds may be the most cost-effective method of fingerling production, and is currently the only proven method for producing perch fingerlings on a large scale. Using this strategy, the production of habituated fingerlings will ultimately be determined by the number of fish harvested from ponds and the percentage of fish successfully habituated to formulated feeds.

The number of fingerling fish that can be reared in production ponds is dependent on many factors, including food availability, cannibalism, and water quality (Li and Mathias 1982; Keast and Eadie 1985; Swanson and Ward 1985; Colsante et al. 1986; McIntyre et al. 1987). Research to date suggests that procedures for optimizing pond production of the young of many fish species having small eggs and a larval feeding stage are often quite similar. Both walleye and hybrid striped bass ponds, for example, are routinely treated with fertilizers to improve primary and secondary production, and ultimately provide a larger zooplankton forage base for the young fish (Richard and Hynes 1986; Buttner 1989; Harrell et al. 1990; Fox and Flowers 1990; Harding 1991; Fox et al. 1992). Optimal fertilization procedures vary from site to site, depending on differences in water chemistry, soil type, pond size, and other factors. A variety of organic and inorganic fertilizers have been used, including alfalfa pellets, various forms of phosphate, animal manures, seed meals, and hays. Such fertilizers provide nutrients and substrates for phytoplankton, and detrital bacteria and protozoa, which in turn are consumed by zooplankton.

Stimulation of heavy phytoplankton and zooplankton blooms by pond fertilization can greatly enhance the growth and production of fingerling fish in ponds. However, fertilization also increases the chemical and biochemical oxygen demand of a pond and can lead to dissolved oxygen depletion and massive fish kills. Oxygen depletion can be prevented by using powerful emergency aerators when dissolved oxygen levels drop, or by the application of various supplemental aeration and water circulation techniques, either continuously or on a regularly scheduled basis (e.g., aeration at night, but not during the day) (for reviews see Boyd 1990 and Mével 1990). Continuous or scheduled aeration and water circulation offer numerous potential benefits in addition to preventing dissolved oxygen depletion. For example, Fast (1986) stated that continuous aeration reduces chemical and thermal stratification, reduces diurnal fluctuations in dissolved oxygen, maintains aerobic conditions throughout a pond, and provides for a more constant decomposition of organic matter.

With proper management, fingerling production for coolwater species such as perch and walleye typically ranges from 50,000 to 150,000 fish/hectare of pond surface area when fish are harvested at 35-65 mm TL (see e.g., Buttner 1989). This has generally been the smallest size of fish routinely produced by public or private hatcheries, and little information is available regarding the production of smaller fingerlings. However, it is implicit that the number of fingerlings which can be produced in ponds will be maximized by harvesting fish at the smallest possible size. The degree to which an early pond harvest strategy can improve fingerling production was recently illustrated by UW-Madison researchers, who successfully harvested over 500,000 perch fingerlings/hectare of pond area (Malison and Held 1992). They suggested that such high production was accomplished primarily because the fingerlings were harvested at a small size (17-20 mm TL).

Fry stocking rates play a critical role in determining the overall production of fingerlings in ponds. Ponds stocked with too few fish fail to meet their production potential. Overstocked ponds, however, can be rapidly depleted of natural forage. Such ponds often produce small fish in poor condition and have low fish survival rates, the latter resulting from starvation and cannibalization.

Working with walleye fingerling production ponds at the North Platte State Fish Hatchery in Nebraska, Harding (1991) found that percent survival, total biomass (in kilograms/hectare) and condition of walleye at harvest (45-59 days after stocking) did not differ significantly between ponds stocked at 250,000 or 375,000 fry/hectare, but the lengths and weights of walleye harvested were lower for the higher stocking rate. In an earlier investigation in Canada, Fox and Flowers (1990) compared the effects of stocking 200,000, 400,000 or 600,000 walleye fry/hectare into 0.04-hectare ponds. At harvest (42-44 days after stocking), mean lengths and weights of fish exhibited an inverse logarithmic relationship with stocking rate, while total biomass of fish produced was positively related to the latter. Percent survival was unrelated to stocking rate or size at harvest. The results of Harding (1991) and Fox and Flowers (1990) suggest that the number of fish harvested can be maximized by high stocking rates if (large) size is not critical. However, little or no information on pond stocking rates and fingerling survival of yellow perch is currently available.

One approach to improving pond fingerling production is to begin broadcasting starter feeds onto ponds when fingerlings reach a certain minimum size. This technique of supplemental (pond) feeding has been recommended for fingerling production of several fish species having larval feeding stages, including hybrid

striped bass (Hodson and Hayes 1990), redbass (Davis 1991) and baitfish (Gray 1990), and should be evaluated for perch.

The size and condition of fingerlings at harvest can be expected to have a profound influence on their habituation to formulated diets, and habituation rates will likely decrease if the fingerlings are harvested at too small a size. Experience by UW-Madison researchers over the last 10 years suggests that habituation rates of 75-85% can be expected when pond-reared yellow perch fingerlings are harvested at 35-45 mm TL. In one study, Best (1981) showed that habituation was lower than 50% for perch harvested at sizes smaller than 15 mm TL, and increased substantially for perch harvested at 20-40 mm TL. However, Best's (1981) study was conducted using very low initial stocking densities and small aquaria, and his results may not be applicable on a scale feasible for commercial aquaculture. More recently, Malison and Held (1992) reported no statistical differences in the habituation rates of perch harvested at 16.9, 32.5, and 42.6 mm TL.

Cumulatively, the above information suggests that the production of perch fingerlings in ponds can be greatly improved by using high fry stocking densities coupled with early pond harvest. However, several important components of this approach have not yet been evaluated. Neither the studies of Best (1981) nor those of Malison and Held (1992) identified the smallest size at which perch will accept commercially available starter diets. Both of these studies utilized conventional salmonid diets, and larval diets such as Fry Feed Kyowa (Kyowa Hakko Kogyo Company, Ltd., Tokyo, Japan) or diets formulated specifically for yellow perch have not yet been tested.

In addition, the fragile nature of small (<25 mm TL) perch poses a potentially serious practical problem to an early pond harvest strategy. Under most conditions, conventional harvesting methods, such as seining or pond draining, will result in unacceptable levels of mechanical injury and subsequent post-harvest mortality to such small fish (T. B. Kayes and J. A. Malison, personal observations). One possible solution to this problem is the use of light-trapping systems similar to that described by Mancini et al. 1983. Researchers at the UW-Madison have been using a modification of this system for several years to successfully harvest small fingerlings from production ponds. As presently designed, however, this system is too labor intensive to be used commercially, and cannot be used effectively in large ponds (e.g., >1 hectare).

This project will field-test, under commercial conditions, the best methods currently available for producing yellow perch fingerlings, using both intensive tank and pond culture systems. Detailed production data for both systems will be generated and provided to the NCRAC Economics Work Group to develop production budgets and evaluate costs of fingerling production. Additionally, we will develop and test modifications of these methods, aimed at selected critical improvements for both types of systems. These latter studies will include: (1) incorporating specific fatty acids into live food items of tank-reared perch fry; (2) comparing the effect of selected fry stocking rates on the survival of pond-reared fingerlings; (3) evaluating the efficacy of supplemental feeding of perch fingerlings in ponds; (4) determining the minimum size at which pond-reared fingerlings can be successfully harvested and habituated to formulated diets, using conventional starter diets and diets developed specifically for fry; and (5) developing and testing pond harvesting systems suitable for capturing small (<25 mm TL) fingerlings on a commercial scale.

Flow-Through, Pond and Net-Pen Culture of Food-Size Yellow Perch (Objective 2)

Aquaculture research is normally done on a small scale under controlled experimental conditions. To test the practicality of technologies and procedures developed by such research, their effectiveness under production conditions needs to be evaluated by field trials that answer critical questions and help fish farmers and investors make informed decisions. Large numbers of replicated experimental treatments are rarely possible under production conditions because of facilities limitations, the number of animals involved, and associated cost constraints. Accordingly, field trials are best used to examine major production variables and evaluate different production strategies, each of which is comprised of an assemblage of discrete techniques that in most instances have been examined by earlier research. Thus field trials are an important link between research and application.

Before the establishment of the NCRAC in 1988, little systematic research had been done to evaluate the potential feasibility of commercially culturing yellow perch by conventional means, in flow-through raceways or tanks, open ponds, or net-pens (see Heidinger and Kayes 1986). In late 1989, funding for the NCRAC Yellow Perch Work Group was initiated, and one main objective of its first project, which is now in its final year, was to "evaluate the survival, growth and feed conversion of yellow perch raised at various loadings or rearing densities in selected flow-through and pond culture systems." Research on this objective has been done by investigators from Michigan State University (MSU) and the UW-Madison. Studies on the culture of perch in flow-through systems have been the responsibility of MSU, and the studies on the pond culture of perch have been the responsibility of the UW-Madison. Here it should be emphasized that these studies have been and are being done on a small experimental scale to develop baseline information on the culture requirements of perch and to examine technical feasibility. Assessments of commercial feasibility are beyond the scope of the initial Yellow Perch Work Group project. However, the findings to date look promising.

In 1989-90, experiments conducted by MSU investigators on perch fingerlings in laboratory tanks demonstrated that the optimum loading rate for intensive culture of perch is between 1.1 and 1.4 kg of fish/L per min of water flow (North Central Regional Aquaculture Center February 1991). There were no significant differences in mean weight gain or feed conversion between fish reared at loading rates of 0.28 to 1.1 kg/L per min. Mean gains in body length were not significantly different in fish reared at loading rates of 0.28 to 0.85 kg/L per min. Studies of dissolved oxygen profiles in tanks indicated that about 3.5 mg/L dissolved oxygen is necessary to maintain optimum growth. At the loading rates tested, un-ionized ammonia levels in the rearing tanks were well below that considered to be limiting for other species of freshwater fish. In 1990-91, MSU researchers found no significant differences in mean length increase, weight gain, or feed conversion by perch reared at densities of 85, 44 or 21 kg/m³ of rearing space in experimental tanks over a 70-day period (North Central Regional Aquaculture Center December 1991). Throughout the experiment, the dissolved oxygen concentrations at all rearing densities remained above 5.4 mg/L, and when tested, un-ionized ammonia levels between treatment groups were not significantly different.

In 1989-90, experiments conducted by UW-Madison investigators demonstrated that Age-0 perch fingerlings can be successfully raised in net-pens in small ponds and that groundwater addition offers several important benefits to such a culture system, including moderation of seasonal temperature extremes and better maintenance of dissolved oxygen levels, especially during prolonged periods of cloudy weather (North Central Regional Aquaculture Center February 1991). Past research has shown that the optimum temperature for growth in perch is about 20-24 °C (Heidinger and Kayes 1986). Pond water temperatures during summer in much of the North Central Region are often significantly above 25 °C, which can cause major problems with disease, reduced growth, and mortality in perch (T.B. Kayes and J.A. Malison, unpublished observations). Key findings by UW-Madison researchers in 1989 were that (1) the addition of 75-150 L/min of 11 °C groundwater to a 0.07-hectare pond was sufficient to keep the maximum summer pond water temperature below 24 °C, and (2) perch reared in 1.2-m X 1.2-m X 1.8-m-deep net-pens grew faster and seemed less disturbed by shadows and movements than those reared in 1.2-m X 1.2-m X 1.2-m-deep net-pens. In 1990, Age-0 perch fingerlings stocked at densities of about 148 fish/m³ into 1.2-m X 1.2-m X 1.8-m-deep net-pens, each of which was continuously aerated by a single diffuser, gained significantly more weight over the summer than those stocked at densities of about 610 fish/m³.

In 1991, UW-Madison investigators verified that groundwater addition to ponds, combined with aeration, could be used to prevent ice formation in the vicinity of net-pens, and demonstrated that perch overwintered at temperatures greater than 9 °C (i.e., groundwater temperatures throughout most of the North Central Region) grow significantly better than fish held at pond water temperatures of less than 5 °C (North Central Regional Aquaculture Center December 1991). In 1991, UW-Madison researchers also completed a study that compared the survival and growth of Age-1 perch stocked at densities of about 37 fish/m³ and about 148 fish/m³ into separate 1.2-m X 1.2-m X 1.8-m-deep net-pens, located in two 0.07-hectare ponds either with or without groundwater addition. The findings from this study—plus those from 1992 by MSU researchers to test laboratory-generated optimum loading and density rates in tanks under commercial-scale conditions and by UW-Madison investigators to verify and improve on the net-pen culture data on Age-0 perch—were delineated in the NCRAC Yellow Perch Work Group Progress Report (North Central Regional Aquaculture Center December 1992). Collectively, all the Work Group's findings clearly indicate that the culture of perch in flow-through systems, ponds, and net-pens is technically feasible, with the appropriate facility design and management procedures.

Regardless of species or production system, feed costs comprise a large portion of production costs in most types of aquaculture. From a commercial perspective, optimal diets are those that maximize weight gain and health at minimum cost. Such diets can only be achieved through controlled nutritional studies on the species in question. Until recently, most diets fed to yellow perch and many other fish species, including hybrid striped bass, have been ones originally formulated for salmonids. These diets have been used because salmonids, perch and hybrid striped bass are generally all considered to be carnivorous. However, detailed investigations on hybrid striped bass have revealed significant differences in optimal nutritional requirements from salmonids (Griffin et al. 1992; Brown et al. In press). Feeding dietary lipid levels above 8% depressed weight gain and feed conversion in hybrid striped bass (D.M. Gatlin, Texas A&M University, personal communications), while dietary levels of 15% are common in diets for salmonids and have been increased up to 30% in some European salmonid diets (Johnsen and Wandsvik 1991). Similarly, recent studies have indicated that optimal levels of essential amino acids in diets for hybrid striped bass are relatively low, compared to salmonids.

Griffin et al. (1992) reported a dietary lysine requirement for hybrid striped bass of 1.4% of the diet, or 4.0% of dietary protein. Dietary lysine requirements vary among fish species, but generally range from 1.2-2.9% of the diet, or 3.7-6.1% of dietary protein. For the hybrid striped bass, Griffin and Brown (1992) reported a dietary total sulfur amino acid (TSAA) requirement of 0.73% of the dry diet and estimated the TSAA requirement at 0.84% of the dry diet. Differences between experimental diets (primarily crystalline amino acids vs. intact protein, respectively) probably explain these minor differences. Brown and Griffin (1992) reported a dietary arginine requirement for hybrid striped bass of 1.5% of the dry diet. Total sulfur amino acid and arginine requirements for other fish species range from 0.6-1.6% and from 1.0-2.8%, respectively. Thus,

certain salmonid diets containing high levels of lipid appear to be detrimental to growth of hybrid striped bass, and their essential amino acid contents may be excessive, which diminishes cost-effectiveness for hybrid striped bass culture. A similar pattern seems to be emerging with yellow perch.

Detailed nutritional studies on yellow perch have been done only in the past 3 years. Don Garling and his students at MSU initiated this line of research by determining the optimum ratio of protein to non-protein dietary energy for perch. In their studies, perch on purified diets grew as well when fed 26% dietary protein as when fed higher protein levels (D.L. Garling, personal communication). This 26% value is much lower than the optimal dietary protein requirement reported for any other fish species. This finding emphasizes the possible advances that nutritional research can make in helping a new aquaculture industry. The most expensive component of most animal diets is protein, and any reduction can result in significant savings in feed costs, and eventual production costs. Again, diets normally considered near optimal for salmonids may be overly fortified for perch.

Despite the overall lack of information on yellow perch nutritional requirements, feed mills in the North Central Region are being contacted regarding perch diet manufacture. Hubbard Milling Company (Mankato, Minnesota), one of the largest feed companies in the region, recently began offering a diet for perch that is being formulated based on the results of recent research at MSU and Purdue University. While that diet and Hubbard's participation in aquaculture development hold the promise of significantly lower feed costs, production-scale field trials using diets manufactured in the region have not been conducted.

Irrespective of technical feasibility, yellow perch aquaculture will not be commercialized unless it can be proven cost-effective. Specific procedures for estimating production costs have been developed for catfish, trout, salmon, and a variety of other cultured fishes (Shang 1981; Keenum and Waldrop 1988; Meade 1989; Bjorndal 1990; Hinshaw et al. 1990; Pillay 1990). The fixed costs associated with aquaculture--e.g., for land, capital, buildings, ponds, tanks, water supply and electrical systems, machinery and equipment, labor, insurance, property taxes, overhead, and management--are often highly variable, depending on region, site, management skills, and other factors. The variable costs of aquaculture--e.g. for seed stock or fingerlings, feed, pond fertilizers, chemicals (herbicides and chemotherapeutants), electricity, and pumping--tend to be strongly influenced by species and production method (i.e., flow-through raceway or tank, pond, cage or net-pen culture). To our knowledge, no systematic evaluations of different methods of commercially producing food-size yellow perch have ever been made. Field trials, because of their focus on evaluating (small-scale) research findings under (larger-scale) practical conditions, provide a mechanism for doing this.

ANTICIPATED BENEFITS

This project is aimed at addressing the priority needs for advancing yellow perch aquaculture that have been identified by the Industry Advisory Council of the NCRAC. These needs are: (1) developing economic information for various fish culture strategies; (2) transferring technology developed in laboratories to the aquaculture industry; and (3) improving technology for certain key facets of yellow perch aquaculture. The proposed field trials will generate much needed data on the costs of selected components of yellow perch aquaculture, using production-scale settings and the best technologies currently available. The field trials will also be an excellent vehicle by which to scale-up technologies developed in (small) laboratory settings to commercial systems. In this regard, the distribution of technology will be greatly aided by the participation of numerous private fish farms that are spread across the region and use a wide range of fish culture practices. Finally, the results of the experiments incorporated into this proposal will immediately help fish farmers improve the production efficiency of both fingerling and food-size yellow perch.

OBJECTIVES

The overall goal of this project is to develop practical strategies for commercial yellow perch aquaculture under the diverse environmental conditions that exist in the North Central Region. Specific objectives are:

1. To determine the commercial scale feasibility and improve on the best intensive tank and pond culture practices for the production of yellow perch fingerlings.
2. To determine the commercial scale feasibility of raising food-size yellow perch in flow-through raceways or tanks, open ponds, and large net-pens, comparing the best available formulated diets.

PROCEDURES

Intensive Tank and Pond Culture of Fingerling Yellow Perch (Objective 1)

Field trials and studies to evaluate and improve on present best intensive tank and pond rearing practices for the large-scale culture of yellow perch from fry to fingerlings will be coordinated by investigators from the University of Nebraska-Lincoln (UN-L), Ohio State University (OSU), the University of Wisconsin-Madison (UW-Madison) and the University of Wisconsin-Milwaukee (UW-Milwaukee). Culture techniques developed by the Yellow Perch Work Group's research will be evaluated by field trials under practical conditions, in cooperation with Pleasant Valley Fish Farm of McCook, Nebraska; Red Hook Fisheries, Inc. of David City, Nebraska; Perch Research International, Inc. of Bently, Michigan; Aquatic Management, Inc. of Lisbon, Ohio; Alpine Farms of Sheboygan Falls, Wisconsin; and Coolwater Farms of Dousman, Wisconsin. Production cost data generated by the field trials will be made available to the NCRAC Economics and Marketing Work Group for budget and other detailed economic analyses.

In a cooperative effort with the Alpine Farms/Glacier Springs fish hatcheries, the UW-Milwaukee will conduct a production-scale field demonstration of intensive yellow perch fry rearing. For these studies the Prquimans River (North Carolina) stock of perch will be used, because in a previous study, fry of this stock exhibited better swim-bladder infection and survival than other stocks when reared intensively in tanks. The owners of Alpine Farms/Glacier Springs will be instructed in the intensive rearing strategies used at the UW-Milwaukee. Green tank water (GTW) and brine shrimp nauplii culture facilities will be set up at Alpine Farms, in advance of perch spawning. Arrangements for procurement and spawning of the required brood fish will be made by the UW-Milwaukee. Fertilized egg strands will be obtained either from tank-reared and spawned broodstock, or alternatively from wild caught fish through arrangements with agencies in North Carolina. The eggs will be incubated and hatched in flow-through incubation tanks. The hatched fry will be reared in 2.4-m-diameter insulated fiberglass rearing units.

Using one or two GTW tanks, and four to six 2.4-m-diameter rearing units, we expect to produce enough fingerlings habituated to starter diet at Alpine Farms to operate their grow-out tank facilities at full capacity for a complete production cycle. Alpine Farms personnel will be trained by UW-Milwaukee personnel in all phases of intensive larval rearing as practiced in previous NCRAC studies. Alpine Farms will make necessary modifications to their facilities to conduct these operations. During the first 6-8 weeks post hatch the UW-Milwaukee will closely monitor the rearing activities at Alpine Farms, but Alpine Farms personnel will conduct the actual food preparation, feeding, and associated activities.

Records of costs, labor and other expenses associated with implementing these rearing activities will be kept. The volume of eggs stocked in the rearing units, the incidence and timing of periods of substantial mortality will be recorded. Samples of fish (20-30 per tank) will be examined, at 1, 2 and 3 weeks post hatch to determine growth and swim bladder inflation success. At 6-8 weeks post hatch, following complete habituation to formulated starter diet, the number of surviving fish in each rearing unit will be determined and samples (20-30) of fish will be collected from each rearing unit for assessment of growth. From this point forward in the production cycle Alpine Farms will be responsible for record keeping of daily mortality, amounts fed, the time required to reach market size, and the subsequent numbers and weights of fish eventually sold or kept as brood fish.

At the UW-Milwaukee, intensive rearing trials will be conducted comparing duplicate groups of perch reared using the standard feeding procedure and duplicate groups of perch fry incorporating fatty-acid boosted food items. For these trials, perch eggs from a stock (Lake Mendota or Green Bay) of perch having serious swim bladder inflation and spinal deformation problems when reared intensively will be incubated, hatched and stocked into four 2.4-m-diameter rearing units. We will prepare an emulsion containing a commercially available fatty-acid booster having significant proportions of highly saturated fatty acids (85.05% of total fatty-acids; 22:6w3 = 49.26% and 20:5w3 = 27.43%). Green tank organisms and artemia nauplii will be incubated in aerated solutions containing this emulsion at approximately 100 ppm for 6-12 hour prior to being fed to the perch larvae. Two of the rearing units will receive these fatty-acid boosted live foods, and the two other rearing units will be fed live foods prepared without this treatment. Both experimental groups will be monitored for survival, growth and swim bladder inflation weekly for 6 weeks post hatch, to determine whether this technique can improve the performance of the intensive larval rearing scheme.

In the second year of the project, the intensive fingerling production effort will be repeated at Alpine Farms, incorporating any new improvements or developments in the intensive larval rearing strategy.

A second perch farm (Perch Research International, Inc., Bently, Michigan) is willing to participate in the transfer of intensive larval rearing technology from the UW-Milwaukee. Although this fish farm is too distant to permit close monitoring by the UW-Milwaukee, we will instruct the operators in intensive larval rearing techniques. Using their own broodstock and recording the numbers of eggs stocked and the resulting

fingerlings produced and habituated to formulated feeds, Perch Research International will provide an additional field demonstration of the feasibility of these culture practices under commercial conditions.

Researchers at the UW-Madison will conduct field trials in collaboration with Coolwater Farms, Dousman Wisconsin, a commercial fish farm that has been producing pond-reared perch fingerlings habituated to formulated diets for over 8 years. These field trials will evaluate, under commercial conditions, the effectiveness of using high pond stocking densities, supplemental (pond) feeding and early pond harvest as methods to maximize the production of pond-reared perch fingerlings under intensive culture conditions. For these studies, Coolwater Farms and UW-Madison personnel will be jointly responsible for all data collection and record keeping, and Coolwater Farms will be responsible for routine operating costs, utilities, fish and fish eggs, pond fertilizers, and supplies used at their facility.

Perch fry used in these studies will be the offspring of Coolwater Farms' domesticated broodstock. By precisely controlling environmental conditions and other variables, Coolwater Farms personnel are able to induce oocyte maturation and ovulation in hundreds of female brood fish within a 2-4-day time frame during late April. Routine procedures will be used to strip, fertilize, and incubate eggs collected from ripe female perch. All eggs will be "force-hatched" in tanks using a recently developed method that permits an accurate determination of the number of hatched fry (Malison et al. In preparation). Fry will be stocked into production ponds that are supplied with continuous aeration and inorganic and organic fertilizers at rates determined to be optimum for Coolwater Farms' ponds.

One field trial will evaluate selected high stocking rates of fry to maximize the production of pond-reared perch fingerlings. This trial will use several of the 0.15-0.25-hectare production ponds at the Coolwater Farms facility. Additional fingerling production ponds at the UW-Madison Aquaculture Center's main research facility at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin are also available if needed. All ponds in the study will be stocked with 1-6 million fry/hectare (exact stocking rates will be determined following preliminary studies conducted in 1993). A selected number of the ponds will be managed using supplemental feeding techniques. The proposed stocking rates are based on the observations of UW-Madison researchers who harvested over 500,000 fingerlings/hectare from ponds stocked with 1 million fry/hectare (Malison and Held 1992). To provide for as many replicate groups as possible, the trial will be repeated in the two successive years of this project.

Dissolved oxygen levels and temperatures in the ponds will be measured in the morning at depths of 0.3 and 1.2 m. The growth of the fish will be monitored by measuring samples of 10 fish from each pond at regular intervals (e.g., weekly). When the mean fish size in a pond reaches 16-18 mm TL (a size at which fingerling perch can be successfully habituated to formulated diets--see **RELATED CURRENT AND PREVIOUS WORK**), harvesting or supplemental feeding for that pond will be initiated. Supplemental feeding will continue until the fish reach 22-28 mm TL, at which size our preliminary observations suggest that the vast majority should exhibit a strong feeding response.

Ponds will be harvested with a light trap system similar to that described by Mancini et al. (1983). Each pond will be harvested on a nightly basis until the number of fish harvested from a pond decreases to less than 10,000 per night. Based on previous observations, 80-90% of the fish in each pond should be captured using the light trap system.

The number of fish harvested from each pond will be estimated gravimetrically, and the mean weight and length of fish from each pond will be determined from subsamples. Cumulatively, the procedures used for this field trial should provide an accurate assessment of the total number of perch fingerlings/hectare that can be harvested from production ponds under practical conditions.

A second set of field trials will be conducted by UW-Madison investigators and Coolwater Farms to evaluate the effects of fingerling size at harvest and supplemental (pond) feeding on the habituation of pond-reared perch fingerlings to formulated diets and intensive culture conditions. These studies will be done on a commercial production scale and utilize two commercially available diets.

In one study, perch fingerlings not exposed to supplemental feeding will be transported to the UW-Madison Aquaculture Center's Lake Mills research facility. Groups of fingerlings will be harvested from ponds when they reach 13, 15, and 17 mm TL, and each group will be stocked into three 750-L flow-through tanks at 15,000 fish/tank. Initially, the perch will be fed Fry Feed Kyowa (Kyowa Hakko Kogyo Company, Ltd., Tokyo, Japan), a diet used successfully with other larval fishes and small fingerlings. When the fish reach an appropriate size, the diet will be switched to Ziegler Salmon Starter (Ziegler Bros. Inc., Gardner, Pennsylvania), a diet known to be readily accepted by perch fingerlings >17 mm TL.

In a second study we will compare the habituation to intensive culture conditions of fingerlings either exposed or not exposed to supplemental feeding. The methods used will be similar to those outlined above, except that fingerlings will be harvested from ponds at 22-28 mm TL.

For both of the above trials the general protocols and fish husbandry procedures described by Malison and Held (1992) will be used. In brief, the rearing tanks will be provided with tempered water (21 ± 0.5 °C at a flow rate of 12 L/min), airstone aeration, and continuous illumination using submerged lights. Fish will be fed continuously throughout the day with automatic feeders, as well as several times daily by hand. The tanks will be cleaned and dead fish removed and counted on a daily basis.

The end points measured in each of these trials will be: (1) habituation, defined as the percentage of fish that survive the transition to formulated feeds and intensive culture conditions; (2) starvation, defined as the percentage of fish that die and are recovered; and (3) cannibalism, defined as the percentage of fish that cannot be accounted for at the end of the habituation intervals. Our definition of starvation has been substantiated by observations in similar studies in which virtually all dead fish recovered have been extremely emaciated, and losses which could be attributed to disease or other causes (e.g., mechanical injury) have been negligible. Our definition of cannibalism has been substantiated by observations of cannibalistic behavior and the fact that fish cannot escape from the tanks through the standpipe screens or by any other means. Trials will be terminated when the number of dead fish recovered daily drops to less than 0.05% of the total, and all remaining fish are actively feeding. Growth rates of fish from the different groups will be measured both during the habituation interval and for the following 90 days.

For all field trials coordinated by UW-Madison researchers, accurate records on all cost inputs and net total production will be kept, and the information will be forwarded to the NCRAC Economics and Marketing Work Group.

The Nebraska studies on perch fingerling production will consist of field trials that will focus primarily on evaluating the effectiveness and costs, under practical conditions, of best pond culture practices, as determined by recent biological research. These studies will be integrated with related Nebraska field trials (Objective 2) that will compare different methods of culturing perch from fingerling to food size. Terry Kayes of the UN-L will coordinate and provide guidance on the set up and conduct of the Nebraska field trials, will provide oversight on appropriate technical matters and data collection, and will be responsible for data analysis and the preparation of NCRAC reports and any publications from those trials. William Hahle, the owner/operator of Pleasant Valley Fish Farm (Pleasant Valley), and David Gerhold, the principal proprietor of Red Hook Fisheries (Red Hook), will be responsible for all routine fish culture activities, pond management, water quality monitoring, data collection and record keeping, as well as all on-site licenses or permits and on-site overhead and routine operating costs, e.g., for labor, utilities, fish or fish eggs, pond fertilizers, fish feeds, or chemicals.) (Background information on these two fish farmers and their operations is provided under **FACILITIES**).

The Nebraska fingerling production field trials will be performed in three 0.2-0.3 hectare x 1.5-m-deep ponds at Pleasant Valley and two 0.2-hectare x 1.2-m-deep ponds at Red Hook. All five ponds have sandy or sandy-clay bottoms, can be supplied with 14-15 °C well water, and for the field trials will be equipped for aeration. Electrical service for the aeration systems will be provided by Pleasant Valley and Red Hook. The UN-L will supply the aeration equipment, plus any other specialized research equipment required, and will provide technical assistance on critical matters, such as aeration systems installation and pond harvest. Each year of the project, all five ponds will be stocked and managed in as similar a manner as possible, to compare production and cost data at the two fish farms, which are about 338 km (210 miles) apart (Red Hook is in east central Nebraska; Pleasant Valley is in southwest Nebraska, about 20 miles north of Kansas).

Fertilized eggs for the Nebraska field trials will be obtained by collection from broodstock ponds or by stripping broodstock perch owned by Pleasant Valley, during the normal April spawning season. After water-hardening, the eggs, which are arranged in concertina-shaped strands (Heidinger and Kayes 1986), will be incubated at Pleasant Valley by suspending them from plastic-coated wire hangers in aerated flow-through tanks supplied with pond water at ambient temperatures for 7-10 days. One or 2 days before hatch, the eggs will be transferred into floating wire-mesh cages placed in the ponds at both Pleasant Valley and Red Hook. Present plans are to fertilize all the ponds with alfalfa pellets at a rate of 200 kg/hectare per week, initiated a week before stocking and continued on a weekly basis as needed. Also, an inorganic phosphate fertilizer may be added to the ponds as a supplement, as described by Fox et al. (1992). This fertilization strategy may be modified, however, depending on the maintenance of dissolved oxygen concentrations above critical levels in the ponds.

All five ponds will be equipped with subsurface diffused-air distribution systems because of concerns that mechanical aerators or airlift pumps might kill perch fry. Present plans are to employ "FAT CAT" systems (Aquatic Ecosystems, Inc., Apopka, Florida), which essentially consist of a low-pressure blower, delivery pipe, and floating plastic airlines with hanging air tubing with air stones, which are suspended above the pond bottoms. The FAT CAT and similar systems are widely used in the ornamental fish industry in Florida and the penaid shrimp industry in Central and South America, and have the advantages of simplicity of design and easy removal from ponds to facilitate repairs, fish harvest and other management activities. These systems

are normally designed to operate on a continuous basis and work primarily by mixing the water in ponds to facilitate gas exchange with the atmosphere (Boyd 1990).

In Year 1 of the project, all five ponds will be stocked at a rate of about 1.2 million eyed-eggs/hectare, as described by Malison and Held (1992). In Year 2, the stocking rate may be increased, decreased, or kept the same, depending on the results of Year 1 and the need for replicate production and cost data. Both years, perch fingerlings will be harvested by a "pond-cropping" strategy that employs a light-harvesting system (similar to that described by Mancini et al. 1983), small-mesh trap nets, and pond drainage, in a sequential manner as the fish remaining in the ponds continue to grow larger (see Malison and Held 1992). Significant efforts will be made at modifying Mancini et al.'s (1983) light-harvesting system for production-scale use. One system to be tested will combine moveable floating lights with specially-designed trap nets to harvest fish. Present plans are to begin harvesting when the perch in the ponds first reach about 16-18 mm TL. When the perch in the ponds reach 30-40 mm TL, they will be harvested by pond drainage and/or seining. Following harvest, some or all of the perch will be habituated to intensive culture conditions and a conventional formulated salmon starter diet, using procedures similar to those described by Malison and Held (1992). Present plans are to do this in a variety of indoor flow-through tanks, supplied with pond water (possibly mixed with well water for temperature control), at both Pleasant Valley and Red Hook.

The Nebraska field trials on perch fingerling production will be considered completed each year when the fish reach a size of about 50 mm TL. Throughout the project, principal end points examined will be the percent survival, number, size, size variation, condition factor and general health of the fish produced. Water temperature and dissolved oxygen concentration in tanks and ponds will be measured routinely. In addition, cost inputs will be recorded or determined, as prescribed by the NCRAC Economics and Marketing Work Group. On completion of the fingerling production field trial, perch not scheduled for use in Nebraska field trials on the production of food-size fish (Objective 2) will be sold by Pleasant Valley and Red Hook through normal marketing channels.

Field tests and studies at OSU will evaluate (1) the efficacy of supplemental feeding of perch fingerlings in ponds, and (2) diets formulated based on the findings of ongoing NCRAC-funded studies which are determining the amino acid and fatty acid content of zooplanktonic food of larval perch. Yellow perch broodstock to be used in these studies at Piketon will be offspring of semi-domesticated fish kept originally in ponds at the St. Mary State Hatchery and then weaned to a dry diet indoors at the age of 5 months. Ten days before intended spawning in April fish will be transferred from 5-8 to 13 °C and injected with 100 ug LHRH kg⁻¹. This same procedure was previously used to obtain the present broodstock. According to our experience 100% of females will be ovulating and ready to be stripped within the next 4-5 days. Pre-weighed eggs will be incubated in troughs, with strands of eggs hanging over the wires. At the eyed-stage, embryos will be transferred to the immersing ponds. At the Aquaculture Center at Piketon, six 0.1 hectare ponds will be stocked with 100,000 embryos per pond.

In Byron Bezdek's facility (Aquatic Management, Lisbon, Ohio 44432) located in Trumbull county, four ponds will be available for raising yellow perch. The broodstock was originally brought from a Nebraska farming operation. About 6 racks (sections of pine trees) will be placed in the broodstock pond by the end of March. Spawning is completed in a window of just a few days based on the former three years experience. When the eggs disappear from the spawning racks the breeders will be removed by seine. Previous experience of Bezdek suggests that the presence of broodstock fish in the ponds during this time interval does not impact the survival of the larval fish.

Fry ponds are fertilized with sheep manure and brewer's yeast added at the rate of 56 kg/hectare (50 lbs/acre) to develop a plankton bloom. Juvenile perch are usually observed in schools along the shore about the third week of June.

Historically, the feeding started during the last week of June. In cooperative effort with the owner, we will conduct a production scale field demonstration of a high density (1,000,000 per hectare) yellow perch fry rearing. Four automatic (battery powered) spin feeders will be placed in the pond an equal distance apart already 2-3 weeks after hatching of fish. In previous years Purina 5101 and subsequently 5102 and 5104 were used, but we will introduce a starter diet of smaller size, salmon starter (Ziegler Bros., Inc., Gardner, Pennsylvania). Feeding is set every hour from sunrise to sunset (photocell regulator). Adjustments will be made on frequency and feeding rate during the season. In the second year of the project, the intensive fingerling production will be repeated at Bezdek's farm, incorporating any new findings or improvements experienced in the first year strategy.

Growth of fish at Aquatic Management will be evaluated by trapping fish periodically (one month intervals). At the completion of the grow-out season the total biomass and number of fish will be evaluated. Two experiments at Piketon will compare mass rearing of yellow perch in ponds with intensively reared perch fry in tanks. In the first of these experiments, fish will be raised in two ponds and supplementary feeding will be supplied using formulated diets and salmon starter (Ziegler Bros. Inc., Gardner, Pennsylvania) with automatic

feeders. High fish density forces yellow perch (B. Bezdek, personal communication) to accept dry diets. Feed will be distributed based on samples of fish weight and an 80% survival at 2-4% body weight day⁻¹. Approximately the second week after hatching the supplementary feedings will start. Two ponds will serve as controls without supplementary feeding. Growth rate and survival will be evaluated after 4 weeks.

In the second experiment, fish initially raised in ponds, as described above, will be transferred indoor into six 946 L tanks and stocked at 15 fish per L. Three tanks will be stocked with fish of 10-12 mm TL and three tanks with fish of 12-14 mm TL to evaluate the influence of initial size on habituation of yellow perch to intensive tank rearing. In the second year of studies fish initial size of weaning to formulated diets will be adjusted based on the results obtained. Diets will be formulated in this laboratory based on the findings of amino acid and fatty acid analysis of zooplanktonic food. We will examine the additives of fatty acids, attractants (betaine) and enzyme preparations (Finish Sugar Co., Helsinki) after a preliminary experiment in Spring 1993.

In both the pond and tank experiments, fish growth and survival (based on number of embryos stocked) will be monitored. Production of yellow perch fingerlings will be evaluated based on the number of fish weaned to dry feeds.

Flow-Through, Pond, and Net-Pen Culture of Food-Size Yellow Perch (Objective 2)

Field trials evaluate the production of food-size perch in flow-through raceways or tanks, open ponds, and large net-pens, comparing the best available formulated feeds, will be coordinated by investigators from Purdue University and the UN-L. Culture techniques developed by the Yellow Perch Work Group's research will be evaluated by field trials under practical conditions, in cooperation with Pleasant Valley Fish Farm of McCook, Nebraska; Red Hook Fisheries, Inc. of David City, Nebraska; Sandhills Aquafarm of Keystone, Nebraska; Perch Research International, Inc. of Bentley, Michigan; and Freshwater Farms of Ohio, Urbana, Ohio. Production cost data generated by the field trials will be made available to the NCRAC Economics and Marketing Work Group for budget and other detailed economic analyses.

The Nebraska field trials on the production of food-size perch will focus primarily on evaluating the effectiveness and costs, under practical conditions, of best culture practice in raceways or tanks, open ponds, and large net-pens, as extrapolated from recent smaller-scale experiments by the Yellow Perch Work Group. As part of this effort, selected practical formulated diets will be tested in the different types of culture systems examined. Terry Kayes of the UN-L will coordinate and provide guidance on the set up and conduct of the Nebraska field trials and will provide oversight on appropriate technical matters and data collection from those trials. William Hahle, the owner/operator of Pleasant Valley Fish Farm (Pleasant Valley), David Gerhold, the principal proprietor of Red Hook Fisheries (Red Hook), and Michael Wyatt, the owner/operator of Sandhills Aquafarm (Sandhills), will be responsible for all routine fish culture activities, general management, water quality monitoring, data collection and record keeping, as well as all on-site licenses or permits and on-site overhead and routine operating costs -- e.g., for labor, utilities, fish or fish eggs, fish feeds, or chemicals. (Background information on these fish farmers and their operations is provided under **FACILITIES**).

Paul Brown of Purdue University will focus primarily on the diet-testing aspects of Objective 2, will conduct controlled feeding trials at the Purdue University Fish Nutrition Laboratory, and will provide guidance on the set up and conduct of the Michigan and Ohio field trials and oversight on data collection from those trials. George Matousek, the principal proprietor of Perch Research International, and David Smith, the owner/operator of Freshwater Farms of Ohio, will be responsible for all routine fish culture activities, general management, water quality monitoring, data collection and record keeping, as well as all on-site licenses or permits and on-site overhead and routine operating costs -- e.g., for labor, utilities, fish or fish eggs, fish feeds, or chemicals. Kayes of the UN-L and Brown of Purdue will coordinate on data analysis and the preparation of NCRAC reports and any publications, for the field trials in all three states (Nebraska, Michigan, and Ohio).

At each field trial site, perch fingerlings obtained or provided by the respective owner/operator involved will be stocked into the production system(s) to be evaluated, as soon as practical in the spring of both 1994 and 1995. To the extent possible, the assigned rearing densities in all systems and the assigned loading rates in raceways or tanks will be at levels determined to be optimal by prior small-scale experiments of the Yellow Perch Work Group. The fish at each site will be assigned to replicate treatment groups for the appropriate statistical evaluation of the culture systems and diets being tested. In situations where rearing space and time allow, three or four groups of fish will be assigned to each treatment. Otherwise, duplicate treatment groups will be used. Every effort will be made to initiate the field trials on about the same date each year at all sites. Depending on size, the fish at all sites will be fed two to four times daily, either to satiation (in raceways or tanks) or on a set ration based on estimated body weight (in open ponds or large net-pens); and apparent feed consumption will be determined or estimated for the fish fed each diet.

The field trials examining production technologies and diets will be continued until about October 15 of each year, at which time all the fish in each treatment group at each site will be harvested, counted, and weighed.

For these studies, principal end points examined will be the percent survival, number, size, size variation, weight gain, condition factor and general health of the fish produced, as well as feed consumption and conversion efficiency by the different treatment groups. Fillet samples will be collected from representative fish from the different treatment groups at each site, then immediately frozen and shipped to Purdue University for proximate analysis (AOAC 1984). Water temperature and dissolved oxygen concentration in raceways, tanks, ponds, and net-pens will be measured routinely throughout these field trials (as will pH and ammonia- and nitrate-nitrogen, when appropriate). In addition, cost inputs will be recorded or determined, as prescribed by the NCRAC Economics and Marketing Work Group. On completion of the field trials, the perch produced will be sold by the participating fish farmers through normal marketing channels.

Turning to the specific experimental treatments to be evaluated by these production trials, diets fed in Year 1 will be the new yellow perch diet manufactured by Hubbard Milling Company (Mankato, Minnesota), a floating trout-grower diet from Ziegler Brothers, Inc. (Gardners, Pennsylvania), a sinking trout diet from Silver Cup (Sterling H. Nelson and Sons, Inc., Murray, Utah), and a "soft-moist" diet from Bioproducts, Inc. (Warrenton, Oregon). Every effort will be made to keep gross nutritional parameters (e.g., crude protein and fat) similar among the various diets tested, realizing that their essential amino acid patterns will most likely vary depending on ingredients. Diets evaluated in Year 2 of the project will include the best diet from Year 1, plus two additional commercial diets that are available to fish producers in the North Central Region.

The Nebraska studies on the production of food-size perch will be integrated with related Nebraska field trials (Objective 1) that will evaluate the effectiveness and costs of perch fingerling production in ponds. At Pleasant Valley, fingerlings of 50-60 mm TL that have been habituated to two of the diets to be tested will be stocked into four 0.03-0.04 hectare x 1.5-m-deep ponds. Present plans are to stock each pond with about 8,000 fingerlings, feed the fish in two of the ponds on one test diet and the fish in the other two ponds on the other diet, then transfer the fish when they reach 100-125 mm TL to four larger 0.1-hectare x 1.5-m-deep ponds for "grow-out" on the same two diets. All the ponds will be equipped for continuous aeration using the same type of subsurface diffused-air distribution systems employed for Objective 1. In addition, mechanical aerators will be available for emergency aeration. The ponds will also be supplied with 14-15 °C well water to keep pond water temperatures between 20 and 24 °C during hot weather and to maintain water quality. The ponds will be harvested by drainage and/or seining.

At Red Hook, fingerlings that have been habituated to the same two diets being tested at Pleasant Valley will be raised to a size of about 100 mm TL in replicate sets of either 1.8- or 2.4-m-diameter x 0.9-m-deep cylindrical tanks or 2.0-m x 2.0-m x 2.0-m-deep net-pens suspended in a single 12-m-diameter x 3.0-m-deep tank, supplied with a temperature-adjusted (20-24 °C) mixture of 56 °C well water and water from a 20-hectare x 12-m-deep sandpit lake. Regardless of size, the tanks or net-pens will be stocked uniformly and at levels to ensure optimum performance -- i.e., tank rearing densities and loading rates will not exceed 85 kg/m³ and 0.85 kg/L per min of water flow, respectively. At about 100 mm TL, fish raised on each of the two diets will be transferred into each of two 4.0-m x 4.0-m x 3.0-m-deep net-pens located in the sandpit lake. Present plans are to stock each net-pen with about 6,000 fish for "grow-out" on the same two diets. All of the tanks and net-pens will be aerated by diffusers; the four large net-pens will be equipped for continuous aeration by airlift pumps. Mechanical aerators will be available for emergency aeration. Generally, the water temperature in the sandpit lake does not exceed 25 °C.

At Sandhills, fingerlings that have been habituated to the same two diets being tested at the other two Nebraska field trial sites will be stocked into replicate net-pens arranged at the head end and tail end of a series of four side-by-side, three in-series trout raceways (for a total of 12 raceways) that are each 2.4-m wide x 33.5-m long x 1.2-m deep (with a water depth of 0.9 m). This arrangement will allow for the comparison of the two diets at two different dissolved oxygen and ammonia levels and will provide information on the potential feasibility of using the effluent water from trout raceways for perch culture. Donaldson-strain rainbow trout will continue to be raised in the raceways, but at levels adjusted to account for the rearing space used by the perch. The perch net-pens will be separated from the trout by screens or screened baffles. The loading rates (kilograms of fish/L of water flow) will be the same as those normally used at Sandhills.

At Sandhills, present plans are to (1) place two 1.0-m³ square net-pens at the head end of each of the first four raceways and at the tail end of each of the last four raceways, (2) stock the two net-pens at each of the eight locations with an equal number of perch of about 100 mm TL that have been raised on either one or the other of the two diets being tested, and (3) then continue the "grow-out" of these eight groups of fish in the raceways comparing the same two diets. In essence, this is a 2 x 2 factorial experimental design with four replicate groups per treatment, to evaluate the effects of diet and water quality. Because perch are not particularly tolerant of sustained strong water currents, all of the net-pens will be arranged behind baffles, such that the main water flow in the raceways is directed below the net-pens. Present plans are to maintain perch rearing densities at uniform levels between treatment groups at about 85 kg/m³, if possible. However, this value may be changed, depending on the availability of fish and the need to maintain fish health. Water temperatures in the raceways at Sandhills during the growing season can vary between 13 and 22 °C but are normally about 17-20 °C.

As previously noted, in a given year the same two diets will be tested at all three Nebraska field trial sites. Over the 2-year course of the project, this strategy will provide three different diets in several different culture systems -- including flow-through raceways and tanks, open ponds, and net-pens. At Purdue University, the same diets, plus two or three others, will be evaluated under controlled experimental conditions in indoor tank recirculating systems. At Perch Research International in Michigan, perch will be raised in cages in existing bodies of water. At Freshwater Farms of Ohio, perch will be raised either in recirculating systems or in cages in existing ponds. As with the Nebraska field trials, stocking rates, rearing densities, and management practices for the Purdue, Michigan and Ohio studies, to the extent possible, will be consistent with procedures for optimal "grow-out" of perch, as determined by previous small-scale experiments of the Yellow Perch Work Group.

For all studies and field trials conducted under Objectives 1 and 2, data will be collected and analyzed, and the findings published in a timely manner in appropriate peer-reviewed national or international scientific journals. Extension information outlining the practical implications and benefits of the work will be published through regional and station bulletins, in collaboration with the NCRAC Extension Work Group.

FACILITIES

Intensive Tank and Pond Culture of Fingerling Yellow Perch (Objective 1)

The aquaculture laboratories at the UW-Milwaukee Center for Great Lakes Studies have over 740 m² of floor space for rearing units. They are supplied with municipal tap water from a Lake Michigan source. This water supply is dechlorinated by chemical reduction with sodium sulfite. The total capacity of the dechlorination system is approximately 1,900 Lpm (500 gpm). A portion of this water is heated by natural gas boilers and electrical immersion heaters. Hot and cold water supply lines and compressed air lines supply the rearing facilities. Rearing temperatures are typically controlled by blending the hot and cold supplies and passing the inflow to the rearing unit through packed columns to adjust gas saturation to near atmospheric equilibrium. Refrigeration units are available to maintain cold temperatures. The rearing units have photoperiod controlled lighting fixtures. A variety of large circular fiberglass tanks are available as rearing units, ranging in 2.4 m (8 ft), 1.2 m (4 ft., and 0.76 m (30 in) diameters. There are also rectangular and oval tanks and a variety of small aquaria. Total tank capacity is approximately 77 m³ volume (>20,000 gal). Rearing units are typically operated on a flow through basis, but we have limited volume operated on a recirculating basis. We also have fish transporting units, the largest of which holds 1,400 L (370 gal.) In addition there are a wide variety of instrument shop, analytical laboratory, research vessel limnological equipment, library and computing facilities housed at the Great Lakes Research Facility.

Alpine Farms is a recently established indoor fish culture facility supplied with artesian well water. This facility is in Sheboygan Falls, Wisconsin, and is owned and operated by John Hyink and John Wolf. The owners also are in the well drilling business and have the equipment and ability to further develop their ground water supply. The current operation involves the rearing of whitefish and yellow perch in eight 2.4 m (8 ft.) diameter fiberglass tanks. Additional outdoor ponds are under construction and additional outdoor rearing tanks or raceway tanks are being considered to expand these facilities. John Hyink and John Wolf also own "Glacier Springs", a second rearing facility in Sheboygan County, Wisconsin. They are in the process of renovating this former trout hatchery which was originally established in the late 1940's but has been inactive for 15 years. On this site are earthen raceways and existing ponds ranging in size from less than one to several acres in size. Both of these sites are within 80 km of the University of Wisconsin-Milwaukee/CGLS laboratory.

Perch Research International, Inc. is operated by George Matausek and currently has broodstocks of perch from the Great Lakes region. Most rearing is currently carried out extensively with a variety of ponds. Operations of an intensive rearing type are planned within the time frame of this proposal.

Field trials coordinated and/or conducted by the UW-Madison will use fry and fingerling perch supplied by Coolwater Farms, Dousman, Wisconsin. Coolwater Farms currently has over 1,000 perch selected as brood fish and annually produces over five million perch fry. Field trials evaluating high pond stocking densities and early pond harvest will be conducted at Coolwater Farms. For these studies, Coolwater Farms has offered the use of three of their 0.2-0.25 hectare fingerling production ponds. These ponds are provided with high-volume well water inputs, electrical service, gravity drains, continuous aeration systems, and fixed or floating piers; effective fertilization regimes have been developed for the ponds by Coolwater Farms personnel over the last 8 years. Coolwater Farms also has much of the equipment needed to conduct the proposed trials, including that for monitoring water quality and harvesting and accurately enumerating fingerlings. Depending on their availability, ponds of the UW-Madison Aquaculture Center at the Lake Mills State Fish Hatchery (see below) may be used in these trials, to increase the number of replications and/or to serve as back-ups to the ponds at Coolwater Farms.

Field trials designed to evaluate the effects of fingerling size at harvest and supplemental (pond) feeding on the habituation of pond-reared perch fingerlings to formulated diets and intensive culture conditions will be done at the UW-Madison Aquaculture Center's main wet and analytical laboratories at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin. The Center has all of the facilities and equipment needed to capture and transport brood fish and fingerlings, collect and incubate eggs, and rear fish in tanks and ponds. These facilities include access to many of the 32 ponds at the hatchery, a live-haul truck, two boats, 11 trap nets, and over 100 fiberglass rearing tanks. The facility has an ample supply of temperature-regulated (10 to 30 ± 0.5 °C) well or carbon-filtered city water. For these field trials 9 750-L round fiberglass tanks will be used to habituate perch fingerlings to formulated feeds.

The Nebraska field trials on the pond production of fingerling perch will be coordinated by Terry Kayes of the UN-L and will be done at the Pleasant Valley Fish Farm (Pleasant Valley) near McCook and at Red Hook Fisheries, Inc. (Red Hook) near David City. William Hahle, the owner/operator of Pleasant Valley, has 20 years of experience with the commercial culture of many different cold-, cool- and warm-water fish species, and has had over six years of experience with the commercial production of perch fingerlings that are habituated to formulated feeds. Physical resources available at Pleasant Valley include: 40 1.2-1.5 m deep earthen ponds ranging in surface area from 100 m² to 0.3 hectare, seven wells with pumping depths of 3-24 m and a combined capacity of 1,800 L/min of 14-15 °C water, a 93-m² hatch house supplies with both pond and well water, a variety of indoor and outdoor rearing tanks, and amply electrical power to run pond and tank aeration systems. David Gerhold, the principal proprietor of Red Hook, has been a commercial fish producer for about five years, presently runs a virtually integrated operation that raises and processes about 100,000 kg of rainbow trout and other fish per year, and has been working on perch aquaculture for about two years. Physical resources available at Red Hook include: a 20-hectare X 12-m-deep sandpit (high-volume groundwater seepage) lake equipped with a floating pier, five 12-m X 12-m X 9.1-m-deep net-pens, three 12-m X 12-m X 4.6-m-deep net-pens, plus a variety of smaller net-pens; two 0.2-hectare X 1.2-m-deep earthen ponds; four 30-m-long X 2.4-m-wide X 1.2-m-deep concrete raceways; two 12-m-diameter X 3.0-m-deep cylindrical steel rearing tanks, plus a variety of smaller rearing tanks; three wells with a combined capacity of 13,600 L/min of 14-15 °C water; a hatch house supplied with both lake and well water; and sufficient electrical power to run pond and tank aeration systems. Both Pleasant Valley and Red Hook, as well as the UN-L, have the "live-haul" tanks and trucks necessary to transport fish and fish eggs. The UN-L has all the field gear, aeration and research equipment needed to coordinate and facilitate the field trials proposed.

At OSU, Konrad Dabrowski's wet laboratory in Kottman Hall (167 m²) is equipped with fish rearing tanks, fish egg incubation apparatus and acclimation chambers. This laboratory includes features for water temperature-control and sterilization systems. The biochemical laboratory in Kottman Hall includes a biofreezer (-85 °C), refrigerate centrifuge, freeze-drier, drying ovens, spectrophotometer DU-70, Beckman HPLC system, Varian 3400 gas chromatography system, and other accessories for biochemical research studies. Facilities at Piketon Research and Extension Center include 14 ponds, an aquaculture building equipped with several fish tanks and recirculation system, and temperature and light control rooms. The main building of the field station contains aquaculture, chemical, and biological laboratories. Facilities available for this project at Aquatic Management, Inc., in Lisbon, Ohio will include four ponds and all necessary equipment to conduct the proposed studies.

Flow-Through, Pond, and Net-Pen Culture of Food-Size Yellow Perch (Objective 2)

The Nebraska field trials on the production of food-size yellow perch in different types of culture systems will be coordinated by Terry Kayes of the UN-L and will be done at the Pleasant Valley Fish Farm (Pleasant Valley) near McCook, at Red Hook Fisheries, Inc. (Red Hook) near David City, and at Sandhills Aquafarm (Sandhills) near Keystone. The facilities available at Pleasant Valley and Red Hook have been described previously (for Objective 1). Sandhills is a modern, well-designed trout production facility that was built in 1989. Michael Wyatt, the owner/operator of Sandhills and the current President of the Nebraska Fish Farmers Association, is an experienced trout grower who is interested in expanding into the production of other species. The primary rearing facilities at Sandhills consist of 12 concrete raceways; four side-by-side and three in series. Each raceway is 2.4 m wide X 3.5 m long X 1.2 m wall height (with a 0.9 m water depth) and is equipped with baffles. The water flow through each raceway is 5,870 L/min for a total flow of 23,500 L/min through the facility. Bypass flow around the raceways through a 15.2-cm-diameter pipe is 1,890 L/min. In 1990, the raceways were equipped with a low-head pure oxygen supplementation system. Production is presently about 36,300 kg/year of Donaldson-strain rainbow trout, with a projected maximum capability of about 77,000 kg/year. The water supply at Sandhills comes from Whitetail Creek, which originates from springs about 1.6 km upstream of the raceways. Water temperatures in the raceways during the summer can vary between 13 and 22 °C but are normally about 17-20 °C. During winter, the water temperatures can vary between 2 and 8 °C but are normally about 6-7 °C. All three participating fish farms, as well as the UN-L, have the "live-haul" tanks and trucks necessary to transport fish. The UN-L has all the field gear, aeration and research equipment needed to coordinate and facilitate the field trials proposed.

Feeding trials at Purdue University will be conducted in a new aquaculture research facility that is operational and fully equipped for such studies. The new facility encloses a 687-m² wet laboratory, supplies with temperature-controlled, filtered well water. Similarly the Purdue University Fish Nutrition Laboratory is completely equipped for routine proximate analyses of fish and crustaceans. The Michigan and Ohio fish producers participating in the project have the necessary production systems, fish, and expertise necessary to initiate the field trials proposed.

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PROJECT LEADERS

<u>State</u>	<u>Name/Institution</u>	<u>Area of Specialization</u>
Indiana	Paul B. Brown Purdue University	Aquaculture/Nutrition
Nebraska	Terrence B. Kayes University of Nebraska-Lincoln	Aquaculture Production/Fish Physiology and Nutrition
Ohio	Konrad Dabrowski Ohio State University	Larval Fish Culture/Nutrition/Physiology
	James E. Ebeling Ohio State University	Aquaculture
Wisconsin	Fred P. Binkowski University of Wisconsin-Milwaukee	Finfish Aquaculture/Larval Fish Culture
	Jeffrey A. Malison University of Wisconsin-Madison	Aquaculture/Physiology/Endocrinology

PARTICIPATING INSTITUTIONS AND PRINCIPAL INVESTIGATORS

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University of Wisconsin-Madison (UW-Madison)

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Terrence B. Kayes

Ohio State University (OSU)

Konrad Dabrowski

James M. Ebeling

Purdue University

Paul B. Brown

**PROPOSED YELLOW PERCH BUDGET FOR
UNIVERSITY OF WISCONSIN-MILWAUKEE**

(Binkowski)

Objective 1

					Year 1	Year 2
					Year 1	Year 2
A. Salaries and Wages	No.	FTEs	No.	FTEs		
1. No. of Senior Personnel & FTEs ¹						
a. (Co)-PI(s)	1	0.08	1	0.08	\$0	\$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals	2	0.25	2	0.25	\$10,000	\$10,000
c. Graduate Students						
d. Prebaccalaureate Students ...						
e. Secretarial-Clerical						
f. Technical, Shop, and Other ...						
Total Salaries and Wages					10,000	10,000
B. Fringe Benefits (30% of 2b)					\$3,000	\$3,000
C. Total Salaries, Wages and Fringe Benefits					13,000	13,000
D. Nonexpendable Equipment					\$0	\$0
E. Materials and Supplies					\$1,000	\$1,000
F. Travel - Domestic (<i>Including Canada</i>)					\$1,000	\$1,000
G. Other Direct Costs					\$0	\$0
TOTAL PROJECT COSTS PER YEAR (C through G)					15,000	15,000
TOTAL PROJECT COSTS					30,000	

¹FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR UNIVERSITY OF WISCONSIN-MILWAUKEE

(Binkowski)

- A. Salaries and Wages.** This covers the labor for the UW-Milwaukee/Center for Great Lakes Studies laboratory investigations for "improvements" to the intensive larval fish rearing practices, and the interactive activities with the private aquaculturists and the associated sampling, data analysis and report preparation.
- E. Materials and Supplies.** This covers the cost of fish foods, fatty acid booster, miscellaneous aquarium supplies and hardware, phone charges, office and record keeping supplies, computer paper, discs, etc., for the UW-Milwaukee/CGLS based activities.
- F Travel.** This covers the cost of travel by UW-Milwaukee/CGLS to interact with Alpine Farms/Glacier Springs during the intensive larval perch rearing. In addition, one trip to Perch Research International, Inc. in Bentley, Michigan will be included in our travel schedule.

**PROPOSED YELLOW PERCH BUDGET FOR
UNIVERSITY OF WISCONSIN-MADISON**

(Malison)

Objective 1

					Year 1	Year 2
					Year 1	Year 2
A. Salaries and Wages	No.	FTEs	No.	FTEs		
1. No. of Senior Personnel & FTEs ¹						
a. (Co)-PI(s)	1	0.06	1	0.06	\$0	\$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals	1	0.30	1	0.30	\$8,000	\$8,480
c. Graduate Students						
d. Prebaccalaureate Students ...						
e. Secretarial-Clerical						
f. Technical, Shop, and Other ...	1	0.40	1	0.40	\$7,700	\$7,700
Total Salaries and Wages					15,700	16,180
B. Fringe Benefits					\$3,300	\$3,450
C. Total Salaries, Wages and Fringe Benefits					19,000	19,630
D. Nonexpendable Equipment					\$0	\$0
E. Materials and Supplies					\$2,800	\$2,170
F. Travel - Domestic (<i>Including Canada</i>)					\$1,200	\$1,200
G. Other Direct Costs					\$0	\$0
TOTAL PROJECT COSTS PER YEAR (C through G)					23,000	23,000
TOTAL PROJECT COSTS					46,000	

¹FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR UNIVERSITY OF WISCONSIN-MADISON

(Malison)

- A. **Salaries and Wages.** Salaries are needed for personnel to conduct the habituation trials and collect and collate data for both the pond harvest and habituation trials.
- E. **Materials and Supplies.** Supplies needed include fish food, general wet-laboratory supplies used to conduct the habituation trial, and office and record keeping supplies needed for both trials.
- F. **Travel.** Travel needed to attend NCRAC Yellow Perch Work Group meetings and for UW-Madison personnel to travel to Coolwater Farms for data collection.

**PROPOSED YELLOW PERCH BUDGET FOR
UNIVERSITY OF NEBRASKA-LINCOLN**

(Kayes)

Objectives 1 and 2

					Year 1	Year 2		
					Year 1		Year 2	
A. Salaries and Wages	No.	FTEs	No.	FTEs				
1. No. of Senior Personnel & FTEs ¹								
a. (Co)-PI(s)	1	0.05	1	0.05	\$0	\$0		
b. Senior Associates								
2. No. of Other Personnel (Non-Faculty) & FTEs								
a. Research Assoc./Postdoc								
b. Other Professionals								
c. Graduate Students								
d. Prebaccalaureate Students								
e. Secretarial-Clerical								
f. Technical, Shop, and Other	1	0.50	1	0.50	\$8,600	\$9,200		
Total Salaries and Wages					8,600	9,200		
B. Fringe Benefits (25% of 2f)					\$2,150	\$2,300		
C. Total Salaries, Wages and Fringe Benefits					10,750	11,500		
D. Nonexpendable Equipment					\$0	\$0		
E. Materials and Supplies					\$1,330	\$760		
F. Travel - Domestic (<i>Including Canada</i>)					\$2,720	\$2,540		
G. Other Direct Costs					\$200	\$200		
TOTAL PROJECT COSTS PER YEAR (C through G)					15,000	15,000		
TOTAL PROJECT COSTS					30,000			

¹FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR THE UNIVERSITY OF NEBRASKA-LINCOLN

(Kayes)

- A. Salaries and Wages.** A research technician (0.5 FTE) is needed to assist the principal investigator with (1) the fabrication, installation and/or maintenance of all research equipment for the field trials, including water-temperature monitoring, aeration, and pond harvesting systems or gear; (2) the set up, coordination, and monitoring of the field trials; (3) gathering critical data, such as fish size and numbers at the beginning and end of field trials; and (4) the compilation of production and cost data for more detailed analyses. The technician will also help the participating fish farmers with troubleshooting problems and critical operations such as pond harvesting, when necessary and appropriate.
- E. Materials and Supplies.** Hardware and other supplies are needed to fabricate, install and/or maintain the aeration systems, pond harvesting systems or gear, and research equipment necessary to conduct and collect data on the field trials (e.g., temperature recorders, dissolved-oxygen meters). Office and computer supplies are needed for data entry and processing, statistical analyses and graphics production. The total funding required for supplies in year 1 and 2 is \$1,330 and \$760, respectively.
- F. Travel.** The UN-L components of the proposed project will require considerable in-state travel during both funding years. Critical travel distances are as follows: (1) from the UN-L to Pleasant Valley Fish Farm 246 miles; (2) from the UN-L to Red Hook Fisheries 58 miles; (3) from Red Hook Fisheries to Pleasant Valley Fish Farm 257 miles; and (4) a round-trip from the UN-L to both sites 561 miles. Total estimated in-state travel costs for lodging, meals and fleet vehicle rental for Year 1 and 2, respectively, are \$5,440 and \$4,080. About 50% of these costs can be covered by pooling appropriate travel expenses on various UN-L programs and projects under the principal investigator's supervision, which brings the total in-state travel funds requested for year 1 and 2 down to \$2,720 and \$2,040, respectively. In year 2, an additional \$500 is needed to attend a NCRAC Yellow Perch Work Group meeting.
- G. Other Direct Costs.** About \$200 per year is needed to meet telecommunications (telephone, FAX, e-mail), postage, and photocopying expenses.

**PROPOSED YELLOW PERCH BUDGET FOR
OHIO STATE UNIVERSITY
(Dabrowski and Ebeling)**

Objective 1

					Year 1	Year 2
					Year 1	Year 2
					No.	FTEs
					No.	FTEs
A.	Salaries and Wages					
1.	No. of Senior Personnel & FTEs ¹					
a.	(Co)-PI(s)	1	0.05	1	0.05	\$0
b.	Senior Associates					
2.	No. of Other Personnel (Non-Faculty) & FTEs					
a.	Research Assoc./Postdoc					
b.	Other Professionals					
c.	Graduate Students	1	0.25	1	0.25	\$2,400
d.	Prebaccalaureate Students					
e.	Secretarial-Clerical					
f.	Technical, Shop, and Other	1	0.15	1	0.15	\$1,500
	Total Salaries and Wages					3,900
B.	Fringe Benefits					\$300
C.	Total Salaries, Wages and Fringe Benefits					4,200
D.	Nonexpendable Equipment					\$2,700
E.	Materials and Supplies					\$4,100
F.	Travel - Domestic (<i>Including Canada</i>)					\$1,000
G.	Other Direct Costs					\$0
	TOTAL PROJECT COSTS PER YEAR (C through G)					12,000
						TOTAL PROJECT COSTS
						24,000

¹FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR OHIO STATE UNIVERSITY

(Dabrowski and Ebeling)

- A. Salaries and Wages.** Field and laboratory studies will be conducted by a graduate student and a research assistant. Their tasks include sampling at two locations, Mr. Bezdek's facility and at Piketon, initial preparation of samples for analysis, transportation to Piketon, fish and zooplankton sample analysis. Approximately half of the labor in pond and tank experiments will be supported by moneys from the Piketon Center. Additional responsibilities of a graduate student will include: diet preparation and analysis, preparation of daily, weekly and monthly tables and graphs of field and laboratory experiments' schedule.
- D. Nonexpendable Equipment.** We request an addition to our DU-70 Beckman Spectrophotometer, fluorescent detector. This would allow us to use more precise and sensitive methods for enzyme analysis using fluorescent substrates.
- E. Materials and Supplies.** General laboratory and field supplies will include: reagents, glassware, diet ingredients, commercial feeds and replacement parts for laboratory equipment (homogenizers, spectrophotometer).
- F. Travel.** These funds will support transportation, meals and if necessary lodging for the collection of samples in Mr. Bezdek's facility (round trip distance 400 miles). Travel funds will also be used to attend the annual work group meetings and the NCRAC conference to present initial results.

**PROPOSED YELLOW PERCH BUDGET FOR
PURDUE UNIVERSITY**

(Brown)

Objective 2

					Year 1	Year 2		
					Year 1		Year 2	
A. Salaries and Wages	No.	FTEs	No.	FTEs				
1. No. of Senior Personnel & FTEs ¹								
a. (Co)-PI(s)	1	0.01	1	0.01	\$0		\$0	
b. Senior Associates								
2. No. of Other Personnel (Non-Faculty) & FTEs								
a. Research Assoc./Postdoc								
b. Other Professionals								
c. Graduate Students								
d. Prebaccalaureate Students ...	1	0.07	1	0.07	\$1,000		\$1,000	
e. Secretarial-Clerical								
f. Technical, Shop, and Other ...								
Total Salaries and Wages					1,000		1,000	
B. Fringe Benefits					\$32		\$32	
C. Total Salaries, Wages and Fringe Benefits					1,032		1,032	
D. Nonexpendable Equipment					\$0		\$0	
E. Materials and Supplies					\$7,000		\$7,000	
F. Travel - Domestic (<i>Including Canada</i>)					\$1,500		\$1,500	
G. Other Direct Costs					\$468		\$468	
TOTAL PROJECT COSTS PER YEAR (C through G)					10,000		10,000	
TOTAL PROJECT COSTS							20,000	

¹FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR PURDUE UNIVERSITY

(Brown)

- A. **Salaries and Wages.** Salaries, wages and fringe benefits will be used to partially support an hourly employee to help with fish husbandry, water quality measurements and other aspects of the study.
- E. **Materials and Supplies.** Materials and supplies funds will be used for acquisition of fish, feeds and chemicals.
- F. **Travel.** Travel funds will be used for transportation of fish, and dissemination of results.
- G. **Other Direct Costs.** Other direct costs include telephone, FAX, postage, and photocopying.

RESOURCE COMMITMENT FROM INSTITUTIONS¹

State/Institution	Year 1	Year 2
University of Wisconsin-Milwaukee		
Salaries and Benefits: SY @ 0.08 FTE	\$7,150	\$7,507
Supplies, Expenses, and Equipment	\$1,500	\$2,000
Alpine Farms and Perch Research International, Inc. Materials and Supplies	\$3,000	\$5,500
Facilities and Utilities	\$14,700	\$8,500
Total	26,350	23,507
University of Wisconsin-Madison		
Salaries and Benefits: SY @ 0.06 FTE	\$3,200	\$3,200
TY @ 0.1 FTE	\$3,300	\$3,300
Supplies, Expenses, Equipment, and Waiver of Overhead	\$13,500	\$13,500
Coolwater Farms Salaries and Benefits	\$4,500	\$4,500
Supplies and Equipment	\$7,500	\$7,500
Total	32,000	32,000
University of Nebraska-Lincoln		
Salaries and Benefits: SY @ 0.05	\$3,370	\$3,540
Temperature Recorders, Dissolved Oxygen Meters, Aeration Equipment and Systems (installed)	\$6,000	\$0
Travel, Miscellaneous Supplies, and Waiver of Overhead	\$9,220	\$8,540
Red Hook Fisheries, Pleasant Valley Fish Farm and Sandhills Aquafarm (Salaries, Supplies, and Equipment)	\$36,000	\$27,000
Total	54,590	39,080
Ohio State University		
Salaries and Benefits: SY @ 0.08 FTE	\$6,000	\$6,000
TY @ 0.25 FTE	\$8,000	\$8,000
Aquatic Management, Inc. Labor, Supplies, and Equipment	\$6,000	\$6,000
Total	20,000	20,000
Purdue University		
Salaries and Benefits: SY @ 0.20 FTE	\$8,000	\$8,000
Supplies, Expenses, and Equipment	\$8,000	\$8,000
Waiver of Overhead	\$10,000	\$10,000
Perch Research International Salaries and Wages	\$6,000	\$6,000
Supplies and Equipment	\$8,000	\$8,000
Freshwater Farms of Ohio Salaries and Wages	\$8,000	\$8,000
Supplies and Equipment	\$8,000	\$8,000
Total	56,000	56,000
Total per Year	188,940	170,587
GRAND TOTAL	359,527	

¹Since cost sharing is not a legal requirement some universities chose not to provide resource commitment from institutions

SCHEDULE FOR COMPLETION OF OBJECTIVES

Objective 1: Initiated in Year 1 and completed in Year 2.

Objective 2: Initiated in Year 1 and completed in Year 2.

LIST OF PRINCIPAL INVESTIGATORS

Fred P. Binkowski, University of Wisconsin-Milwaukee

Paul B. Brown, Purdue University

Konrad Dabrowski, Ohio State University

James M. Ebeling, Ohio State University

Terrence B. Kayes, University of Nebraska-Lincoln

Jeffrey A. Malison, University of Wisconsin-Madison

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EDUCATION

B.S. University of Wisconsin-Milwaukee, 1971
M.S. University of Wisconsin-Milwaukee, 1974

POSITIONS

Senior Scientist (1991-present) and Associate Scientist (1987-1990), Center for Great Lakes Studies/University of Wisconsin Great Lakes Research Facility (GLRF)
Senior Fisheries Biologist (1984-1986), Associate Fisheries Biologist (1981-1983), and Assistant Fisheries Biologist (1978-1980), Center for Great Lakes Studies/University of Wisconsin GLRF
Research Specialist, Fisheries, Dept. of Zoology, University of Wisconsin-Milwaukee (1975-1978)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society: Early Life History and Fish Culture Sections
International Association for Great Lakes Research (Associate Editor)
World Aquaculture Society

SELECTED PUBLICATIONS

- Miller, T., L. Crowder, J. Rice, and F.P. Binkowski. 1992. Body size and the ontogeny of the functional response in fishes. *Canadian Journal of Fisheries and Aquatic Sciences* 49:805-812.
- Miller, T., L. Crowder, and F.P. Binkowski. 1990. Zooplankton size dynamics and recruitment success of bloater in Lake Michigan. *Transactions of the American Fisheries Society* 119:484-491.
- Luecke, C, J.A. Rice, L.B. Crowder, S.E. Yeo, and F.P. Binkowski. 1990. Recruitment mechanisms of bloater in Lake Michigan: an analysis of the predatory gauntlet. *Canadian Journal of Fisheries and Aquatic Sciences* 47:524-532.
- Seale, D.B., and F.P. Binkowski. 1988. Vulnerability of early life intervals of *Coregonus hoyi* to predation by a freshwater mysid, *Mysis relicta*. *Environmental Biology of Fishes* 21:117-125.
- Rice, J.A., L.B. Crowder, and F.P. Binkowski. 1987. Evaluating potential sources of mortality for larval bloater (*Coregonus hoyi*): starvation and vulnerability to predation. *Canadian Journal of Fisheries and Aquatic Sciences* 44:467-472.
- Sommer, C.V., F.P. Binkowski, M.A. Schalk, and J.M. Bartos. 1986. Stress factors that can affect studies of drug metabolism in fish. *Veterinary and Human Toxicology* 28 (Supplement 1):45-54.
- Stewart, D.J., and F.P. Binkowski. 1986. Dynamics of consumption and food conversion by Lake Michigan alewives: an energetics-modeling synthesis. *Transactions of the American Fisheries Society* 115:643-661.

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EDUCATION

B.S. University of Tennessee, 1981
M.S. University of Tennessee, 1983
Ph.D. Texas A&M University, 1987

POSITIONS

Associate Professor, Department of Forestry and Natural Resources, Purdue University (1993-present)
Assistant Professor, Department of Forestry and Natural Resources, Purdue University (1989-1993)
Assistant Professional Scientist/Field Station Director, Illinois Natural History Survey (1987-1989)
Research Associate, Texas A&M University (1986-1987)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Association for the Advancement of Science
American Fisheries Society: Indiana Chapter; Membership Concerns Committee (National) 1985-present;
Walleye Technical Committee and Walleye Technical Committee (North Central Division) 1988-present;
Fish Culture Section
American Institute of Fishery Research Biologists
International Association of Astacology
World Aquaculture Society
Sigma Xi, Gamma Sigma Delta

SELECTED PUBLICATIONS

- Brown, P.B., M.E. Griffin, and M.R. White. In press. Experimental and practical diet evaluations with juvenile hybrid striped bass. *Journal of the World Aquaculture Society*.
- Brown, P.B., and E.H. Robinson. 1992. Vitamin D studies with juvenile channel catfish (*Ictalurus punctatus*) reared in calcium-free water. *Comparative Biochemistry and Physiology* 193A:213-219.
- Griffin, M.E., P.B. Brown, and A. Grant. 1992. Dietary lysine requirements of juvenile hybrid striped bass. *Journal of Nutrition* 122:1332-1337.
- Reigh, R.C., E.H. Robinson, and P.B. Brown. 1991. Effects of dietary magnesium on growth and tissue magnesium content of blue tilapia *Oreochromis aureus*. *Journal of the World Aquaculture Society* 22:192-200.
- Brown, P.B., W.H. Neill, and E.H. Robinson. 1990. Preliminary evaluation of whole body energy changes as a method of estimating maintenance energy needs of fish. *Journal of Fish Biology* 36:107-108.
- Brown, P.B., and E.H. Robinson. 1989. Comparison of 26 and 30 percent protein feeds for channel catfish. *The Progressive Fish-Culturist* 51:149-151.

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EDUCATION

M.S. Agriculture and Technical University, Olsztyn, Poland, 1972
Ph.D. Agriculture and Technical University, Olsztyn, Poland, 1976
D.Sc. Agricultural University, Szczecin, Poland, 1984

POSITIONS

Visiting Professor of Aquaculture, Ohio State University (1989-present)
Visiting Professor, University of Innsbruck, Austria (1987-1989)
Visiting Professor, Tokyo University of Fisheries, Japan (1984-1985)
Associate Professor, Agriculture and Technical University, Olsztyn, Poland (1972-1985)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

Editorial Board Member for Aquaculture and Aquatic Living Resources
Fisheries Society of British Isles
Japanese Fisheries Society
National Research Council, Washington, Subcommittee on Fish Nutrition (1990-1992)
World Aquaculture Society

SELECTED PUBLICATIONS

- Dabrowski, K., G. Krumschnabel, M. Pauku, and J. Labanowski. 1992. Cyclic growth and activity of pancreatic enzymes of Arctic charr (*Salvelinus alpinus L.*). *Journal of Fish Biology* 40:511-521.
- Dabrowski, K., and G. Kock. 1989. Absorption of ascorbic acid and ascorbic sulfate and their interaction with minerals in digestive tract of rainbow trout. *Canadian Journal of Fisheries and Aquatic Science* 46:1952-1957.
- Dabrowski, K. 1989. Formulation of a bioenergetic model for coregonine early life history. *Transactions of the American Fisheries Society* 118:138-150.
- Dabrowski, K., P. Boczyczynski, G. Kock, and B. Berger. 1989. Effect of fish meal protein substitution by soybean protein in diet on growth, diet utilization and proteolytic enzymes activities in rainbow trout. *New in vivo test for exocrine pancreatic secretion. Aquaculture* 77:29-49.
- Dabrowski, K., F. Takashima, and Y.K. Law. 1988. Bioenergetical model of planktivorous fish feeding, growth and metabolism. Theoretical optimum swimming speed in fish larva. *Journal of Fish Biology* 32:443-458.
- Georgopoulou, U., K. Dabrowski, M.F. Sire, and J.M. Vernier. 1988. Absorption of intact proteins by the intestinal epithelium of trout. Demonstration by luminescence enzyme immunoassay and cytochemistry. *Cell and Tissue Research* 251:145-152.

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EDUCATION

B.A. Albion College, 1971
M.S. Washington State University, 1974
M.S. Washington State University, 1977

POSITIONS

Research and Extension Associate, Piketon Research and Extension Center, Ohio State University (1991-present)
Project Manager, Recirculation Aquaculture Demonstration Project, North Carolina State University (1990-1991)
Research Coordinator, Mariculture Research & Training Center, University of Hawaii (1988-1990)
Research Assistant, Department of Agricultural Engineering, University of California-Davis (1983-1988)
Research Technologist II, Department of Agricultural Engineering, Washington State University (1981-1983)
Technical Specialist, Washington Energy Extension Service-Cooperative Extension Service (1979-1981)
Research Technologist II, Department of Agricultural Engineering, Washington State University (1977-1979)
American Peace Corps Volunteer, Secondary Education Program, Ghana (1971-1972)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Society of Agricultural Engineers
Sigma Xi
World Aquacultural Society

SELECTED PUBLICATIONS

Ebeling, J.M. 1991. A computer based water quality monitoring and management system for pond aquaculture. Pages 233-248 *in* Proceedings from the Aquaculture Symposium, Cornell University, Ithaca, NY, NRAES-49.

Ebeling, J.M., and T.M. Losordo. 1989. Continuous environmental monitoring systems for aquaculture. Pages 54-70 *in* J.A. Wyban and E. Antill, editors. Instrumentation in aquaculture. Proceedings of the World Aquaculture Society, January, Los Angeles, CA.

Losordo, T.M., R.H. Piedrahita, and J.M. Ebeling. 1988. An automated water quality data acquisition system for use in aquaculture ponds. *Aquacultural Engineering* 7:265-278.

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EDUCATION

B.A. Chico State College, 1968
M.A. California State University at Chico, 1972
Ph.D. University of Wisconsin-Madison, 1978

POSITIONS

Associate Professor, Dept. of Forestry, Fisheries and Wildlife, University of Nebraska-Lincoln (1990-present)
Assistant Director and Associate Scientist, University of Wisconsin Aquaculture Program, University of Wisconsin-Madison (1979-1990)
Project Biologist, Aquaculture Research Laboratory, University of Wisconsin-Madison (1974-1979)
EPA Trainee, Laboratory of Limnology, University of Wisconsin-Madison (1970-1972)
Instructor, Department of Biological Sciences, Chico State College (1968-1970)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society: Fish Culture, Bioengineering, Fish Health, Water Quality, and Early Life History Sections
American Society of Zoologists: Divisions of Comparative Endocrinology, Comparative Physiology and Biochemistry, Ecology, and Comparative Immunology
World Aquaculture Society

SELECTED PUBLICATIONS

- Malison, J.A., T.B. Kayes, J.A. Held, T.P. Barry, and C.H. Amundson. In press. Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. *Aquaculture*.
- Kebus, M.J., M.T. Collins, M.S. Brownfield, C.H. Amundson, T.B. Kayes, and J.A. Malison. 1992. Effects of rearing density on the stress response and growth of rainbow trout. *Journal of Aquatic Animal Health* 4:1-6.
- Malison, J.A., T.B. Kayes, J.A. Held, and C.H. Amundson. 1990. Comparative survival, growth and reproductive development of juvenile walleye (*Stizostedion vitreum*), sauger (*S. cadense*) and their hybrids reared under intensive culture conditions. *The Progressive Fish-Culturist* 52:73-82.
- Malison, J.A., T.B. Kayes, B.C. Wentworth, and C.H. Amundson. 1988. Growth and feeding responses of male versus female yellow perch (*Perca flavescens*) treated with estradiol-17 β . *Canadian Journal of Fisheries and Aquatic Sciences* 45:1942-1948.
- Kim, K.I., T.B. Kayes, and C.H. Amundson. 1987. Effects of dietary tryptophan levels on growth, feed/gain, carcass composition and liver glutamate dehydrogenase activity in rainbow trout (*Salmo gairdneri*). *Comparative Biochemistry and Physiology* 88B:737-741.

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Ph.D. University of Wisconsin-Madison, 1985

POSITIONS

Assistant Director, University of Wisconsin Aquaculture Program, University of Wisconsin-Madison (1990-present)
Associate Researcher, University of Wisconsin Aquaculture Program, University of Wisconsin-Madison (1987-1990)
Project Associate, University of Wisconsin Aquaculture Program, University of Wisconsin-Madison (1985-1987)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Association for the Advancement of Science
American Fisheries Society
American Society of Zoologists
World Aquaculture Society

SELECTED PUBLICATIONS

- Barry, T.P., A.F. Lapp, T.B. Kayes, and J.A. Malison. Submitted. Validation of an (ELISA) for measuring cortisol in fish and comparison of stress responses in rainbow trout (*Onchorhynchus mykiss*) and lake trout (*Salvelinus namaycush*). Aquaculture.
- Malison, J.A., T.B. Kayes, J.A. Held, T.P. Barry, and C.H. Amundson. In press. Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. Aquaculture.
- Kebus, M.J., M.T. Collins, M.S. Brownfield, C.H. Amundson, T.B. Kayes, and J.A. Malison. 1992. Effects of rearing density on the stress response and growth of rainbow trout. *Journal of Aquatic Animal Health* 4:1-6.
- Malison, J.A., and J.A. Held. 1992. Effects of fish size at harvest, initial stocking density and tank lighting conditions on the habituation of pond-reared yellow perch (*Perca flavescens*) to intensive culture conditions. *Aquaculture* 104:67-88.
- Kebus, M.J., M.T. Collins, M.S. Brownfield, C.H. Amundson, T.B. Kayes, and J.A. Malison. 1992. Measurement of resting and stress-elevated serum cortisol in rainbow trout *Oncorhynchus mykiss* in experimental net-pens. *Journal of the World Aquaculture Society* 23:83-88.
- Malison, J.A., T.B. Kayes, B.C. Wentworth, and C.H. Amundson. 1988. Growth and feeding responses of male versus female yellow perch (*Perca flavescens*) treated with estradiol-17 β . *Canadian Journal of Fisheries and Aquatic Sciences* 45:1942-1948.