ADVANCEMENT OF YELLOW PERCH AQUACULTURE

Chairperson: Jeffrey A. Malison, University of Wisconsin-Madison

Extension Liaison: Donald L. Garling, Michigan State University (lead); Fred P. Binkowski, University of Wisconsin-Milwaukee; James E. Ebeling, Ohio State University; & Terrence B. Kayes, University of Nebraska-Lincoln

Funding Request: $200,000

Duration: 2 Years (September 1, 1995 - August 31, 1997)

Objectives:

1. Continue to improve larval rearing techniques by developing and evaluating starter diets in relation to size at transfer to formulated feeds under selected environmental conditions.

2. Continue to improve pond fingerling production through examination of in pond feeding using physical/chemical attractants and improved harvesting strategies for different sized fingerlings from various types and sizes of ponds.

3. Continue to develop extension materials and workshops emphasizing techniques coinciding with production events to meet the needs of potential and established perch culturists through on-site presentations at two or more locations in different parts of the region.

Proposed Budgets:

Institution	Principal Investigator(s)	Objec-tive(s)	Year 1	Year 2	Total
Michigan State University	Donald L. Garling	1 & 3	$19,900	$22,600	$42,500
Ohio State University	Konrad Dabrowski	1 & 3	$20,000	$21,000	$41,000
Purdue University	Paul B. Brown	1	$18,000	$18,000	$36,000
Univ. of Nebraska-Lincoln	Terrence B. Kayes	2 & 3	$22,370	$13,630	$36,000
Univ. of Wisconsin-Madison	Jeffrey A. Malison	2 & 3	$18,816	$17,684	$36,500
Univ. of Wisconsin-Milwaukee	Fred P. Binkowski	3	$8,000	$0	$8,000
		TOTALS	**$107,086**	**$92,914**	**$200,000**

Non-funded Collaborators:

Facility	Collaborator(s)
Pleasant Valley Fish Farm, McCook, Nebraska	William Hahle
North Platte State Fish Hatchery, North Platte, Nebraska	Nebraska Game & Parks Commission
Calamus State Fish Hatchery, Burwell, Nebraska	Nebraska Game & Parks Commission
Coolwater Farms LLC, Cambridge, Wisconsin	Dave Northey, Jeff Malison, Harlan Bradt, Vasby Farms, Inc.
Bay Port Aquaculture Systems, Inc., West Olive, Michigan	Forrest Williams and Chris Starr
National Center for Physical Acoustics, University of Mississippi	Robert Derrow II

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JUSTIFICATION

The yellow perch is a highly valued food fish having many characteristics that make it an excellent candidate for commercial aquaculture in the North Central Region (NCR) (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 of perch 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. Stuiber, 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 restauranteurs and homemakers.

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 imbalance between supply and demand of yellow perch fillets has resulted in prices that have remained high for over a decade and continue to climb. For example, in 1990-91 fresh yellow perch fillets retailed for \$17-25/kg (\$8-11/lb) in most markets, and by 1994 had increased to \$22-32/kg (\$10-15/lb). 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).

Early studies on yellow perch conducted in the 1970s and 1980s demonstrated that this species has many biological characteristics that recommend 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 perch under laboratory conditions have been known for some time (Huh 1975; Kocurek 1979), as are methods of raising perch to sexual maturity under natural photoperiod/temperature conditions, so that they can be successfully spawned (Malison et al. 1986).

Despite the excellent long-standing markets for yellow perch and the positive attributes of this species for commercial culture, no significant yellow perch aquaculture industry existed at the inception of the North Central Regional Aquaculture Center (NCRAC) in 1988. During the first several years of its existence, NCRAC identified three primary impediments constraining the development of a perch culture industry. These were: (1) the comparatively slow growth of perch, especially above 50-80 g body weight; (2) the lack of available information on the feasibility of raising food-size perch under a variety of practical rearing conditions; and (3) the lack of information on methods for producing fingerlings that are trained (habituated) to formulated feeds. These constraints were targeted by three separate projects (1989, 1990, and 1991) that were conducted by the NCRAC Yellow Perch Work Group, which have since been completed.

As part of those projects, one line of research was conducted to compare the growth and performance of selected wild stocks of yellow perch, as well as triploids, when reared under intensive culture conditions. Results of this work demonstrated that the offspring of stocks from different geographical locales have temperature-dependent differences in survival, growth, and feed conversion. These findings have been employed by potential perch culturists to select the best performing stocks for specific culture systems. Another line of research evaluated flow-through and pond culture systems for grow-out. In these studies, key production characteristics, including optimum stocking densities, loading rates, and critical water quality parameters, were delineated for perch. A third line of research compared and improved on methods of producing perch fingerlings in tanks and ponds. This latter work identified important advantages and disadvantages inherent to each of these two approaches.

Much of this early research was conducted on a small scale under laboratory conditions, largely because of budgetary constraints and the need for precise (analytical) measurements. Another reason was the relative lack of private perch producers available to cooperate on projects focused on developing or improving practical production technologies and testing new innovations. Over the past several years, however, an emerging yellow perch aquaculture industry has begun to develop in the NCR (see North Central Regional Aquaculture Center 1993 for an overview of the industry). At least six private operations are currently producing significant numbers of food-size perch, and many more are presently starting up. In line with this development, in 1993 NCRAC established as its top research priority on yellow perch to field test (working with private-sector producers under commercial-scale conditions) and improve on the best available methods for producing perch fingerlings and food-size fish. This priority need is the main focus of an ongoing NCRAC project scheduled for completion in August 1995.

The developing yellow perch aquaculture industry, even at its present small size, has created a significant demand for fingerlings that are habituated to formulated feeds. Accordingly, the price of perch fingerlings has recently been increasing, and fingerling producers have not been able to meet the existing demand. In most aquaculture industries, fingerling costs represent a significant percentage of total operating costs (e.g., Landau 1992). For the culture of fish species that are ultimately harvested for the table at such a small size as perch (which are normally marketed in "the round" at 6-11 fish/kg, or 3-5 fish/lb), the cost of fingerlings is an especially important determinant of total production costs. For this reason, NCRAC has determined that the research focus of the proposed yellow perch project should be on improving methods of fingerling production and harvest.

This proposal by the NCRAC Yellow Perch Work Group addresses immediate critical problems that presently constrain the commercial culture of yellow perch. The project is ideally suited for a cooperative regional research effort and involves investigators with appropriate expertise from six different institutions: Michigan State University (MSU), Ohio State University (OSU), Purdue University (Purdue), the University of Nebraska-Lincoln (UNL), the University of Wisconsin-Madison (UW-Madison), and the University of Wisconsin-Milwaukee (UW-Milwaukee). The overall goal of the project is to develop practical strategies for commercial yellow perch aquaculture under the diverse environmental conditions that exist in the NCR. The specific research objectives of the proposed project are to: (1) improve larval rearing techniques by developing and evaluating different starter diets in relation to size at transfer to formulated feeds under selected environmental conditions, and (2) improve pond fingerling production through examination of in-pond feeding techniques using physical/chemical attractants and improved harvesting strategies for different sizes of fingerlings from various types and sizes of ponds. In addition, extension programming will be continued to develop new extension materials and conduct workshops emphasizing techniques, coinciding with production events, to meet the needs of established and potential perch culturists through on-site presentations at two or more locations in different parts of the region.

RELATED CURRENT AND PREVIOUS WORK

Conceptually, there are two basic approaches to producing fingerling fish for commercial aquaculture. In the first, sac-fry are raised to the fingerling stage entirely in tanks. In the second, the fry are stocked in ponds and raised to the fingerling stage, at which time they can be habituated to formulated diets. At present, the best established approach to raising yellow perch to food size is to stock and raise the sac-fry to fingerlings on natural forage in intensively managed fertilized ponds, and then to harvest the ponds and habituate the fingerlings to formulated feed in tanks. After that, the feed-trained fingerlings can be raised to food size in tanks, ponds, cages, or net-pens.

The principle advantages of intensively culturing fish fry in tanks are that pond culture facilities are not needed, survival at different stages of fry development can be monitored, and environmental and nutritional variables can be manipulated (with the long-term goal of maximizing survival and growth). An additional potential advantage of tank culture is that, if methods can be developed to control the annual reproductive cycle and induce out-of-season spawning, then fry could be raised to fingerling size throughout the year.

The principle disadvantages of intensive fry culture in tanks are that it tends to be labor intensive, and typically requires elaborate incubation, rearing, and environmental control systems, all of which can be expensive and rarely have any equity value to help secure financing. A critical disadvantage of existing procedures for tank-culturing perch fry is that, in fish smaller than 25 mm total length (TL), an inverse relationship exists between fish size and survival on formulated diets (Best 1981). Accordingly, fish below about 17 mm TL must be fed live food organisms that have been cultured in the laboratory or collected from wild sources.

The principle advantages of pond culture are that large numbers of fish can be produced (over 570,000 perch of 25 mm TL/ha) (Manci et al. 1983) in already existing ponds at a comparatively low cost in labor and supplies, and that ponds and the land they are built on typically have equity value that can be used to secure financing. The success rate in training healthy pond-raised perch above 25 mm TL to formulated feed is normally high (Best 1981). In addition, skeletal and other deformities often observed in tank-cultured fry and early fingerlings are rarely observed in pond-cultured perch (though emaciation may occur if the forage base in ponds drops below critical levels).

The principle disadvantages of pond culture techniques are that new pond construction can be expensive and is feasible only at certain sites, and that survival, numbers, and condition of fish produced are sometimes difficult to predict and can be quite variable from year-to-year and pond-to-pond. Signs of specific nutritional deficiencies or imbalances are almost never observed in pond-raised perch. However, young pond-reared perch that have been subjected to food deprivation (due to forage depletion) or excessive harvesting stress can be difficult to habituate to formulated diets and are quite susceptible to disease. In this regard, the timing and method of harvest are critical to effective pond culture and the subsequent habituation of fingerlings to feed in tank culture (Best 1981; Manci et al. 1983; Malison and Held 1992).

At present, it is not clear which exact approach or combination of approaches to producing perch fingerlings will ultimately prove to be the most cost effective and widely accepted by commercial growers. Furthermore, a choice of effective approaches for producing perch fingerlings would benefit a broader spectrum of fish producers than one single "best method." Accordingly, the research described in this proposal is aimed at improving both tank and pond fingerling production techniques.

Improve Larval Rearing Techniques by Developing and Evaluating Starter Diets (Objective 1)

Ultimately, the preferred method for rearing larval perch in tanks would be to develop a formulated diet which is both accepted by the fry and nutritionally complete. Perch fry at hatch are normally about 5 mm TL (see Heidinger 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. Until recently, attempts to culture large numbers of yellow perch from hatch through early-fry stages in tanks have not been successful.

Over the past six years, researchers at 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 one week at 18-23°C, large numbers of large ciliate protozoa and rotifers bloom, and within two to four 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 d 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 tanks was dramatically lower than those reared in ponds. 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.

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.

During 1994, workers at Bay Port Aquaculture Systems, with assistance from Don Garling of MSU, intensively raised yellow perch fry on *Artemia* nauplii from first feeding. They collected spawn from wild yellow perch captured from the outer Saginaw Bay of Lake Huron near Bayport, Michigan. Female brood fish ranged from 200 to 350 mm TL. Over 50% of the females were larger than 250 mm TL. Through experience, workers at Bayport have observed that smaller and larger females do not produce acceptable spawn. Smaller female spawners produce eggs of poorer quality as evidenced by lower hatch rates, while larger females often produce flaccid egg masses.

Eggs were incubated in specially designed incubation units that consistently produce high hatch rates. Well water, at approximately 11°C, was used throughout egg incubation. Approximately 165 fry/L were reared in 330-L oval tanks containing approximately 185-L of water. A constant flow of well water was supplied to replicate tanks with either top or bottom inflow at a rate of 5.4 L/min (1.75 turnover/hr). Temperature was increased slowly to approximately 15°C over the next five days.

At 3 d posthatch (initiation of swim up), fry were approximately 5.8 mm TL. Fry were fed <u>newly</u> hatched Great Salt Lake brine shrimp at a density of 7500/L at 12 d posthatch. This was increased to 15,000/L at 15 d posthatch. These levels of *Artemia* were maintained until the conclusion of the total *Artemia* feeding stage. At approximately 30 d posthatch, the yellow perch larvae were weaned from *Artemia* nauplii to dry feeds, a combination of Biokyowa and AP 100. The amount of dry feed was increased daily and the brine shrimp were reduced daily until approximately Day 40 when only the dry feeds were fed.

Fry reared in tanks supplied with bottom water inflows had extremely low initial survival and were discontinued. Fry reared in tanks supplied with top water inflows had excellent survival (> 50%) over the first 30 d. At Day 33 to 35 posthatch, mortalities increased substantially. Many of the moribund and dead fry had non-inflated swim bladders, a common problem observed in intensively reared walleye (*Stizostedion vitreum*) fry until new tank systems designed to remove surface protein/lipid films were developed to reduce the incidence of non-inflated swim bladders (R. Summerfelt, Iowa State University, personal communication). After the three day period of very high mortalities, survival remained high. Approximately 15% survival was observed at three months posthatching.

The excellent survival of yellow perch fry fed *Artemia* from first feeding by Bayport Aquaculture may have resulted from a number of factors.

First, the relatively low incubation temperatures used by Bay Port could have been responsible. Hokanson and Kleiner (1974) observed that yellow perch subjected to low incubation temperatures over the optimum range (10-20°C) had an increased chance for survival when transferred to higher temperatures. They also survived longer on available yolk reserves.

Second, rotifers or other small feed items may have been present in the water supply. Although possible, this seems unlikely since fry were initially maintained on well water.

Third, the larvae may have been large enough to consume first hatch *Artemia* nauplii because of the large size of female spawners. Larger female spawners may produce larger eggs and larvae. Mansuetti (1964) has observed that yellow perch egg diameters ranged from 1.6-2.1 mm TL before water hardening and expanded to 1.7-4.5 mm TL after water hardening. Newly hatched prolarvae have been observed to range from 4.7 to 6.6 mm TL (Heidinger and Kayes 1986) and fry lengths at hatch have been shown to be extremely variable (Mansuetti 1964). However, no attempts have been made to correlate the average size of perch eggs or prolarvae with the size of the female spawner. The sizes of eggs and fry of some marine fish do, however, increase with the size of female spawner within the same strain of fish (Rothschild 1986).

Fourth, the <u>newly</u> hatched *Artemia* used by Bayport may have produced small sized nauplii. Mansuetti (1964) did have limited success feeding *Artemia* to perch greater than 13 mm TL. However the yellow perch larvae fed artemia by Bayport Aquaculture did not reach 13 mm TL until Day 25, and nauplii had been observed in their stomachs before this size. The size and nutritional quality of newly hatched brine shrimp has been shown to be a function of the strain and size of cyst (Bengtson et al. 1991; Beck and Bengtson 1982). Raisanen and Applegate (1983) observed that first feeding yellow perch larvae consumed prey items from 0.2 to 0.4 mm when fed mixed wild collected zooplankton. Similar observations have been made when rearing the closely related European perch (*Perca fluviatilis* L.). Wang and Ward (1972) determined that the ratio of mouth gape width to total length of yellow perch fry increases rapidly compared to body length. Based on their observations, a 10 mm TL yellow perch would have a mouth gape width of approximately 0.8 mm while a 15 mm TL yellow perch would have a mouth gape of approximately 1.6 mm. Unfortunately, the ratio was not reported for smaller larvae. Using these estimates, very small *Artemia* nauplii (Beck and Bengtson, 1982) should be able to be consumed by larval perch smaller than 10 mm TL.

Fifth, fry and prey densities used by Bayport were <u>much</u> higher than most previous workers have used with yellow perch. Larval densities in laboratory larvae feeding trials have been at or below 5/L (Confer and Lake 1987; Hale and Carlson 1972; Raisanen and Applegate 1983). Prey concentrations have also been lower than that used by Bayport. Hale and Carlson (1972) recommended feeding 250 lake collected zooplanktonic organisms per larval yellow perch daily over four feedings to obtain 50% survival during the first three weeks of feeding. At their larval densities, total prey density was only 1,250/L or about one-sixth that used at Bayport. A. Ostrowski (Oceanic Institute, personal communication) has also observed that larval survival of both mahimahi (*Coryphaena hippurus*) and moi (*Polydactylus sexfilus*) are increased dramatically at higher densities of larvae and *Artemia* nauplii.

Sixth, larval yellow perch were reared at cooler temperatures at Bayport than those normally considered optimum for prolarvae or rearing and feeding larval perch. Hokanson and Kliener (1974) reported that optimum temperatures for these stages range from 20 to 23.9°C.

The significant mortalities that occurred on Days 33 to 35 posthatch in the 1994 trial at Bayport may have been the result of the quality of *Artemia* used, the failure of the fingerlings to transfer to dry feeds, or the type of feed used. Larval mahimahi survival rates have been improved significantly by including enrichment regimes for *Artemia* nauplii high in n-3 HUFAs (Brownell and Ostrowski 1989). Mortality of larval mahimahi attributed to unenriched *Artemia* nauplii were observed relatively early during larval development. Consequently, *Artemia* nauplii enrichment may not be required to successfully rear larval perch on *Artemia* nauplii since high levels of early mortalities were not observed. Increased mortality has also been observed to occur a few days after the initiation of the weaning process in other larval fishes (Kim et al. 1993). Best (1981) observed that survival of yellow perch larvae was directly related to size. Less than 50% of 16 mm TL yellow perch survived when started on the Spearfish W-7 starter mash and #1 crumble (600 to 800 µm). Binkowski (personal communication) has been able to feed small yellow perch dry feeds. The Bayport yellow perch were approximately 15 mm TL when weaning to dry feeds was attempted. Hale and Carlson (1972) were able to wean late postlarvae yellow perch from zooplankton to Oregon Moist Pellets at about three weeks posthatch.

Part of this project is designed to enhance intensive larval rearing at commercially viable levels. MSU will work cooperatively with Bayport Aquaculture Systems to develop commercially viable, simplified intensive fry culture techniques. The techniques will be based on Bayport Aquaculture's limited initial success, techniques developed through previous NCRAC sponsored programs and research completed at the Oceanic Institute (OI). OI has developed successful larval culture methods for the mahimahi that have recently been used successfully for the Pacific threadfin or moi.

Fry of the mahimahi and moi are similar in size to yellow perch fry at first feeding. The principal features of the larval rearing system at OI were outlined by Kim et al. (1993) as: (1) incubation of eggs at low temperature and rearing larvae at high temperature; (2) *Artemia* as the sole food, initially unenriched and later enriched; (3) absence of phytoplankton; (4) carefully regulated feeding rate; (5) daily cleaning of the tank bottom; (6) transfer to a clean tank on about Day 14; (7) high water flow; (8) moderate aeration and water turbulence; (9) transfer of larvae to raceway systems at metamorphosis; (10) weaning to pellets as early as possible; and (11) water current to control aggressive behavior. Many of these features were used by Bayport in their first attempt to intensively rear larval yellow perch. In addition to improved culture conditions, research efforts will simultaneously focus on improved diets.

Numerous chemical compounds have been identified as feed flavors in diets fed to fish. Feed flavors are defined as chemical compounds that elicit a feeding response when incorporated into diets for the target species. Crystalline amino acid diets have been readily accepted by juvenile hybrid striped bass (Brown et al. 1993), yellow perch (unpublished data from Purdue University), and several other species. These have been the focus of numerous studies (Caprio 1975; Caprio and Byrd 1984; Mearns 1985; Jones 1989; Pavlov and Kasumyan 1990; Sveinsson and Hara 1990; Crnjar et al. 1992; Hughes 1993). Commercial supplies of feed grade amino acids are just now becoming available.

Most recently, there has been interest in betaine as a flavor additive in diets fed to fish. Betaine is commercially available from a number of suppliers, and in the free base form is a known flavor additive (G.L. Rumsey, personal communication). It has less of a response in the hydrochloride form (Hughes 1993). There are also several new compounded flavor additives that are available, but the composition is proprietary. Both betaine and the compounded additives can be legally used at the present time, if labeled properly. According to sources within the U.S. Food and Drug Administration (FDA), if chemical compounds added to fish diets are labeled as flavor additives, then they would not be a concern to FDA. If they are labeled as gustatory stimulants, then that implies a physiological response and the compounds would have to be labeled as drugs. The swine and poultry industries use a number of flavor additives in diets without undergoing FDA scrutiny and petitions.

The legal use of betaine at the present time is as a partial substitute for the choline requirement. Biochemical pathways in fish are similar to other vertebrates. The essential amino acid methionine is catabolized to a number of metabolic products including cyst(e)ine, the water soluble vitamin choline and betaine. Supplying any of these compounds in the diet spares some of the dietary requirement for methionine (Combs 1992). Thus, the interrelationship among nutrients becomes quite complex, but the bottom line is that there are legal mechanisms for using the flavor additive betaine in diets fed to fish. This will be one of the focal points in this line of research. If we can identify flavor additives that elicit a feeding response in first-feeding yellow perch, we will have the capability of uniform, predictable growth and survival of this new aquaculture species.

Production techniques for freshwater larval fish have been considerably improved in the last decade (Dabrowski 1984; Dabrowski and Culver 1991). However, the variable mortality encountered during larval fish "metamorphosis" (this definition excludes freshwater salmonids, acipenserids and ictalurids, which have large, precocious larvae) continuously impairs a steady supply of hatchery-reared juveniles. Houde (1994) argued, based on comparison of weight-specific metabolic rate, that oxygen consumption of marine fish larvae was nearly twice that of freshwater larvae, and concluded that the former are unlikely to suffer from starvation but rather from variation or sudden changes in their habitat. However, freshwater percids, yellow perch specifically, have larvae size and appearance resembling the marine fish. The probability of episodic mortalities due to incomplete, nutritionally unbalanced diets in association with high metabolic demand, in intensive, high density conditions, is increased. Therefore, taxa-specific, as well as related to the metamorphosis of this species, systematic studies on the formulated diet acceptance and utilization are required. Despite the overall lack of information on nutritional requirements of percids, the findings in the previously funded projects of this work group established the amino acid and fatty acid profiles of yellow perch body during early ontogeny (Dabrowski et al. 1991). This data is essential in providing guidance in dry diet formulations for the proposed, detailed study.

Improvements in larval diet formulation to be tested include the following: (1) additives acting as attractant as well as of nutritional value to fish, such as freeze-dried zooplankton, krill, fish tissues, and soluble fish protein concentrate; (2) enzyme additives (partly purified pancreatic enzymes which include proteases and amylase; Carter et al. 1994; Kolkowski et al. 1993); (3) attractant additives (betaine, free amino acids); and (4) technical aspects of diet preparation (micro-particulated diets, protein-bounded, etc.).

The second area of interest in intensive culture of yellow perch is the properties of the physical environment, light intensity and ionic strength (salinity). Although, European perch (*Perca fluviatilis* L.) larvae require light to feed (Dabrowski and Jewson 1984), the optimum threshold is unknown for yellow perch, and it would not be surprising that tank-reared fish would perform significantly better when the habitat is optimized.

Improve Pond Fingerling Production and Harvest Strategies (Objective 2)

The fish culture and management techniques that characterize most types of commercially profitable aquaculture are almost always operationally simple, though considerable ingenuity and much experimentation may have gone into their development. From the practical standpoint, simple yet effective approaches to stocking, feeding, and harvesting are critical components of most finfish aquaculture industries, and are typically among the primary determinants of profitability (Dupree and Huner 1984; Pillay 1990). As an example, the methods devised to determine appropriate stocking and rearing densities, the discovery and advancement of procedures used to feed fish in ponds, and the invention and improvement of the seine-reel/live-car harvesting system not only help define modern large-scale catfish farming, they have also played a major role in making that industry such a commercial success (Dupree and Huner 1984; Tucker 1985; Tucker and Robinson 1990).

Because of its inherent simplicity, pond culture remains by far the predominant and generally preferred method of producing fingerling fish worldwide, even in certain species for which technologically sophisticated intensive culture procedures have been developed (Pillay 1990). As with many species, the standard strategy for producing yellow perch fingerlings that are trained to formulated diets involves the use of tandem pond-tank rearing systems in which sac-fry are stocked into fertilized production ponds, reared until they reach 35-50 mm TL, and then harvested and stocked into flow-through tanks where they are habituated to formulated feed. With this strategy, the efficiency of production of feed-trained fingerlings is ultimately determined by the number of fish harvested from ponds and the percentage of fish successfully habituated to formulated feed.

From the practical standpoint, assuming an inverse relationship between the number and the size of young fish that can be raised on a given amount of natural forage, the number of fingerlings that can be produced in a pond is normally directly linked to the number of fry stocked, which in turn is normally geared by the producer to the size of fish desired at harvest. Historically, however, the latter has been determined largely on the basis of the size of fish that can be harvested by conventional methods, such as seining or pond drawdown to a catch basin, rather than on maximizing the numbers of fish harvested of a size that can be readily habituated to formulated feed. This traditional approach has been the most common one used in the pond culture of yellow perch fingerlings.

Under most conditions, harvesting fish at sizes less than 30-35 mm TL by seining or pond drawdown typically results in unacceptable levels of stress or mechanical injury and subsequent post-harvest mortality. Best (1981), Malison and Held (1992), and more recent related research by UW-Madison and UNL investigators have repeatedly demonstrated that yellow perch at 17-30 mm TL can be readily habituated to formulated diets. To optimize the tandem pond-tank rearing strategy of producing feed-trained perch fingerlings, cost-effective low-stress methods of harvesting large numbers of small fish (17-30 mm TL and smaller) on a commercial scale from heavily stocked ponds need to be developed and systematically evaluated.

The number of fingerling fish that can be reared in production ponds is dependant on many factors, including water quality, food availability, predation, and cannibalism (Li and Mathias 1982; Keast and Eadie 1985; Swanson and Ward 1985; Colesante et al. 1986; McIntyre et al. 1987). Stimulation of heavy phytoplankton and zooplankton blooms by pond fertilization can greatly enhance the growth and production of fry and early fingerling fish in ponds. A variety of organic and inorganic fertilizers have been used, including alfalfa pellets, various forms of phosphate, animal manures, seed meals, and hays (Richard and Hynes 1986; Buttner 1989; Harrell et al. 1990; Fox and Flowers 1990; Harding 1991; Fox et al. 1992). Such fertilizers provide nutrients and substrates for phytoplankton, and detrital bacteria and protozoa, which in turn are consumed by zooplankton.

Fertilization, however, also increases the chemical and biochemical oxygen demand of ponds, 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 to critical levels, 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; 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 rate of decomposition of organic matter.

With proper management, fingerling production of coolwater species such as yellow perch and walleye typically ranges from 40,000-140,000 fish/ha of pond surface area when fish are harvested at 35-50 mm TL (e.g., Buttner 1989; Summerfelt et al. 1993). Until recently, this was generally the smallest size fish routinely produced by public or private hatcheries. Little published information is available regarding the production of smaller fingerlings. However, it is implicit that the number of fingerlings that can be produced in ponds will be maximized by using high fry stocking densities and harvesting fish at the smallest possible size. The degree to which this strategy can improve fingerling production has been repeatedly demonstrated by UW-Madison researchers, who have successfully harvested over 500,000 perch fingerlings/ha of pond area (Manci et al. 1983; Malison and Held 1992). Malison and Held (1992) suggested that such high production was accomplished primarily because the fingerlings were harvested at a small size (17-20 mm TL). Using a similar approach, UNL investigators have also produced large numbers (300,000 - 600,000+/ha) of both perch and walleye fingerlings of 18 - 30 mm TL.

Habituation rates of pond-reared fingerlings to formulated diets are profoundly influenced by the size and condition of the fish at harvest, and habituation rates will likely decrease if fingerlings are harvested at too small a size. Experience by UW-Madison researchers over the past 10 years indicates that habituation rates of 65-85% 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, but increased substantially at 20-40 mm TL. 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 clearly indicates that the production of habituated perch fingerlings using tandem pond-tank systems can be greatly enhanced by using high fry stocking densities coupled with early pond harvest. An important component of the ongoing NCRAC yellow perch project is to examine the use of these and other techniques to maximize fingerling perch production under practical field conditions. This project is scheduled to end in August 1995.

Although tandem pond-tank culture systems have been used successfully for years to produce fingerlings, these systems tend to be labor intensive and require both pond and tank culture facilities. A potentially simpler and less costly approach, if feasible, would be to habituate fingerlings to formulated feed while they are still in ponds. Such an approach (e.g., by broadcasting starter diets onto ponds when fingerlings reach a certain minimum size) has been recommended for the production of fingerlings of several fish species having larval feeding stages, including hybrid striped bass (Hodson and Hayes 1990), redfish (Davis 1991), and baitfish (Gray 1990). Potential drawbacks to this method are that it may require frequent feeding and feeding rates of 25-50% of body weight per day (Kerby 1986). Such high feeding rates are required primarily to present feed to fish that are probably widely dispersed throughout the ponds. In recent years (according to Mike Freeze of Keo Fish Farms, Keo, Arkansas, and others, personal communications), many, if not most, major producers of hybrid striped bass have been using truck-mounted blowers to broadcast formulated starter diets, two or three times daily, around the periphery of production ponds containing phase-I fry and early fingerlings, apparently with excellent results in terms of fish production. However, the extent to which the fish are directly consuming the feed, compared to the extent to which the latter may be being utilized by plankton and various forage organisms, is apparently unknown.

As part of the ongoing NCRAC yellow perch project, UW-Madison investigators are presently evaluating systems and methods of habituating perch fingerlings to formulated feeds while still in ponds. A key feature of their approach is the use of underwater lights to attract the highly photopositive young perch to the vicinity of vibrating automatic feeders. Briefly, one system being tested consists of a set of vibrating automatic feeders attached to floatation devices that are distributed over a pond's surface. There are 15-30 such feeding stations per hectare of pond surface area. A submerged 12 V light is located next to each feeder. A timing system activates the feeders to deliver feed in a series of short (< 1 s) pulses. When the system is activated at night the lights act to concentrate large numbers of the photopositive perch in the vicinity of the feeders, and the fish are frequently exposed to the feed as it is released. Overall, the five tests that have been conducted to date using this system have yielded very promising results. Complementary field and laboratory analysis indicate that more than 625,000 perch/surface ha (250,000 perch at 25 - 40 mm TL /surface acre) can be produced, and that >95% of these are habituated to formulated feed.

Until now, methods of rearing perch fingerlings trained to formulated feed in ponds have focused on the production of relatively small (25-40 mm TL) fish. Conceptually, if these methods are as potentially effective as initial results indicate, there may be no need to harvest the fingerlings from production ponds until the end of the first growing season. Almost nothing is known about perch growth or the production levels (i.e., number or weight of fish per surface ha of pond area) that could be achieved employing this approach. Based on tank studies using near optimal growing conditions, perch could reach 100-140 mm TL and 10-40 g in their first growing season (Malison 1985, Malison et al. 1988). As a part of the proposed project UW-Madison researchers will evaluate the feasibility of rearing large perch fingerlings in ponds through the first growing season, and measure key production parameters at several locations using several feeding strategies and systems.

The evaluation of several types of feeding and lighting systems will be a critical component of the proposed project. The initial 12 V systems developed and tested by UW-Madison investigators (Malison et al. 1994) were adequate for producing small (25-40 mm TL) perch fingerlings in rearing ponds of 0.15 ha or less. However, larger (e.g., 0.5-1.0 ha) ponds may be better suited for the continued grow-out of fingerlings through an entire season. In such ponds, the lighting and feeding systems preliminarily tested by UW-Madison proved to be problematic for several reasons. First, for large ponds, the expense of maintaining large numbers of low-power feeders and lights (and all of the associated wire and hardware needed) was considerable. Second, a significant voltage drop resulted from the long-distance wiring of the 12 V systems, causing sub-optimal feeder performance and lighting. Third, the low-power feeders that were used each distributed food over a fairly small area (about 0.2 m^2). Such a small pattern of food distribution, if continued through an entire growing season, could result in wide variations in fish growth and size, due to social interactions (i.e., territorial behavior or feeding hierarchies) among the fish.

A wide variety of both active (e.g., seines, lift nets, trawls) and passive (e.g., traps, trap nets, fyke nets, gill nets) capture gear and associated procedures have been used to harvest fish from the wild and from aquaculture production ponds (Hayes 1983; Hubert 1983; Dupree and Huner 1984; Pillay 1990). Of all the available methods, various types of seining procedures are probably most commonly used in aquaculture, particularly for the final harvest of market-size fish from large ponds (Dupree and Huner 1984; Tucker 1985; Tucker and Robinson 1990; Pillay 1990). The commercial-scale seining of fish below about 50 mm TL becomes increasingly problematic with decreasing fish size, however, because: (1) with decreasing mesh size, seines become increasingly difficult to draw through water, and are more prone to fouling and tearing; and (2) small fish, especially below 30-35 mm TL, tend to be increasingly fragile with decreasing size, and are often badly stressed or injured by seining.

A commonly used alternative to harvesting fingerling fish by seining is pond drawdown to a catch basin, which requires that the production of these fish be done in ponds constructed for this type of operation (Piper et al. 1982; Dupree and Huner 1984; Pillay 1990). Three disadvantages of this approach are: (1) all the water must be discharged from the pond, which must eventually be replaced and may require careful regulation to avoid flooding or other problems downstream; (2) pond drawdown form late spring to mid autumn in the NCR, without appropriate countermeasures, typically results in reduced dissolved oxygen levels and elevated water temperatures during the final stages of drawdown and in the catch basin, which collectively is very stressful to the fish being harvested; and (3) the ability to crop fish on an "as needed" basis is impaired, because all the fish in any given pond must be harvested over a very short time interval - which in turn requires careful planning with respect to transport and receiving facilities.

An added disadvantage of the drawdown technique of harvesting fingerlings is that if their size at harvest is below 30-35 mm TL, large numbers of fish may be trapped in depressions in the pond bottom as the water recedes, and if aquatic weeds or filamentous algae are present, many fish may become entangled and are unable to escape because of their small size. Dealing with this is not only extremely labor intensive but also very stressful to the fish. Accordingly, pond drawdown, like seining, in most situations is not well suited for the routine low-stress harvest of fingerlings at 18-30 mm TL, a size-range at which yellow perch can be produced in large numbers (over 600,000 fish/ha) and can be readily habituated for formulated diets either in tanks or in ponds (Best 1981; Malison and Held 1992; plus ongoing NCRAC perch studies by UW-Madison and UNL investigators).

In the early 1980s Manci et al. (1983) developed a system that combined a 152-cm-wide × 366-cm-long × 30-cm-deep lift net with floating underwater lights, which proved to be very effective for harvesting perch of 8-44 mm TL from small (e.g., 0.08-ha) ponds. With this system, after a period of illumination ("light set") of 10-20 minutes, between 2,000 and 10,000 perch could be captured, depending on fish size and the number of repeated light sets at a given location. As a rule, the number of fish harvested per light set declined with increasing fish size and number of sets. To maintain its efficiency in terms of number of fish captured per light set, this system had to be moved after two or three light sets at any one location during the same night. Though labor intensive, this system's performance was shown to be superior to conventional seining in terms of catch per unit of effort for the size of fish harvested (Manci et al. 1983).

Since the studies by Manci et al. (1983), the basic approach of using light to harvest fry and early fingerlings has been expanded upon by UW-Madison and UNL investigators, both for yellow perch and walleye. The first improvement by UW-Madison workers was the addition of a string of floating subsurface lights that were first all turned on for 10-15 min, then turned off sequentially towards the lift net at about 5-min intervals, attracting fish from a greater distance than the original lighting system. The improved system increased the relative number of fish harvested per set and decreased the frequency with which the entire system had to be moved. However, the light string was subject to failure, and was powered by 12 V DC batteries that required frequent recharging. Operating and moving the lift net and light string proved to be workable, but unwieldy and laborious to use in larger (e.g., 0.4-ha) production ponds.

More recently, UW-Madison researchers have developed a simpler, more reliable light-capture system for harvesting larger production ponds that is composed of a modified floating 2.4-m-square × 1.2-m-deep net-pen, and a simpler, less failure-prone floating light string. One side of this "Wisconsin net-pen" can be lowered, allowing the passage of fish attracted by the light string from the pond into the net-pen. After the fish are concentrated in the net-pen by sequentially turning off the lights in the string, the open side of the net-pen is raised to capture the fish. This system can capture more fish than the lift-net light-harvesting system - experience to date indicates in excess of 15,000. However, the utility and cost-effectiveness for commercial application of the "Wisconsin net-pen" harvesting system, or anything similar to it, have not yet been fully evaluated.

As part of the ongoing NCRAC walleye project, UNL investigators have developed a light-capture system designed specifically to harvest fish on a commercial scale from larger production ponds. This system also employs a floating string of submerged lights, but one that is much larger, longer, and capable of brighter levels of illumination than any of the other systems built to date. The expanded capacity of the UNL light string was made possible by the development of an improved control, wiring, and illumination system that employs electronic and lighting components which provide far more effective power transfer of DC electricity to light.

The UNL light string can be powered either by a 12-V DC generator or by a heavy-duty vehicle electrical system with the vehicle engine running. In the past year, UNL researchers have also developed a raft equipped with high-efficiency underwater lights and 12-V deep-cycle batteries that can be pulled across the surface of a pond from any point desired. Studies done in the spring of 1994 suggest that the UNL light raft is almost as effective as the UNL light string at attracting walleye of 12-35 mm TL to a harvesting system.

The capture component of the UNL light-harvesting system is comprised of a modified form of a trap net equipped with a floating string of submerged lights that are turned off sequentially from the mouth to the pot end of the net. This "Nebraska trap-net" harvesting system has wing nets attached to the mouth, is open at the top, can be used with either the UNL light string or the UNL light raft, and can either be staked in place or equipped with a floatation collar and billets for mobility. The netting used in the trap is about 4 m, and its mouth is about 1.4-m-wide × 1.2-m-deep. The 0.6-m-wide × 0.6-m-deep × 1.2-m-long fish-harvesting pot at the opposite end of the trap from the mouth is unique in that its bottom, left, right, and rear sides are made of black vinyl, while the front side facing the trap's mouth consists of a perpendicular panel of knotless nylon mesh with a central opening to the small end of a mesh funnel in the throat of the trap.

The individual lights in the light string inside the Nebraska trap-net, during harvest, are all turned on, then turned off sequentially with dimmer switches, except for the final light located at the rear of the pot. Because of the construction of the pot, this light forms a beam of illumination projecting up the throat of the trap towards the mouth. After the other lights in the light string are turned off, this beam attracts nearly all of the photopositive fish from the mouth and throat of the trap into the pot. The size and rectangular shape of the pot make it extremely easy to catch the fish contained with a hand net, and transfer them to a holding pen or live-haul tank. As part of the ongoing NCRAC walleye project, UNL researchers harvested over 38,000 fish of 18-21 mm TL in a single 30-min set of the Nebraska trap-net combined with the improved UNL light string. However, improvements in all the types of systems being tested are presently being planned for evaluation in 1995. At this state of development, any conclusions about which systems or combinations of systems would be best for harvesting different species or sizes of fish under different harvesting conditions would be premature.

In addition to light, sound and food (baiting) have been used to attract fish into passive capture gear, such as the Nebraska trap-net, or to concentrate fish in preselected areas where they can be harvested with active capture gear, such as seines (Hashimoto and Maniwa 1967; Richard 1968; Ben-Yami 1976; Hubert 1983; Dupree and Huner 1984; Tucker 1985; Tucker and Robinson 1990). One example of the latter is the baiting of the ends or corners of channel catfish fingerling production ponds near shore with sinking feeds, followed periodically by seining (Dupree and Huner 1984). Another example is the use of "corral" seines to harvest market-size catfish at regular intervals from designated near-shore feeding areas of watershed ponds in the south (Dupree and Huner 1984; Tucker 1985; Tucker and Robinson 1990).

According to Robert W Derrow II of the National Center for Physical Acoustics at the University of Mississippi (personal communication), channel catfish are strongly attracted by the low-frequency sound of feed trucks and other vehicles driving on the levees of Mississippi Delta catfish ponds. In a preliminary experiment done by Derrow and UNL investigators at the North Platte State Fish Hatchery in Nebraska, about 2,000 walleye of 20-25 mm TL were captured in a Nebraska trap-net within minutes after underwater speakers emitting a pulsating pattern of different sound frequencies were placed adjacent to the trap's pot behind the trap's outspread wings. A recent literature search conducted by Derrow (personal communication) suggests that more walleye may have been attracted by a lower frequency tone than was used in the 1994 trial. The same may apply to yellow perch.

Depending on the fish size and a variety of site-specific variables (e.g., pond design, bottom substrate, turbidity), light, feed presentation, and sound all have potential as attractants to facilitate the low-stress harvest of yellow perch. To our knowledge, aside from the initial study of Manci et al. (1983), which examined light as an attractant, no systematic evaluation of different systems and procedures for harvesting large numbers of young perch from different types and sizes has ever been done. This project will address that need.

Continue Development of Extension Materials and Workshops (Objective 3)

With the growing interest in yellow perch aquaculture, the need for continued extension education on the culture of this species by NCRAC is apparent. This need is evidenced by the high levels of participation in lectures and seminars on perch aquaculture that have been presented at meetings throughout the region. Most participants have expressed a desire for more readily available specific information on the development and operation of aquaculture ventures, above and beyond that available in lectures and seminars. Some have suggested the need for a regional "clearing house" of information, to provide reading lists of pertinent literature, audiovisuals, problem-solving workshops, and specific hands-on training. Because of the continuing increase in such requests, we feel that it is essential to modify our present approach to extension programming to meet the needs of NCRAC clientele and maintain an effective and productive program.

The NCRAC Extension Work Group is responsible for assessing and meeting the information needs of aquaculture clientele through cooperative and coordinated regional educational programming. Short courses, extension publications, site visits, hands-on assistance, and personal interviews have been, and will continue to be, fundamental components of NCRAC extension activities. Extension objectives are now being incorporated into the NCRAC yellow perch project and other species-specific projects. "How to" manuals and workshops are being developed for region-specific aquaculture practices. Hands-on workshops to provide training have been developed for those clientele with serious interests in developing aquaculture operations, and to assist established fish farmers with problem solving.

Extension efforts by the NCRAC Yellow Perch Work Group will continue the ongoing development of extension materials and workshops, emphasizing practical production techniques. A collaborative effort to develop and implement educational materials and programs on perch aquaculture is being led by Don Garling of MSU and Terry Kayes of the UNL, working in concert with extension liaisons and researchers of the NCRAC Yellow Perch Work Group. The emphasis of this effort is on the production of audiovisual instructional materials and extension publications that complement one another, and can be used as teaching aids in interactive workshops.

Specifically, the UNL is leading an effort to develop a minimum of three fact sheets or bulletins on perch brood stock management and propagation techniques, egg incubation and hatching, and procedures for training fingerlings to formulated feeds. The UNL is also leading an effort to produce techniques-centered videotapes and/or photographic slide sets to complement these publications. Researchers at the UW-Madison are providing technical information and assistance in the production of these publications, videotapes, and slide sets, as appropriate and needed. Personnel at MSU are responsible for at least one fact sheet or bulletin and a videotape on the production of perch to market size by intensive culture in flow-through tanks. The UW-Milwaukee is responsible for the development of at least one fact sheet or bulletin on the intensive culture of perch from fry to fingerlings. In the second year of the ongoing NCRAC extension project, these educational materials will be utilized in interactive workshops on perch aquaculture, to be held in Michigan and Nebraska.

ANTICIPATED BENEFITS

This project will address priority needs identified by the NCRAC Industry Advisory Council (IAC) for advancing yellow perch aquaculture in the NCR. The IAC has indicated that one major constraint that presently limits perch aquaculture is the lack of reliable methods of producing perch fingerlings habituated to formulated feeds. In addition, there is a continuing need to provide producer training on key aspects of perch aquaculture, and to transfer advances in perch culture technology to the public sector. Our proposed research on Objective 1 will improve larval rearing techniques by developing and evaluating different starter diets and environmental conditions; and studies on Objective 2 will improve pond fingerling production by the examination of in-pond feeding techniques using physical/chemical attractants, and through improved harvesting strategies. The information generated by these studies will greatly assist perch producers in their efforts to reliably raise the large numbers of perch fingerlings needed by the industry. Extension activities will continue to promote and advance yellow perch aquaculture through expanded outreach, education, and training programs. Additional extension materials (bulletins, fact sheets, audiovisual materials) developed by the NCRAC Yellow Perch and Extension Work Groups and a series of hands-on workshops and field demonstrations will transfer current technology to established and potential fish farmers, and increase public awareness of the potential of yellow perch aquaculture as a viable agricultural enterprise in the NCR.

OBJECTIVES

1. Continue to improve larval rearing techniques by developing and evaluating different starter diets in relation to size at transfer to formulated feeds under selected environmental conditions.

2. Continue to improve pond fingerling production through examination of in-pond feeding techniques using physical/chemical attractants and improved harvesting strategies for different sizes of fingerlings from various types and sizes of ponds.

3. Continue development of extension materials and workshops emphasizing practical techniques, coinciding with production events, to meet the needs of established and potential yellow perch culturists through on-site presentations at two or more locations in different parts of the region.

PROCEDURES

Improve Larval Rearing Techniques by Developing and Evaluating Starter Diets (Objective 1)

MSU

MSU will work cooperatively with Bayport Aquaculture Systems to develop simplified commercial-scale intensive fry culture techniques. Initial experiments will be conducted to determine the effect of the size of female brood fish on egg size, fry size at and three d posthatch, and gape of mouth at first feeding and subsequent larval sizes. During Year 2, work will focus on improved larval feeding regimes and will be developed based on Year 1 results at MSU and larval feed work completed by Paul Brown at Purdue and Konrad Dabrowski at OSU.

Prior to fry feeding experiments, MSU will evaluate the brine shrimp to be used during the study. Several strains of brine shrimp will be hatched, and the newly hatched nauplii will be measured. Micro-sieves may be made from nitex plankton screening to separate different size *Artemia* cysts if a large variation occurs in the size of newly hatched nauplii. The smallest size *Artemia* available will be used during the initial feeding of yellow perch. As the feeding experiments progress, larger size brine shrimp nauplii may be fed.

In the spring of 1996, Bayport Aquaculture will provide and assist MSU in spawning brood fish from either their captive brood stock or from wild brood fish collected from the outer Saginaw Bay, near Bayport, Michigan. Eggs will be collected from five females from each of the following size classes: 200-225, 226-250, 251-275, 276-300, 301-325, and 326-350 mm TL. Initially, a sample of eggs will be collected from the anterior, mid-, and posterior portion of the ribbon from five females, each from a relatively small and large size class to determine if there are differences in the size of eggs based on the position of the sampling point in the ribbon. The egg masses will be weighed, a 1g sample will be counted, and egg diameters will be measured from a random subsample of 25 eggs from each female.

Each sample of eggs will be incubated in a separate, specially constructed incubation chamber that has been used by researchers at MSU to incubate bluegill sunfish eggs, as part of the NCRAC Sunfish project. Each chamber will be made from 67.5 and 75 mm PVC pipe sections to form the bottom and top, respectively. The 67.5 mm PVC pipe will be cut approximately 5 mm larger than the depth of standard Heath incubator trays, while the 75 mm PVC pipe will be cut approximately 10 mm smaller than the 67.5 mm PVC pipe. One end on each of the PVC pipe sections will be covered with the appropriate mesh size of plankton screen to prevent loss of eggs or larval perch after hatch. An attachment device will be placed on opposite sides of the smaller PVC section to retain the ribbon sections in an extended position. When the bottom and top pieces are placed in Heath incubation trays, the slightly larger size of the bottom vessel cause sufficient pressure from the tray screens to seal the top cover. The eggs will be incubated with well water (11°C). Hatch rates of eggs incubated using the standard methods developed by Bayport Aquaculture will be used as controls.

For fry feeding experiments, five replicates will be run for each of three female spawner size groups (200-250, 251-300, and 301-340 mm TL). Approximately 175 fry/L, estimated volumetrically, will be reared in round tanks with conical bottoms containing approximately 50 L of water similar to tanks with top inflow at a rate of approximately 50 L of water, similar to tanks described by Kim et al. (1993). A constant flow of well water will be supplied with top inflow at a rate of approximately 1.3 L/min (1.75 turnover/h). Temperature will be increased slowly to approximately 15°C over the next five days.

At 3 d posthatch, fry will be fed newly hatched brine shrimp nauplii, using the smallest strain of brine shrimp available at a density of 7500/L for the first seven to nine days increased to 15,000/L over the next 14-21 days to determine percent of gas bladder inflation and verify consumption of *Artemia* consumption by yellow perch fry. At approximately 30 d posthatch, dry feeds will be fed in combination with brine shrimp. The amount of dry feed will be increased daily and the brine shrimp will be reduced daily until approximately Day 40 when only the commercial feeds will be fed. Results of the replicated trials based on size of female spawners in small culture tanks will be compared to larger commercial-scale trials completed by Bayport Aquaculture.

Results will be reported on a day posthatch and temperature unit basis as defined by Piper et al. (1980). Effects of cyst size for various *Artemia* strains on size of *Artemia* nauplii will be analyzed using ANOVA and orthogonal contrasts. Effects of female brood fish size on egg size, larvae size at 3 d posthatch, growth, and gape/TL ratios will be analyzed using ANOVA and orthogonal contrasts. The effects of initial larval size on growth and survival using *Artemia* nauplii will be assessed by computing linear regression analysis. Size frequency distributions for both *Artemia* nauplii and larval perch will be analyzed by chi-square goodness of fit test.

In 1997, experiments will build on results gained in previous years. The relationship of mouth gape to length of yellow perch fry will be used to determine the best time of feeding various sized brine shrimp nauplii from selected strains and to begin feeding formulated practical diets. Experiments will be initiated to determine the appropriate density of *Artemia* nauplii per liter. If mortalities occur after the yellow perch larvae have reached a size when they can consume 2-d-old brine shrimp in 1996, *Artemia* enrichment with commercial mixes, such as Acalypha Nutri-Pack, will be included in the feeding program in Year 2. If possible, larval starter diets formulated by Paul Brown and Konrad Dabrowski will be used in 1997.

<u>OSU</u>

Research at OSU will be conducted in controlled experiments at Piketon Research and Extension Center and will evaluate the effect of initial fish size on formulated diet acceptance, growth, and survival. Diet will be 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 brood stock used in these studies will be the offspring of semi-domesticated fish kept originally in ponds at the St. Mary State Hatchery, and then trained to a dry diet indoors at an age of five months. Ten d 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 brood stock. According to our experience, 100% of females will have ovulated and be ready to be stripped within the next four to five 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 nursery ponds. At the Aquaculture Center at Piketon, six 0.1-ha ponds will be stocked with 100,000 embryos per pond.

Perch fry raised initially in ponds will be transferred to an indoor facility and maintained in rectangular tanks (40 L volume), supplied with filtered and aerated water of desired temperature. Perch fry number will be adjusted based on initial size, between 20 fish/L at 10 mm TL and five fish/L at 20 mm TL. Water temperature will be maintained at 20-22°C and light intensity at 1.1 Wm^{-2} (Dabrowski and Jewson 1984).

Experimental diets will be based on single-cell proteins, freeze-dried zooplankton, and fish tissues, as described earlier (Dabrowski and Culver 1991). Diets will be supplemented with 0.05% pancreatin (Sigma Chemical Company, St. Louis, Missouri) or a mixture of enzymes (1% on dry basis) as specified by Carter et al. (1994). Other supplements to be tested will include betaine (2%), soluble fish protein concentrate (Suprapeche, France), and a free amino acid mixture (glycine, alanine, and proline) at the molar concentration encountered in zooplankton (Dabrowski and Rusiecki 1983).

Three to six diets containing fish meal (as a control), or other major protein sources will be made isonitrogenous, supplemented with pancreatin or a multi-enzyme additive, vitamin and mineral mixtures, and gelatin (3%) as binder. Diets will be freeze-dried and appropriate particle sizes, adjusted to fish, will be separated. The fish, triplicate per dietary treatment, will be fed at hourly intervals from 9 a.m. to 5 p.m. during the first two weeks. Older fish will be fed by automatic feeders continuously at a nominal ration of 5% body weight per day. Toward the end of the experiment 20-30 fish will be taken from each tank and weighed. Depending on the size of fish at the termination of the experiment, fish will be killed and frozen for further analysis. *Artemia* nauplii or freshwater rotifer cultured at Piketon Station will be used as control live feeds to triplicate groups.

The objective of optimization of rearing conditions of yellow perch will include the evaluation of increased salinity and light intensity. Ribi (1992) reported that the survival of European perch (*P. fluviatilis*) can be increased to 46.6% compared to 13.5%, when water of 0.7% salinity was used instead of lake water. Victoria et al. (1992) also observed increased survival of yellow perch larvae exposed to up to 6 ppt salinity, compared to freshwater.

In the second year of study, formulated diets and live feeds will be offered to yellow perch larvae maintained in freshwater, or 2 and 5 ppt salinity. In the separate set of experiments, light intensity will be adjusted at the minimum threshold of 0.1 Wm^{-2} or 1 and 10 Wm^{-2}.

Purdue

Research at Purdue will be under the direction of Paul Brown. Several experimental diets have been identified as acceptable by yellow perch, and several others were unpalatable. Prior to legal use of betaine in diets fed to yellow perch, we must quantify both the total sulfur amino acid requirement and choline requirements.

Studies at this time have become relatively standardized. Triplicate groups of fish will be offered purified diets containing graded levels of the nutrient in question. Fish will be fed their respective diets for a minimum of eight weeks.

Diets will be similar to those used in previous studies at Purdue with hybrid striped bass (Brown et al. 1993; Griffin et al. 1992; Griffin et al. 1994a, b; Griffin et al. In press). When juvenile yellow perch were fed that diet, growth and feed conversion was not significantly different from fish fed one of the preferred practical diets for perch (Biodiet Grower). Thus, results from this line of research will be appropriate for rapidly growing fish.

The experimental system used in these studies will be similar to those used in previous fish nutrition research at Purdue. Series of 28 40-L glass aquaria are in place and available for this research. Those aquaria are part of a recirculating experimental system equipped with settling chamber and biological filter. Water temperature will be maintained at 22°C and critical water quality parameters will be closely monitored.

Using the data generated in the first two studies (completion is anticipated in the first year of the project), we will incorporate betaine and the proprietary flavor additive into diets for perch fry. Those diets will be manufactured at the Bozeman Fish Technology Center or at Purdue. Rick Barrows, USFWS, Bozeman, has pelleted feeds for previous projects funded through NCRAC and his help will be solicited again if a new piece of equipment is not approved for purchase at Purdue. Otherwise, the studies of flavor additives will be identical to those determining key nutritional requirements.

At the end of the studies, nutritional requirements will be determined based on weight gain, feed efficiency, and liver lipid concentrations (choline study). Effects of flavor additives will be assessed by actual consumption of experimental feeds, as well as survival and growth. All data will be analyzed as a completely randomized design using 0.05 as the critical level of significance.

Improve Pond Fingerling Production and Harvesting Strategies (Objective 2)

UW-Madison

Research conducted by UW-Madison investigators will be done to: (1) determine key parameters for producing yellow perch fingerlings habituated to formulated feed and reared in ponds for an entire growing season, and (2) compare the performance of two types of pond lighting and feeding systems, one designed for relatively small ponds and one for larger ponds. These studies will be conducted in collaboration with Coolwater Farms, LLC (Cambridge and Dousman, Wisconsin). Coolwater Farms and UW-Madison personnel will be jointly responsible for all data collection and record keeping, and Coolwater Farms will be responsible for all routine operating costs, utilities, equipment, fish and fish eggs, pond fertilizers, and supplies used at their facility.

Perch fry used for these studies will be the offspring of Coolwater Farms' domesticated brood stock. 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 two to four day time frame during mid-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 (unpublished) that permits an accurate determination of the number of hatched fry.

All ponds in these studies will be stocked with fry at the same rate, between 0.5 and 2.0 million fry/ha. The exact stocking rate will be that shown to be optimal by studies which are part of the ongoing NCRAC yellow perch project (which will end before the proposed project begins). The ponds used will be a combination of 0.1-0.6 ha ponds of the UW-Madison, at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin, and of Coolwater Farms, LLC, located in Cambridge and Dousman, Wisconsin. All three sites are within 80 km of each other. All ponds will be supplied with continuous aeration and inorganic and organic fertilizers at rates determined to be optimum for the respective sites. Dissolved oxygen levels and temperatures in the ponds will be measured in the morning at depths of 0.3 and 1.2 m. Well or lake water will be added to each pond as needed to moderate summer water temperatures. The growth of the perch will be monitored by measuring samples of 20-40 fish from each pond at regular intervals (e.g., weekly).

The lighting and feeding systems of each pond will be activated about three to four weeks after the fry are stocked, i.e., when they reach about 15-17 mm TL, which is the size at which they will first accept conventional salmon starter diets. The lights will be turned on at dusk and will remain illuminated throughout the night. Initially, the feeders will be programmed to dispense a small amount of food twice per minute for one 20-minute interval during each night-time hour. After two to three weeks of feeding in this manner, our experience has shown that a large number of fish will begin to exhibit an aggressive feeding response, and clearly respond to the vibration of the feeders. Then, the feeders will be gradually adjusted to dispense food both day and night. Eventually, nighttime feeding will be discontinued and the lighting systems deactivated.

Ziegler Salmon Starter feeds (Ziegler Bros. Inc., Gardners, Pennsylvania) will be used throughout the Wisconsin studies. The perch will be fed to excess (10% of the approximate total fish weight/d) when the pond feeding systems are first activated, and to near satiation (3-5%/d) once the fish are habituated to formulated feeds.

The study will involve three treatments using three sets of duplicate ponds, and will be repeated in the two successive years of the project to provide a sufficient number of replicates for accurate statistical analysis (N = 4/treatment). Two of the three experimental treatments (Treatments 1 and 2) will each consist of two 0.1-0.2- ha production ponds equipped with 12V lighting and feeding systems identical to those successfully used by UW-Madison investigators on similar-size ponds (see **RELATED AND CURRENT PREVIOUS WORK**). Each system will consist of 30 feeders/ha of pond surface area (i.e., three-six feeders/pond, using Sweeney SF-6 or SF-7 feeders, Sweeney Enterprises, Inc. Boerne, Texas) attached to foam floatation devices that are distributed evenly over the pond surface. A submerged 12V light (each illuminating an area of about 7 m^2) will be located next to each feeder. For Treatment 1 (two ponds), fingerlings will be reared from spring until mid-autumn, when water temperatures drop to 10°C or less and the growing season has essentially ended. For Treatment 2, two ponds will be drained and harvested approximately two weeks after a strong feeding response is observed in a large number of fingerlings. Based on previous experiences, this response becomes apparent in early June, or about five to six weeks after fry are stocked.

Treatment 3 will employ two 0.55-ha ponds equipped with 110 V lighting and feeding systems designed for relatively large ponds. These systems will consist of six shore-mounted 150-W floodlights on swinging arms, placed at regular intervals along the perimeter of each pond and extending about 3 m beyond the edge of the water. Each light will be suspended about 1-2 m above the surface of the water, and positioned to illuminate an area of 80-100 m^2. A 110V vibrating feeder, designed to dispense feed over 5-10 m^2 of water surface, will be mounted adjacent to each light. As with the 12V systems, the lights will be illuminated at night, and a timing system will control the feeders to deliver the feed in a series of short (< 1 s) pulses. The fingerlings in these ponds will be reared from spring until mid-autumn when the growing season has ended.

The ponds will be drained and fish harvested, either in mid-autumn when water temperatures fall below 10°C (Treatments 1 and 3), or about two weeks after the fingerlings are exhibiting a clear feeding response to the formulated diet, and are at 25-35 mm TL (Treatment 2). The number of fish harvested from each pond will be determined gravimetrically, and the mean length and weight of fish from each pond will be determined from samples. We will also determine the percentage of fingerlings from each pond treatment that are habituated to formulated feeds. These determinations will be conducted in tanks at the UW-Madison's main wet-laboratory facility at the Lake Mills State Fish Hatchery (see **FACILITIES**). Briefly, random subsamples of fish from each pond treatment will be stocked into flow-through tanks at three tanks/treatment. Habituation levels will then be determined using the general protocols and fish husbandry procedures described by Malison and Held (1992). The data will be analyzed using one-way analysis of variance. Cumulatively, these studies should provide an accurate assessment of the total number of feed-trained fingerlings and advanced fingerlings that can be produced in ponds of different sizes under practical conditions.

UNL

Research by UNL investigators to evaluate various yellow perch pond feeding and pond harvesting strategies will be done in cooperation with William Hahle, owner/operator of Pleasant Valley Fish Farm, near McCook, Nebraska, and with the Nebraska Game and Parks Commission at the North Platte State Fish Hatchery, near North Platte, and the Calamus State Fish Hatchery, near Burwell, Nebraska. The primary focus of the UNL studies will be to evaluate a variety of selected pond harvesting systems and procedures on different sizes of perch fingerlings from different types and sizes of ponds. Pond feeding systems utilizing light and vibrating feeders (which are similar in concept but different in design from those developed by the UW-Madison) will also be tested, but primarily in a context to examine how they affect, and if they can be used to facilitate, pond harvest.

Perch fry used for these pond studies will come from semi-domesticated perch brood stock owned by Pleasant Valley Fish Farm or from wild brood fish captured just prior to the mid-April spawning season from shallow Sandhills lakes, near Valentine, Nebraska, by both Pleasant Valley Fish Farm and the Nebraska Game and Parks Commission. Eggs will be fertilized by traditional tank spawning, in which males and females placed in tanks spawn and fertilize eggs naturally, or by an artificial propagation technique, in which eggs are stripped from ripe females and fertilized with milt from males (see Soderberg 1977). Standard procedures will be employed to incubate the fertilized eggs to the eyed stage of development, and then placing them in floating cages to hatch directly into fingerling production ponds.

Two variations from this standard protocol of producing perch fry will be employed when appropriate and feasible. Specifically, in both years of the project, certain types and configurations of the harvesting gear (and associated procedures) to be tested will be evaluated for their effectiveness in capturing different sizes of wild perch fingerlings from a number of 2.8- to 80-ha Sandhills lakes leased by Pleasant Valley Fish Farm. Also, in the first year of the project, a procedure recently developed by UW-Madison investigators to "force-hatch" sac-fry from mature eyed eggs will be evaluated for its applicability to Nebraska perch culture. If appropriate and feasible, this technique will be employed to hatch all subsequent fry stocked into fingerling production ponds, and the numbers stocked will be determined using an electronic fry counter (Jensorter, Inc., Bend, Oregon).

All production ponds used for the project at any given site will be stocked at the same rate, between 0.5 and 2.0 million fry/ha, as determined by prior experience at the site and the results of ongoing research by the NCRAC Yellow Perch Work Group. The Pleasant Valley Fish Farm has a variety of differently shaped earthen ponds with clay-loam bottoms and surface areas ranging from 100 m^2 to 0.3 ha. The North Platte hatchery has uniformly-shaped rectangular ponds with sandy-loam bottoms and surface areas of about 0.40 ha/pond. The Calamus hatchery has uniformly-shaped rectangular ponds that are lined with low-density polyethylene, and have surface areas of about either 0.20 or 0.40 ha. The ponds at the North Platte and Calamus hatcheries have either external or in-pond harvesting basins to facilitate harvest by pond emptying. The ponds at Pleasant Valley Fish Farm do not have harvesting basins, and are normally harvested by seining or a combination of drawdown and seining. The ponds at all three facilities have an average depth of 1.0-1.3 m, and a maximum depth of 1.5-1.8 m.

Unless otherwise indicated, pond management procedures used in the UNL studies will be those normally employed at the three facilities, as improved by research presently being done the UNL through state and NCRAC funding. Briefly, the ponds will be filled with water and fertilized with alfalfa pellets and a liquid high-phosphorus fertilizer 7-10 days before stocking and on a regular basis thereafter (generally two or three times weekly), either throughout the production period or until just before pond feeding with a formulated diet is initiated. As indicated by preliminary pond feeding trials in 1994, the addition of fertilizers to ponds designated for tandem pond feeding/pond harvesting studies will be discontinued three to four days to a week before the initiation of feeding, depending on the status of the natural forage base. Dissolved oxygen levels and water temperatures in the ponds will be measured daily one to two hours after sunrise at depths of 0.3 and 1.0 m; and 24-h dissolved oxygen and water temperature profiles, as well as other selected limnological and water chemistry variables (e.g., turbidity, pH, ammonia) will be measured at regular intervals.

During warm weather, well or reservoir water will be added to each pond as needed to moderate water temperatures to 20-25°C. At least two ponds at each facility will be equipped with Ryan Model RTM thermographs (Ryan instruments, Inc., Redmond, Washington) set to record water temperatures at 1.0 m depth. Ponds used for the UNL component of the project may or may not be mechanically aerated depending on need, because studies conducted over the past trhee years have demonstrated that such aeration of fingerling production ponds in Nebraska rarely has any effect on dissolved oxygen levels from April through mid-June, due to natural aeration provided by the wind which blows almost constantly in the Great Plains region at that time of year. Even when heavy fertilization rates (e.g., 340 kg/ha of alfalfa pellets per week) are used, dissolved oxygen concentrations from April through mid-June are often close to saturation levels (even just before sunrise), and rarely go below 5.0 mg/L, except when ponds are being harvested by drainage or major drawdown procedures. Accordingly, in most situations, aeration will only be employed on an emergency basis when dissolved oxygen levels fall below 5-6 mg/L.

Present plans are to evaluate selected strategies for harvesting different sizes of perch fingerlings at different times during the growing season from four 0.08-ha production ponds at the Pleasant Valley Fish Farm, four 0.40-ha ponds at the North Platte hatchery, two each 0.20- and 0.40-ha ponds at the Calamus hatchery, and a 2.8- and a 12-ha Sandhills lake managed by Pleasant Valley Fish Farm for perch production. Two ponds each at the Pleasant Valley Fish Farm and North Platte hatchery will be equipped with UNL-designed floating feeding stations, generally arranged such that the distances between neighboring stations are about equal, and employing about 50 stations per ha of pond surface area (i.e., five stations/pond at the Pleasant Valley Fish Farm and 18-20 stations/pond at the North Platte hatchery). Comparisons of fish growth, types of food consumed, and the effectiveness of various pond cropping and harvesting strategies will be made of fed ponds versus fertilized ponds at both the Pleasant Valley and North Platte facilities. Ponds at the Calamus hatchery will not be equipped with feeding stations, and will be used exclusively for the evaluation of different strategies of harvesting young perch from fertilized ponds.

The geometries and electronics of the UNL-designed floating pond feeding systems differ from those developed by the UW-Madison, but the concept is the same. Each of the UNL feeding stations has an electronically operated vibrating feeder (Sweeney Model SF-6 and SF-7 feeders, Sweeney Enterprises, Inc., Boerne, Texas) and a submerged light adjacent to the feeder, and is controlled by an integrated electronic system that can provide feed at almost any time interval for whatever duration desired. The feeders themselves can be set to release feed in very small quantities when activated, thereby keeping feed in the water column almost constantly when in operation. The feeding systems set up on ponds will first be activated about three to four weeks after stocking, when the fry reach about 15-17 mm TL, the size at which they first begin to accept conventional salmon and trout starter diets. Present plans are to operate these feeding systems - with respect to lighting, amounts of formulated diet fed, and time-sequencing of feeding - in a very similar manner to that described for the UW-Madison studies (see UW-Madison procedures). The initial diet fed by UNL investigators will be Silver Cup Salmon Starter (Sterling H. Nelson and Sons, Inc., Murray, Utah), which prior studies have shown is readily consumed by perch fry at 15-17 mm TL.

To determine the approximate time of onset and degree of ingestion of formulated diet by perch in the fed ponds, appropriate portions of the latter will be mixed with a fluorescent marker pigment, and the mixture fed to the ponds for 24 hours at weekly intervals for three or four weeks after the pond feeding systems have first been activated, and about two days before final harvest (see Morris 1988 and Morris et al. 1990 for details on this procedure). Samples of fish will be collected near the feeding stations and randomly from different locations in the ponds, immediately after these feeding periods. This technique provides an effective method of discriminating between ingested formulated feed and natural food during examination of the guts of sampled fish, and should provide a good indication of the percentage of perch in the ponds that are consuming the formulated feed provided.

Different types of capture gear, as well as light, feed presentation (via the feeding stations) and sound, will be evaluated for their utility in harvesting large numbers of young perch of different sizes from different types of ponds. In particular, variations and improved versions of the Wisconsin net-pen, Nebraska trap-net, UNL light string, and UNL light raft will be tested in ponds on perch ranging in size from about 13-45 mm TL. The utility of combining above-surface directed lighting with floating subsurface illumination to harvest fish in this size range will also be examined. This approach will be given particular emphasis in the evaluation of strategies for harvesting fish from large production ponds and the Sandhills lakes managed for perch production by Pleasant Valley Fish Farm.

In fed ponds, two approaches to harvesting feed-habituated perch ranging in size from about 20-130 mm TL will be examined. In the first, operating feeding stations will be arranged in series (as they normally are), with the last station in line located inside a Wisconsin net-pen or in the pot end of a Nebraska trap-net; then the feeding stations will be deactivated sequentially (testing various time intervals between shut-downs) towards the net-pen or trap-net containing the last station. The second approach will be to remove or deactivate all the feeding stations except ones left operational in a number of net-pens or trap-nets set up in the pond(s) being harvested. To determine whether the feed-habituated perch are responding primarily to the presence of feed or to the sound of the operating feeders, both approaches will be tested using full versus empty feeders, and the results compared.

Depending on time and available resources, corral and grader seines used in association with feeding stations arranged near shore will be evaluated for their utility in selectively harvesting larger (over 50-75 mm TL) feed-habituated perch from ponds in the second half of the growing season. The National Center for Physical Acoustics at the University of Mississippi has expressed a strong interest in continuing to work with the UNL to develop methods of harvesting fish of different species and sizes, using specific frequencies or patterns of sound. Towards that end, they are willing to develop an underwater sound generating system that can be tested in association with different types of harvesting gear, such as the Nebraska trap-net. If such a system proves to be effective at attracting small perch fingerlings in significant numbers, we propose to test the combined use of light and sound attraction for harvesting fish from ponds.

When appropriate and feasible, different harvesting systems and procedures will be evaluated using side-by-side comparisons, either in the same (large) pond or in adjacent (small) ponds. Variables recorded will include: (1) climatic conditions through the production season to final harvest; (2) date and location of each harvesting effort; (3) type and size of pond; (4) date of stocking and number or perch fry initially stocked in each production pond; (5) water temperatures in production pond from dates of stocking to final harvest; (6) weather conditions, time of day, ambient lighting levels, water turbidity, and dissolved oxygen levels for each harvesting effort; (7) the harvesting systems and procedures tested; (8) the duration of each harvesting effort; and (9) the number of people and amount of ancillary equipment required for each harvesting effort. The different harvesting systems and procedures evaluated will be standardized and replicated to the extent that available resources and circumstances allow. Results and endpoint examined will include: (1) number, size, and condition of the perch captured at each harvesting effort; (2) time investment and catch/unit of effort; (3) total harvest from each production pond; (4) the capture efficiency (catch per effort/total harvest) of the most effective harvesting systems and procedures; and (5) the final cost of fabricating the harvesting systems developed. When appropriate and feasible, parametric statistical methods will be employed to evaluate the data collected. Alternatively, nonparametric procedures will be used.

Continue Development of Extension Materials and Workshops (Objective 3)

Extension programming is a continuous activity. This project will continue the development of extension materials and workshops on yellow perch aquaculture beyond that now being done (or planned) as part of the ongoing NCRAC extension project. The proposed activities will focus on specific aspects of perch culture that have not been fully addressed by either past or present efforts, and will expand NCRAC's outreach programming to a broader audience. The new workshops proposed will utilize available up-to-date educational materials and present state-of-the-art knowledge to participating established and potential perch culturists throughout the NCR.

Terry Kayes of UNL, with the help of UW-Madison researchers and outreach professionals, will produce two new videotapes on: (1) state-of-the-art methods of pond feeding and pond harvesting perch, and (2) the small-scale processing of perch. He will also conduct a workshop in Nebraska on methods of harvesting perch from ponds. Much of the shooting for the videotape on perch processing has already been done, with the assistance of David A. Stuiber of the UW-Madison Department of Food Science, and the joint support of the UW-Madison School of Natural Resources and UNL Cooperative Extension. Additional funding is needed to edit and complete the production of this videotape.

Jeff Malison of UW-Madison will conduct a workshop on key facets of fingerling production and grow-out at several pond culture facilities, demonstrating both day and night operations. Don Garling of MSU, utilizing facilities at Bay Port Aquaculture Systems, will host a workshop demonstrating the commercial-scale flowthrough culture of perch. Konrad Dabrowski of OSU will conduct a one-day workshop on perch culture at the OSU Piketon Research and Extension Center.

In response to an increasing demand for techniques to culture perch intensively entirely outdoors, Fred Binkowski of the UW-Milwaukee will conduct a workshop that specifically couples intensive-culture strategies for fingerling production with recirculating system technology. As part of the ongoing NCRAC yellow perch project, the UW-Milwaukee is presently involved in a commercial-scale demonstration of the grow-out of intensively cultured feed-habituated fingerling perch in a recirculating system.

FACILITIES

Improve Larval Rearing Techniques by Developing and Evaluating Starter Diets (Objective 1)

At OSU, Konrad Dabrowski's wet laboratory in Kottman Hall (167 m^2) 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), refrigerated 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.

Experiments on *Artemia* nauplii size related to strain and cyst size will be completed at the MSU Aquaculture Laboratory. Appropriate tanks for rearing *Artemia* nauplii are available; however, additional tanks have been included in the budget. Microscopes and dissecting scopes with appropriate glass measuring slides are available to preform all measurements.

Spawning and egg incubation will be conducted by Bayport Aquaculture Systems, West Olive, Michigan. Larval rearing experiments will be completed at Bayport under the direction of Don Garling with the assistance of a graduate research assistant and Bayport personnel. The graduate research assistant will be in residence in West Olive from early-May through August to complete the larval rearing experiments. Space will be provided in the Bayport hatchery building to run the larval rearing experiments. Reliable temperature control systems are available and larval rearing tanks necessary for these experiments are included as part of the budget. Upon completion of the experiments, research tanks will be returned to MSU. Commercial-sized tanks, used as controls, will be provided and maintained by Bayport Aquaculture Systems. Microscopes and dissecting scopes with appropriate glass measuring slides will be made available by MSU to preform all measurements necessary for completion of this phase of the research.

Facilities at Purdue University include a new 687 m^2 wet laboratory equipped with well water. Additionally, diet manufacturing equipment is on site and functioning. The laboratory is equipped with complete water quality analysis equipment and two emergency generators. Yellow perch have been housed at the facility since opening in January 1993.

Improve Pond Fingerling Production and Harvesting Strategies (Objective 2)

<u>UW-Madison</u>

Studies conducted by UW-Madison will use ponds located at the UW-Madison Aquaculture Program's main research facility at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin, and ponds of Coolwater Farms, LLC, located in Dousman and Cambridge, Wisconsin. The Lake Mills Hatchery has 32 ponds ranging in size from 0.2-0.5 ha, all of which have high-volume lake water inputs. Many of these ponds also have continuous aeration systems, and several are equipped with lights and feeding systems (as described in **PROCEDURES**). Coolwater Farms has four 0.1-0.2 ha ponds at their Dousman site and seven 0.1-2.5 ha ponds at their

Cambridge site. These ponds are provided with high-volume well water inputs, electrical service including lights and feeding systems, and continuous aeration systems. All trials will use perch fry supplied by Coolwater Farms, which currently has over 2,000 perch brood fish and can produce over ten million perch fry annually. Both UW-Madison and Coolwater Farms have all of the equipment needed to conduct the proposed trials, including that for monitoring water quality and harvesting and accurately enumerating fingerlings.

At the Lake Mills Hatchery the UW-Madison Aquaculture Program has all of the facilities and equipment needed to rear fish in tanks and ponds. These facilities include over 100 flow-through fiberglass rearing tanks and over 600 L/min of temperature-regulated (10 to 30$\pm$0.5°C) well or carbon-filtered city water. For these studies nine 220-L round fiberglass tanks will be used to evaluate the habituation of perch fingerlings to formulated feeds.

UNL

The Nebraska studies to evaluate various yellow perch pond feeding and pond harvesting strategies will be done by UNL investigators, in cooperation with William Hahle (a Nebraska fish farmer with over eight years of experience at producing yellow perch) at Pleasant Valley Fish Farm, near McCook, and with the Nebraska Game and Parks Commission at the North Platte State Fish Hatchery. Physical resources available at Pleasant Valley Fish Farm include: 40 1.2-1.5 m deep earthen ponds ranging in surface area from 100 m^2 to 0.3 ha; 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-m^2 hatch house supplied with both pond and well water; a variety of indoor and outdoor rearing tanks; and ample electrical power to run pond feeding and pond harvesting systems, as well as pond and tank aeration equipment. Pleasant Valley Fish Farm also leases a number of shallow Sandhills lakes, ranging in size from 2.8 to 80 ha, near Valentine, Nebraska, in which brood stock and fingerling perch are extensively produced.

The North Platte State Fish Hatchery is a 39-ha facility located below the 647-ha Maloney Reservoir, near North Platte, Nebraska. Physical resources available at the North Platte hatchery include: 39 0.40-ha fish production ponds supplied with reservoir water through a 41-cm-diameter main; four 1.2-m-wide × 18-m-long × 1.2-m-deep outdoor raceways; several 1.8-m-diameter cylindrical outdoor rearing tanks; and a 223-m^2 hatch house equipped with 80 McDonald hatching jars and eight 0.61-m-wide × 2.4-m-long × 0.61-m-deep black fiberglass rearing tanks. All raceways, tanks, and hatching jars are supplied with reservoir water, which varies seasonally in temperature from about 2°C in winter to about 25°C in summer. The North Platte hatchery also has a workshop and a garage and storage building. The UNL, Pleasant Valley Fish Farm, and Nebraska Game and Parks Commission all have trucks equipped with live-haul tanks for the transport of fish.

Some UNL testing of pond harvesting systems will also be done at the Calamus State Fish Hatchery, a 24-ha facility located immediately downstream of the 2,023-ha Calamus Reservoir in northcentral Nebraska. Physical resources available at the Calamus hatchery include: 11 0.20-ha and 40 0.40-ha fish production ponds; an 886-m^2 indoor fish production and research facility (which is equipped for water-temperature and light control and includes an analytical and fish pathology laboratory); a large number and variety of indoor and outdoor raceways and rearing tanks; and numerous hatchery troughs and egg incubators. Water resources at the Calamus hatchery include: reservoir water (with a seasonal temperature variation from about 4°C in winter to about 22°C in summer) supplied to all the indoor and outdoor facilities via a 91-cm-diameter main; and about 11-m^3/min and 1.1-m^3/min water flow from eight wells supplying 13° and 11°C water, respectively, from two separate aquifers, to all the raceways and indoor facilities.

Continue Development of Extension Materials and Workshops (Objective 3)

The workshop coordinated by Don Garling (MSU) will use the facilities of Bay Port Aquaculture Systems, West Olive, Michigan. The workshop coordinated by Konrad Dabrowski (OSU) will use the facilities of the Piketon Research and Extension Center. The workshop coordinated by Terry Kayes (UNL) will be conducted at the North Platte State Fish Hatchery, near North Platte, Nebraska, and at the Pleasant Valley Fish Farm, near McCook, Nebraska. The workshop coordinated by Jeff Malison (UW-Madison) will use the facilities of the UW-Madison at the Lake Mills State Fish Hatchery, and also those of one or more private producers in the area, including Coolwater Farms, LLC. The workshops coordinated by Fred Binkowski (UW-Milwaukee) will utilize the facilities of the Aquaculture Institute at the UW-System Great Lakes Research Facility, and will incorporate the experiences of the commercial cooperators with their recirculating rearing systems.

Production of the videotapes on the pond feeding and pond harvesting of yellow perch and on the small-scale processing of perch will be coordinated by Terry Kayes and key support staff of the UNL Department of Forestry, Fisheries and Wildlife (FFW), and done in cooperation with researchers and outreach professionals at UW-Madison. This collective effort will be done in collaboration with the professional video and media staff of the UNL Institute of Agriculture and Natural Resources (IANR) Communications and Computing Services. The UNL FFW has the necessary "in-house" audio-video equipment and expertise to perform much of the routine field videotaping. Any specialized videotaping required, essential video graphics, and final tape editing will be done by the appropriate professionals of the UNL IANR Communications and Computer Services, or associated agencies or services which have the equipment and expertise necessary to perform these functions.

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PROJECT LEADERS

State	Name/Institution	Area of Specialization
Indiana	Paul B. Brown Purdue University	Aquaculture/Nutrition
Michigan	Donald L. Garling Michigan State University	Fish Nutrition/Fish Culture/Extension
Nebraska	Terrence B. Kayes University of Nebraska-Lincoln	Fish Culture/Fish Physiology, Feeding and Nutrition/Aquaculture Extension
Ohio	Konrad Dabrowski Ohio State University	Larval Fish Culture/Nutrition/Physiology
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

Michigan State University (MSU)
Donald L. Garling

Ohio State University (OSU)
Konrad Dabrowski

Purdue University (Purdue)
Paul B. Brown

University of Nebraska-Lincoln (UNL)
Terrence B. Kayes

University of Wisconsin-Madison (UW-Madison)
Jeffrey A. Malison

University of Wisconsin-Milwaukee (UW-Milwaukee)
Fred. P. Binkowski

PROPOSED YELLOW PERCH BUDGET FOR
MICHIGAN STATE UNIVERSTIY

(Garling)

Objectives 1 and 3

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.05	1	0.07	$0	$0
b. Senior Associates			1	0.02	$0	$0
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals						
c. Graduate Students	1	0.50	1	0.50	$12,300	$13,500
d. Prebaccalaureate Students						
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$12,300	$13,500
B. Fringe Benefits (4.9% of 2C)					$600	$650
C. **Total Salaries, Wages and Fringe Benefits**					$12,900	$14,150
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$4,000	$3,250
F. Travel - Domestic (*Including Canada*)					$750	$2,750
G. Other Direct Costs					$2,250	$2,450
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$19,900	$22,600
TOTAL PROJECT COSTS					$42,500	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR MICHIGAN STATE UNIVERSITY

(Garling)

Objectives 1 and 3

A. Salaries and Wages. One 0.5 FTE Graduate Research Assistant is needed to assist the PI in the research project.

B. Fringe Benefits. Michigan State University requires health coverage for Graduate Research Assistants.

E. Materials and Supplies. Materials and supplies needed to accomplish the research objectives include larval fish rearing tanks (majority of costs allocated in Year 1), brine shrimp eggs, brine shrimp rearing units (majority of costs allocated in Year 1), larval fish feeds (ingredients and prepared feeds), and general lab materials and supplies to preserve fish eggs, larval fish and *Artemia* specimens for subsequent analysis. Materials and supplies are needed to advertise and host one yellow perch workshop in year two of the project and for post-workshop evaluation.

F. Travel. Funds are needed for in-state travel to obtain fish and materials, for out-of-state to participate in workgroup meetings., and travel for out-of-state speakers to participate in the yellow perch workshop.

G. Other Direct Costs. Utilities for the MSU off-campus aquaculture wet lab are paid by the PI through grants and contracts. Costs are apportioned to research grants based on amount of use for the project.

PROPOSED YELLOW PERCH BUDGET FOR
OHIO STATE UNIVERSITY

(Dabrowski)

Objectives 1 and 3

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.10	1	0.10	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc	1	0.25	1	0.25	$6,000	$6,500
b. Other Professionals						
c. Graduate Students	1	0.25	1	0.25	$4,000	$4,500
d. Prebaccalaureate Students						
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$10,000	$11,000
B. Fringe Benefits (28% of 2a and 2c)					$2,800	$3,080
C. **Total Salaries, Wages and Fringe Benefits**					$12,800	$14,080
D. Nonexpendable Equipment					$2,880	$0
E. Materials and Supplies					$3,720	$5,120
F. Travel - Domestic (*Including Canada*)					$600	$1,300
G. Other Direct Costs					$0	$500
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$20,000	$21,000
TOTAL PROJECT COSTS					$41,000	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR OHIO STATE UNIVERSITY

(Dabrowski)

Objectives 1 and 3

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, Columbus campus and at Piketon, initial preparation of experimental diets and their analysis, fish and zooplankton sample analysis. Approximately half of the labor in pond and tank experiments will be supported by monies 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.** First year 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 Piketon (round trip distance 160 miles). Travel funds will also be used to attend the annual work group meetings and the NCRAC conference to present initial results. Travel costs for invited speakers and "on-site" initial organization costs are requested. The major part of the cost for the workshop will be covered from conference fees. Travel expenses are also required for out-of-state speakers in the yellow perch workshop.

G. **Other Direct Costs.** Fax, telephone, and the costs needed to prepare the workshop are requested.

PROPOSED YELLOW PERCH BUDGET FOR
PURDUE UNIVERSITY

(Brown)

Objective 1

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
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	1	.50	1	.50	$13,600	$14,000
d. Prebaccalaureate Students	1	.10	1	.10	$2,000	$2,000
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$15,600	$16,000
B. Fringe Benefits (0.7% of 2c & d)					$107	$109
C. **Total Salaries, Wages and Fringe Benefits**					$15,707	$16,109
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$2,000	$1,500
F. Travel - Domestic (*Including Canada*)					$0	$0
G. Other Direct Costs					$293	$391
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$18,000	$18,000
TOTAL PROJECT COSTS					$36,000	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR PURDUE UNIVERSITY

(Brown)

Objective 1

A. **Salaries and Wages.** One graduate student will be employed on this project. Additionally, one undergraduate student will be employed. Both students will be responsible for fish acquisition, diet manufacturing, scientific feeding of fish and data analysis.

E. **Materials and Supplies.** Materials and Supplies include feed ingredients, chemicals, and water quality analysis.

G. **Other Direct Costs.** Other Direct Costs include photocopying, telephone, and faxing charges.

PROPOSED YELLOW PERCH BUDGET FOR
UNIVERSITY OF NEBRASKA-LINCOLN

(Kayes)

Objectives 2 and 3

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.10	1	0.07	$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	0.33	$10,000	$6,667
Total Salaries and Wages					$10,000	$6,667
B. Fringe Benefits (25% of 2f)					$2,500	$1,667
C. **Total Salaries, Wages and Fringe Benefits**					$12,500	$8,334
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$3,500	$1,350
F. Travel - Domestic (*Including Canada*)					$4,300	$2,500
G. Other Direct Costs					$2,070	$1,446
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$22,370	$13,630
TOTAL PROJECT COSTS					$36,000	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR UNIVERSITY OF NEBRASKA-LINCOLN

(Kayes)

Objectives 2 and 3

A. Salaries and Wages. A technician (0.50 and 0.33 FTE) is required in Year 1 and 2, respectively, to assist with the fabrication, set-up, maintenance, and testing of the pond feeding and pond harvesting systems to be evaluated. The technician will also assist (1) with the preparation of video graphics, the coordination, staging, and shooting of videotape segments at selected project field sites in Nebraska and Wisconsin; and (3) conducting at least one workshop at a Nebraska project site on methods of harvesting yellow perch from ponds.

B. Fringe Benefits. The UNL has a standard fringe benefit rate of 25% of staff salaries.

E. Materials and Supplies. About $2,700 in Year 1 and $650 in Year 2 will be required for hardware and netting materials to fabricate, repair, and/or replace vital components of the pond feeding and pond harvesting systems, and to maintain them for the duration of the project. About $500 will be needed each year for miscellaneous supplies. Pleasant Valley Fish Farm and the Nebraska Game and Parks Commission will pay all pond fertilization and feed costs. Additionally, about $300 and $200 are needed in Year 1 and 2, respectively, for videotape, and photographic, art and computer-graphics supplies. The cost of workshop materials and supplies will be covered by charging participants a nominal registration fee.

F. Travel. The UNL component of the project will require considerable in-state travel between the UNL campus and the three principal Nebraska project sites where the pond feeding and pond harvesting systems will be evaluated. Round-trip distances between the UNL campus and Pleasant Valley Fish Farm, the North Platte State Fish Hatchery, and the Calamus State Fish Hatchery are about 576, 460, and 400 miles, respectively. The round-trip distance between the UNL campus and the perch lakes near Valentine, Nebraska, where certain harvesting systems will be tested, is about 690 miles. Both short and long-term stays by UNL researchers at the three principal project sites will be necessary. Most of the cost of long-term stays will be covered by mechanisms separate from NCRAC. Total estimated in-state travel costs for short-term lodging, meals, and fleet vehicle rental for Year 1 and 2 are about $5,170 and $4,170, respectively. About 40% of these costs can be covered by pooling appropriate travel expenses on various UNL projects under the principal investigator's supervision, which brings the total travel funds requested for Year 1 and 2 down to $3,100 and $2,500, respectively. The production of an effective techniques-centered videotape on newly developed methods of pond feeding and pond harvesting yellow perch will require extensive travel from the UNL to different videotaping sites in Nebraska and Wisconsin. Present plans are to do all of the videotaping in Year 1 of the project. Estimated travel costs are $480 for fleet vehicle rental (including mileage charges), and $720 for lodging and meals - calculated on the basis of 8-10 d total time required for two people for vehicle travel, field coordination, set-up, and videotaping at the sites selected. Travel costs to conduct workshops in Nebraska will be covered through other funding mechanisms.

G. Other Direct Costs. Funds are needed in both Year 1 and 2 for electronics and machine shop services, computer and graphic arts services, photographic processing, telecommunications, postage, shipping, and photocopying expenses related to the project. Videotape production will be done in collaboration with professional staff of the UNL IANR Communications and Computing Services, and/or with the assistance of professional videographers and editors of associated agencies (e.g., public television and private-sector video production services) as needed. Projected budget needs for Year 1 are: staff time and use of production equipment (at $35.00-$50.00/h) $588; editing, video-graphics production, and dubbing (at $50.00-$80.00/h) $882. Projected costs for the same services for Year 2 are $298 and $448, respectively.

PROPOSED YELLOW PERCH BUDGET FOR
UNIVERSITY OF WISCONSIN-MADISON

(Malison)

Objectives 2 and 3

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.07	1	0.07	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals	1	0.35	1	0.35	$8,600	$9,080
c. Graduate Students						
d. Prebaccalaureate Students						
e. Secretarial-Clerical	1	0.10	1	0.10	$2,000	$2,000
f. Technical, Shop, and Other						
Total Salaries and Wages					$10,600	$11,080
B. Fringe Benefits (31% of 2b and 2e)					$3,286	$3,435
C. **Total Salaries, Wages and Fringe Benefits**					$13,886	$14,515
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$2,780	$2,619
F. Travel - Domestic (*Including Canada*)					$2,000	$500
G. Other Direct Costs					$150	$50
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$18,816	$17,684
TOTAL PROJECT COSTS					$36,500	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR UNIVERSITY OF WISCONSIN-MADISON

(Malison)

Objectives 2 and 3

A. **Salaries and Wages.** Salaries are needed for personnel to conduct the pond feeding trials and the tank habituation trials, collect, collate and analyze data and assist in the preparation of reports, presentations and manuscripts. In addition, work group chairs are allocated $2,000 per year plus fringe benefits for secretarial services.

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 and to prepare materials that will be distributed at the workshop.

F. **Travel.** Travel funds are needed to attend NCRAC Yellow Perch Work Group meetings, for UW-Madison personnel to travel to Coolwater Farms for data collection, and to (partially) pay for one scientific conference to present our findings. Funds will also be used to provide transportation for invited speakers at the workshop.

PROPOSED YELLOW PERCH BUDGET FOR
UNIVERSITY OF WISCONSIN-MILWAUKEE

(Binkowski)

Objective 3

	Year 1 No.	Year 1 FTEs	Year 2 No.	Year 2 FTEs	Year 1	Year 2
A. Salaries and Wages						
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	1	0.10			$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals	1	0.10			$3,120	$0
c. Graduate Students						
d. Prebaccalaureate Students					$3,913	
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$7,033	$0
B. Fringe Benefits (31% of 2b)					$967	$0
C. **Total Salaries, Wages and Fringe Benefits**					$8,000	$0
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$0	$0
F. Travel - Domestic (*Including Canada*)					$0	$0
G. Other Direct Costs					$0	$0
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$8,000	$0
TOTAL PROJECT COSTS					$8,000	

[1]FTEs = Full Time Equivalents based on 12 months.

BUDGET JUSTIFICATION FOR UNIVERSITY OF WISCONSIN-MILWAUKEE

(Binkowski)

Objective 3

A. **Salaries and Wages.** Salaries are required for personnel to develop, organize and conduct the workshop/training sessions associated with Recirculating System Technology in conjunction with yellow perch production. In addition, salaries will be needed to maintain the daily operation of this system which includes basic animal husbandry techniques.

ADVANCEMENT OF YELLOW PERCH AQUACULTURE

Budget Summary for Each Particpating Institution at $107.1K for First Year

	MSU	OSU	PURDUE	UNL	UW-MADISON	UW-MILWAUKEE	TOTALS
Salaries and Wages	$12,300	$10,000	$15,600	$10,000	$10,600	$7,033	$65,533
Fringe Benefits	$600	$2,800	$107	$2,500	$3,286	$967	$10,260
Total Salaries, Wages and Benefits	$12,900	$12,800	$15,707	$12,500	$13,886	$8,000	$75,793
Nonexpendable Equipment	$0	$2,880	$0	$0	$0	$0	$2,880
Materials and Supplies	$4,000	$3,720	$2,000	$3,500	$2,780	$0	$16,000
Travel	$750	$600	$0	$4,300	$2,000	$0	$7,650
Other Direct Costs	$2,250	$0	$293	$2,070	$150	$0	$4,763
TOTAL PROJECT COSTS	$19,900	$20,000	$18,000	$22,370	$18,816	$8,000	$107,086

Budget Summary for Each Particpating Institution at $92.9K for Second Year

	MSU	OSU	PURDUE	UNL	UW-MADISON	UW-MILWAUKEE	TOTALS
Salaries and Wages	$13,500	$11,000	$16,000	$6,667	$11,080	$0	$58,247
Fringe Benefits	$650	$3,080	$109	$1,667	$3,435	$0	$8,941
Total Salaries, Wages and Benefits	$14,150	$14,080	$16,109	$8,334	$14,515	$0	$67,188
Nonexpendable Equipment	$0	$0	$0	$0	$0	$0	$0
Materials and Supplies	$3,250	$5,120	$1,500	$1,350	$2,619	$0	$13,839
Travel	$2,750	$1,300	$0	$2,500	$500	$0	$7,050
Other Direct Costs	$2,450	$500	$391	$1,446	$50	$0	$4,837
TOTAL PROJECT COSTS	$22,600	$21,000	$18,000	$13,630	$17,684	$0	$92,914

RESOURCE COMMITMENT FROM INSTITUTIONS[1]

State/Institution		Year 1	Year 2
Michigan State University			
Salaries and Benefits: SY @ 0.05 FTE		$4,265	$7,531
Waiver of Overhead		$9,353	$12,097
	Total	$13,618	$19,628
Ohio State University			
Salaries and Benefits: SY @ 0.05 FTE		$6,200	$6,200
Equipment and Waiver of Overhead		$6,000	$6,000
Piketon Research and Extension Center Facilities and Utilities		$4,000	$5,000
	Total	$16,200	$17,200
Purdue University			
Salaries and Benefits: SY @ 0.05		$4,200	$4,800
Supplies, Expenses, and Equipment		$0	$0
Waiver of Overhead		$15,000	$16,000
	Total	$19,200	$20,800
University of Nebraska-Lincoln			
Salaries and Benefits: SY @ 0.10 and 0.07 FTEs (Year 1 and 2)		$6,732	$4,712
TY @ 0.12 FTE		$2,700	$2,700
Supplies, Expenses, Equipment, and Waiver of Overhead		$5,590	$3,981
Pleasant Valley Fish Farm; Nebraska Games and Parks Commission (Salaries, Supplies, Equipment, and Overhead Costs)		$12,000	$9,000
	Total	$27,022	$20,393
University of Wisconsin-Madison			
Salaries and Benefits: SY @ 0.06 FTE		$3,851	$4,044
Supplies, Expenses, Equipment, and Waiver of Overhead		$12,030	$12,030
Coolwater Farms, LLC Salaries and Benefits		$4,500	$4,500
Supplies and Equipment		$7,500	$7,500
	Total	$27,881	$28,074

RESOURCE COMMITMENT FROM INSTITUTIONS[1]

State/Institution		Year 1	Year 2
University of Wisconsin-Milwaukee			
Salaries and Benefits: SY @ 0.10 FTE		$14,148	$0
Supplies, Expenses, and Equipment		$3,000	$0
Equipment (Recirculating System Technology)		$10,000	$0
Facilities and Utilities		$5,000	$0
Waiver of Overhead		$9,745	$0
	Total	$41,893	$0
	Total per Year	$145,814	$106,095
	GRAND TOTAL	$251,909	

[1]Because 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.

Objective 3: 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

Donald L. Garling, Michigan State University

Terrence B. Kayes, University of Nebraska-Lincoln

Jeffrey A. Malison, University of Wisconsin-Madison

VITA

Fred P. Binkowski
Senior Scientist
Center for Great Lakes Studies
600 E. Greenfield Avenue
University of Wisconsin-Milwaukee
Milwaukee, WI 53204

Phone: (414) 382-1700
FAX: (414) 382-1705

EDUCATION

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

POSITIONS

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

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

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

SELECTED PUBLICATIONS

Binkowski, F.P., and L.G. Rudstam. 1994. The maximum daily ration of Great Lakes bloater. Transactions of the American Fisheries Society 123:335-343.

Rudstam, L.G., F.P. Binkowski, and M.A. Miller. 1994. A bioenergetics model for analysis of food consumption patterns by bloater in Lake Michigan. Transactions of the American Fisheries Society 123:344-357.

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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.

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VITA

Paul B. Brown
Associate Professor
Purdue University
Department of Forestry and Natural Resources
1159 Forestry Building
Purdue University
West Lafayette, IN 47907-1159

Phone: (317) 494-4968
FAX: (318) 494-0409
E-mail: pb@forest1.fnr.purdue.edu

EDUCATION

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

POSITIONS

Associate Professor of Fisheries and Aquatic Sciences (1993-present) and Assistant Professor (1989-1993), Department of Forestry and Natural Resources, Purdue University
Assistant Professional Scientist/Field Station Director (1987-1989), Illinois Natural History Survey
Adjunct Assistant Professor (1988-1989), University of Illinois, Department of Animal Sciences

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Association for the Advancement of Science
American Fisheries Society
American Institute of Fishery Research Biologists
American Institute of Nutrition
American Society of Zoologists
International Association of Astacology
World Aquaculture Society
Sigma Xi
Gamma Sigma Delta

SELECTED PUBLICATIONS

Griffin, M.E., M.R. White, and P.B. Brown. 1994. Total sulfur amino acid requirement and cysteine replacement value for juvenile hybrid striped bass (*Morone saxatilis* × *M. chrysops*). Comparative Biochemistry and Physiology 108A:423-429.

Griffin, M.E., K.A. Wilson, and P.B. Brown. 1994. Dietary arginine requirement of juvenile hybrid striped bass. Journal of Nutrition 124:888-893.

Brown, P.B., M.E. Griffin, and M.R. White. 1993. Experimental and practical diet evaluations with juvenile hybrid striped bass. Journal of the World Aquaculture Society 24:80-89.

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 103A:213-219.

Griffin, M.E., P.B. Brown, and A. Grant. 1992. Dietary lysine requirement of juvenile hybrid striped bass. Journal of Nutrition 122:1332-1337.

VITA

Konrad Dabrowski
Professor
School of Natural Resources
2021 Coffey Road
Ohio State University
Columbus, OH 43210

Phone: (614) 292-4555
FAX: (614) 292-7162

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

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., and J. Blom. 1994. Deposition of ascorbic acid in rainbow trout (*Oncorhynchus mykiss*) eggs and survival of embryos. Comparative Biochemical Physiology 1008A:129-135.

Ciereszko, A., and K. Dabrowski. 1994. Some biochemical constituents of fish semen: relationship between semen quality and fertility changes. Fish Physiological Biochemistry 12:357-367.

Matusiewicz, M., K. Dabrowski, L. Volker, and K. Matusiewicz. 1994. Regulation of saturation and depletion of ascorbic acid in rainbow trout. Journal of Nutritional Biochemistry 5:204-212.

Dabrowski, K., A. Ciereszko, L. Ramseyer, D. Culver, and P. Kestemont. 1994. Effects of hormonal treatment on induced spermiation and ovulation of yellow perch (*Perca flavescens*). Aquaculture 120:171-180.

Dabrowski, K., G. Krumschnabel, M. Paukku, and J. Labanowski. 1992. Cyclic growth and activity of pancreatic enzymes of Artic 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.

VITA

Donald L. Garling, Jr.
Professor and Fish Culture and
Fisheries Extension Specialist
Department of Fisheries and Wildlife
Michigan State University
East Lansing, MI 48824

Phone: (517) 353-1989
FAX: (517) 432-1699
E-mail: garlingd@msu.edu

EDUCATION

B.S. University of Dayton, 1970
M.S. Eastern Kentucky University, 1972
Ph.D. Mississippi State University, 1975

POSITIONS

Professor (1990-present), Associate Professor (1985-1990), and Assistant Professor (1980-1985), Department of Fisheries and Wildlife, Michigan State University

Aquaculture and Fisheries Extension Specialist (1985-present), Department of Fisheries and Wildlife, Michigan State University

Assistant Professor Fisheries Science (1976-1980), Department of Fisheries and Wildlife Sciences, Virginia Institute and State University

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society: Fish Culture and Fisheries Educators
World Aquaculture Society,
Sigma Xi
Gamma Sigma Delta

SELECTED PUBLICATIONS

Ramseyer, L.J., and D.L. Garling. In press. Amino acid composition of ovaries, muscle, and whole body of yellow perch (*Perca flavescens*). Progressive Fish-Culturist

Cain, K., and D. Garling. 1993. Trout culture in the north central region. North Central Regional Aquaculture Center, Fact Sheet #108.

Belal, I.E., D.L. Garling, and H. Assem. 1992. Evaluation of practical tilapia feed using a saturation kinetic model. Comparative Biochemistry and Physiology 102A:785-790.

Garling, D.L. 1991. NCRAC research programs to enhance the potential of yellow perch aquaculture in the region. Pages 253-255 *in* Proceedings of the North Central Aquaculture Conference. Michigan Department of Natural Resources, Wolf Lake Fish Hatchery, Mattawan, Michigan.

Machado, J.P., T.G. Bell, D.L. Garling, Jr., N.R. Kevern, and A.L. Trapp. 1989. Effect of carbon monoxide and exposure on gas-bubble trauma in rainbow trout (*Salmo gairdneri*). Canadian Journal of Fisheries and Aquatic Sciences 46:74-80.

VITA

Terrence B. Kayes
Associate Professor
Department of Forestry, Fisheries and Wildlife
12 Plant Industry, East Campus
University of Nebraska-Lincoln
Lincoln, NE 68583-0814

Phone: (402) 472-8183
FAX: (402) 472-2964

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

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

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

SELECTED PUBLICATIONS

Kohler, C.C., R.J. Sheehan, C. Habicht, J.A. Malison, and T.B. Kayes. In press. Habituation to captivity and controlled spawning of white bass. Transactions of the American Fisheries Society.

Malison, J.A., L.S. Procarione, T.P. Barry, A.R. Kapuscinski, and T.B. Kayes. In press. Endocrine and gonadal changes during the annual reproductive cycle of the freshwater teleost, *Stizostedion vitreum* ("walleye"). Fish Physiology and Biochemistry.

Malison, J.A., T.B. Kayes, J.A. Held, T.P. Barry, and C.H. Amundson. 1993. Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. Aquaculture 110:229-242.

Heidinger, R.C., and T.B. Kayes. 1993. Yellow perch. Pages 215-229 *in* R.R. Stickney, editor. Culture of nonsalmonid freshwater fishes, second edition. CRC Press, Boca Raton, Florida.

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. canadense*) and their hybrids reared under intensive culture conditions. Progressive Fish-Culturist 52:73-82.

VITA

Jeffrey A. Malison
Director
University of Wisconsin Aquaculture Program
Department of Food Science
103 Babcock Hall, 1605 Linden Drive
University of Wisconsin-Madison
Madison, WI 53706

Phone: (608) 263-1242
FAX: (608) 262-6872

EDUCATION

B.S. University of Wisconsin-Stevens Point, 1976
M.S. University of Wisconsin-Madison, 1980
Ph.D. University of Wisconsin-Madison, 1985

POSITIONS

Director (1995-present), Assistant Director (1990-1995), Associate Researcher (1987-1990) and Project Associate (1985-1987), University of Wisconsin-Madison Aquaculture Program, University of Wisconsin-Madison

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

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

SELECTED PUBLICATIONS

Malison, J.A., L.S. Procarione, J.A. Held, T.B. Kayes, and C.H. Amundson. 1993. The influence of triploidy and heat and hydrostatic pressure shocks on the growth and reproductive development of yellow perch (*Perca flavescens*). Aquaculture 116:121-133.

Malison, J.A., T.B. Kayes, J.A. Held, T.P. Barry, and C.H. Amundson. 1993. Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. Aquaculture 110:229-242.

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.

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. canadense*) and their hybrids reared under intensive culture conditions. Progressive Fish-Culturist 52:73-82.

Manci, W.E., J.A. Malison, T.B. Kayes, and T.E. Kuczynski. 1983. Harvesting photopositive juvenile fish from a pond using a lift net and light. Aquaculture 34:157-164.