CULTURE TECHNOLOGY OF HYBRID STRIPED BASS

Chairperson: Christopher C. Kohler, Southern Illinois University-Carbondale

Extension Liaisons: Joseph E. Morris, Iowa State University

Funding Request: $160,000

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

Objectives:

1. Examine fry (phase I) to fingerling (phase II) production of three strains of white bass and three strains of hybrid striped bass (sunshine bass) in ponds with and without lights and vibrating feeders.

2. Conduct field testing of fingerling (phase II) to advanced fingerling (phase III) production of three strains of hybrid striped bass (sunshine bass) in various culture systems.

3. Extension component:

   a. Coordinate selection of various culture systems and implement field testing (fingerling to advanced fingerling to food size).

   b. Write an initial culture manual using the information generated by all the hybrid striped bass research sponsored by the NCRAC.

   c. Produce associated fact sheets, bulletins, and videos for hybrid striped bass research in the North Central Region.

Proposed Budgets:

Institution	Principal Investigator(s)	Objective(s)	Year 1	Year 2	Total
Southern Illinois University-Carbondale	Christopher C. Kohler Robert J. Sheehan	1-3	$39,500	$43,500	$83,000
Univ. of Wisconsin-Madison	Jeffrey A. Malison	1	$5,000	$0	$5,000
University of Nebraska-Lincoln	Terrence B. Kayes	1 & 3	$10,000	$0	$10,000
Purdue University	Paul B. Brown	2	$18,000	$18,000	$36,000
South Dakota State University	Michael L. Brown	2	$12,270	$5,730	$18,000
Iowa State University	Joseph E. Morris	3	$2,500	$2,500	$5,000
Univ. of Wisconsin-Milwaukee	Fred P. Binkowski	3	$3,000	$0	$3,000
		TOTALS	**$90,270**	**$69,730**	**$160,000**

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JUSTIFICATION

The immediate concerns for aquaculture development in the North Central Region (NCR) are the identification of suitable species/hybrids for culture, development of brood stocks, and modification of existing technologies for rapid deployment within the emerging industry. Striped bass (*Morone saxatilis*) × white bass (*M. chrysops*) hybrids offer considerable commercial potential within much of the region. As a clear indication of its regional market potential, seafood processors in Chicago are willing to pay a minimum of $1.59/kg ($3.50/lb) in the round for fresh hybrid striped bass (A. Roberts (retired), Illinois Deptartment Agriculture, personal communication).

The striped bass is a temperate-water anadromous fish that is native to the Atlantic coast and is widely stocked in large lakes and reservoirs in many parts of the U.S., including the NCR. The striped bass is prized as a game fish throughout most of its range and commands high market prices as a food fish (Norton et al. 1983). In 1983, the striped bass was identified at the national level (JSA 1983) as having significant potential for commercial aquaculture development.

Since 1983, research related to the development of commercial striped bass aquaculture has focused increasingly on the culture of striped bass × white bass hybrids. Numerous studies have demonstrated that both the female striped bass × male white bass (SB × WB, original cross = palmetto bass) and the female white bass × male striped bass (WB × SB, reciprocal cross = sunshine bass) hybrids are faster growing (at least during the first two years of life), and more robust and more resistant to disease and environmental extremes than purebred striped bass (Kerby 1986).

The identification of the hybrid striped bass as a candidate for commercial aquaculture development in the NCR is appropriate because: (1) the fish has been identified by the Industry Advisory Council (IAC) as a high priority species; (2) a number of fish farmers are producing this fish; and (3) much of the southern half of the region is at approximately the same latitude and has about the same seasonal water temperature conditions as the mid- and southern Atlantic states where hybrid striped bass culture is being pursued. Indeed, the potential for future collaboration among the North Central, Northeastern and Southern Regions in the development of a national hybrid striped bass industry seems clear, particularly in light of the fact that the white bass is a native species and fairly common in the NCR.

According to the National Aquaculture Development Plan (JSA 1983), the principal constraint on commercial striped bass aquaculture in the U.S. is the "nonavailability of seed stock." Declines in the striped bass fisheries along the Atlantic coast in the 1980s, as well as legal constraints, have increasingly limited the availability of wild brood stock (especially females) as a source of gametes (Harrell 1984), even though population numbers have recently rebounded. In part, the problem of limited availability of striped bass gametes in the NCR could be greatly reduced by utilizing female white bass crossed with male striped bass to produce reciprocal cross hybrids, or sunshine bass. White bass are native and fairly common throughout much of the region (Scott and Crossman 1973; Becker 1983). However, legal constraints also limit access to wild white bass stocks (though not as much as for striped bass on the Atlantic coast). To that end, a North Central Regional Aquaculture Center (NCRAC)-sponsored cooperative regional hybrid striped bass research project that is interdisciplinary in scope and involves investigators from three institutions in three states: Southern Illinois University-Carbondale (SIUC), the University of Wisconsin-Madison (UW-Madison) and Iowa State University (ISU), is currently underway. The principal goal of that project is to address key problems that pertain to the development of commercial hybrid striped bass culture in the NCR. Problem areas being addressed include: (1) brood stock development, (2) mechanisms regulating the natural reproductive cycle, (3) manipulation of gonadal maturation and out-of-season spawning, and (4) long- and short-term storage of white bass semen. That project has been highly successful in meeting its objectives (see **RELATED CURRENT AND PREVIOUS WORK**). However, the project only requires rearing developing embryos to swim-up fry. Accordingly, larval rearing protocols are being developed in a follow-up study, as well as further refinements in cryopreservation techniques. This project invovles researchers from SIUC, UW-Milwaukee, Purdue University, and Ohio State University.

Current NCRAC funding has focused on development of white bass brood stock and controlled spawning. There is a need to expand on this focus to include pond production of white bass for brood stock and reciprocal hybrid striped bass for commercial production. Recent work with yellow perch indicates potential for habituation of larvae to formulated feeds can be enhanced using lights and vibrating feeders. This technique needs to be evaluated for white bass and reciprocal cross hybrid striped bass. In addition, field trials need to be conducted in the NCR to identify appropriate culture systems for rearing hybrids to market size.

Production of hybrid striped bass, primarily the reciprocal cross or sunshine bass, in the NCR has been expanding. They are currently grown in earthen culture ponds, indoor recirculating systems, and cages in existing farm ponds.

Perhaps the most economical method of introducing aquaculture into the NCR is cage culture. Culture of fish in cages placed in existing ponds is a relatively low cost method of learning aquaculture without excessive capital investment. Further, the number of possible production sites is high in this region. Estimates of the number of farm ponds in Indiana and Illinois alone range as high as 80,000 (L. Swann, personal communication). Purdue University researchers initiated introduction of cage culture of hybrid striped bass in 1989 and the number of users has increased to approximately 10 individuals. Total production is currently unknown. Thus, this method of fish production serves as a low cost means of entering aquaculture with little economic risk. On the other extreme, several producers of hybrid striped bass have been producing fish in indoor recirculating systems for over five years. Those individuals have identified improved feeds as an important topic. Researchers at Purdue have been working on diets for this hybrid (Griffin et al. 1992; Brown et al. 1993; Griffin et al. 1994a, b; Griffin et al. In press), and are now at a point of testing those formulations on a commercial scale.

While culture of hybrid striped bass has been increasing in the NCR, several problem areas have been identified that restrict further expansion. For example, individuals in Indiana who were initially involved in cage culture evaluations have been steadily increasing the number of cages and desire to increase densities within cages, while producers using recirculating systems have identified improved feeds as a priority area. Both density and feeds are critical components of the IAC's identified objective of production of advanced fingerlings.

Virtually all white bass and striped bass used as brood fish for commercial hybrid striped bass production are obtained from the wild. White bass that have been habituated to captivity at Southern Illinois University come from the Illinois River. Many producers obtain their white bass from commercial fishermen on Lake Erie, while others collect them locally. Likewise, striped bass may originate from the entire eastern seaboard or from numerous land-locked populations that were established from stockings from the East Coast. Recently, Ehtisham et al. (1994) found that northern strains of striped bass outperformed southern strains. Similar work needs to be done with white bass, as well as hybrids obtained from different regions.

Since their inception in 1989, the various Research Work Groups and the Extension Work Group of NCRAC have operated largely as separate entities with distinctly different priorities. The main goal of the NCRAC Research Work Groups has been to pursue selected research objectives on key species or types of fishes identified as having significant potential for aquaculture development in the NCR. The Hybrid Striped Bass Work Group has focused on the sunshine bass, emphasizing applied reproductive biology and the development or verification of procedures for: (1) domesticating white bass brood stock, (2) manipulating their annual reproductive cycle to induce out-of-season spawning, (3) short- and long-term (cryopreservation) storage and transport of semen, (4) the artificial propagation of white bass and hybrid striped bass, and (5) the intensive culture of the larvae of white bass and sunshine bass in tanks.

The principal objectives of the NCRAC Extension Work Group have been to: (1) develop linkages with the various NCRAC Research Work Groups, (2) establish a NCRAC extension network for aquaculture information transfer, (3) provide inservice training to selected landowner assistance personnel, and (4) develop educational programs for the NCR. To date, the Extension Work Group's educational activities have focused primarily on the production of a number of fact sheets and bulletins and on holding workshops and a conference on an array of topics. As yet, no educational materials specifically centered on the research findings of the NCRAC Hybrid Striped Bass Work Group have been produced by NCRAC.

At the 1992 NCRAC Program Planning Meeting held February 14-16, in Columbus, Ohio, the NCRAC IAC expressed a strong desire for the production of more tangible techniques-centered educational tools that can help fish farmers culture those species identified by NCRAC as having significant potential for commercial aquaculture. At the 1993 Program Planning Meeting held February 19-21, in Madison, Wisconsin, the NCRAC IAC specifically stipulated the development of extension educational materials, in particular, a production manual and accompanying videotapes, as the top priority need for demonstrating the commercial feasibility of centrarchid sunfish aquaculture in the region. This priority need was assigned as a project objective to the NCRAC Centrarchid (Sunfish) Work Group, and is presently being addressed by both researchers and extension professionals. At the 1994 Program Planning Meeting held February 4-6, in Lincoln, Nebraska, a similar priority objective was assigned to the NCRAC Hybrid Striped Bass Work Group, and is being addressed by this proposal.

RELATED CURRENT AND PREVIOUS WORK

Over the past 25-30 years, numerous technical articles, theses, reviews, and manuals have been produced on the propagation and/or culture of striped bass and the original-cross (palmetto bass) hybrid striped bass (e.g., see Bonn et al. 1976; Kerby 1986, 1993; Morris 1988, 1989; Harrell et al. 1990). Interest in the culture of the reciprocal-cross hybrid (sunshine bass) has increasingly grown in recent years for reasons already outlined; but less research-based information has been published on the propagation or culture of the purebred white bass (Harrell et al. 1990; Kerby 1993). Much of the information available on the applied reproductive biology and propagation of the white bass and the sunshine bass is experiential or anecdotal in nature, and has often come from the "gray literature," which is generally not subjected to critical peer review.

This proposal is a continuation of and addition to three previously funded NCRAC projects on hybrid striped bass. Results from those projects, as well as selected other works are summarized below.

Domestication and Controlled Spawning of White Bass

Adult white bass *Morone chrysops* were collected via hook-and-line fishing from the Illinois River near LaSalle, Illinois in the fall (1989) and spring (1990). The fish were therapeutically treated for diseases/stress during hauling and for approximately one week after stocking into an indoor 10,000-L, water-recycle system at Southern Illinois University-Carbondale. White bass were trained to dry formulated feed by initially providing moist pellets consisting of commercial dry trout feed (40% crude protein, 11% crude fat), raw gizzard shad *Dorosoma cepedianum* and vitamins. The dry trout feed was concomitantly introduced after a few days, and the relative proportions of each feed was altered (dry feed increased:moist feed decreased until fish solely accepted the dry feed, usually about two weeks). In summer (1990) 300 white bass (300-600 g) of an approximate even sex ratio were spread over three separate 10,000-L water recycle systems, one maintained under an ambient photoperiod/temperature regime, one compressed to about nine months and one held at a temperature at or above spawning temperature (20 ± 5°C) and constant photoperiod (14 hours light/10 hours dark). Using human chorionic gonadotropin (hCG) injections (1100 and 125 IU/kg of female and male fish, respectively), the compressed-cycle fish were induced to spawn in March, 1991; the ambient-cycle fish in May, 1991; and the constant-cycle fish in May, 1991. The hCG-injected constant cycle fish failed to spawn in March, 1991. The spawning condition of wild and the three captive populations, as determined by UW-Madison researchers from serum levels of estradiol-17β and testosterone, as well as gonadal histology, followed patterns congruent with actual spawning events. These results are fully described in Kohler et al. (1994).

Induced Spawning Protocol

In the course of the research described above it became apparent that the traditional hCG dosage (i.e., 1100 IU/kg wet weight female white base), which is 2-3 times higher than that used for striped bass, had not been adequately tested for efficacy. Accordingly, SIUC researchers evaluated hCG dosages ranging from 0-1100 IU/kg in white bass females that had been habituated to captivity and brought into spawning condition through temperature and photoperiod control. Male white bass maintained under identical conditions were injected with hCG at 100 IU/kg to increase semen volume. A minimum of four female white bass were spawned at each dosage.

hCG Dosage	Ovulation Time (h)		% hatch	
(IU/kg wet weight)	Mean	Range	Mean	Range
1100	24	16-32	22	0-58
830	31	26-45	36	6-90
280	28	24-34	58	0-90
250	39	37-40	63	36-81
170	25	21-29	61	15-89
150	38	29-47	44	19-64
50	37	34-39	73	66-89
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These data indicate that hCG dosages considerably less than that traditionally used to induce final oocyte maturation and ovulation in white bass are more efficacious. In addition to providing guidance for improved spawning performance, these data have positive implications toward eventual regulatory approval of hCG for spawning *Morone* spp.

Historical Cryopreservation of Fish Semen

Cryopreservation of fish spermatozoa, in general, has historically met with variable success. Development of suitable cryogenic media and freezing procedures have permitted successful freezing of semen from a number of species (Stoss 1983). Existing methods facilitate experimental and hybridization programs within fish culture; however, many of the methods are inadequate for use in production facilities (Kerby 1983).

A major barrier preventing use of cryopreservation on a large scale basis is the lack of reproducible and reliable results between researchers and techniques. Multiple steps during the freezing process such as stripping and handling of gametes, compatibility of semen with various freezing solutions, and the physical stress of applied freezing and thawing programs contribute to variability. These factors fluctuate from one freezing program to the next, making it impossible for researchers to account for variability in quality. Hence, any one factor in this sequence of freezing steps may influence the results.

Storage of White Bass and Striped Bass Semen

Efficient methods for storage of *Morone* gametes would provide an essentially continuous supply of gametes for use in: (1) year-round hybrid production including hybridization of stocks that spawn at different times, (2) experimental ploidy manipulations, and (3) as a tool in genetic conservation of *Morone* stocks. Protocols for the successful collection, short- and long-term storage, and transportation of *Morone* gametes have been developed collaboratively between ISU and SIUC.

White bass sperm were collected from three groups of fish given either monthly hCG injections, weekly hCG injections, or no hCG. Five extender solutions were evaluated. Extended and non-extended semen samples were shipped to ISU where motility was determined. Extended sperm had significantly greater post-shipment motility when compared to non-extended samples. Only two of the five extenders resulted in significant differences in motility; a simple sodium chloride solution performed as well or better than more complex solutions. Sperm from monthly injected fish had significantly better motilities than sperm from weekly injected fish. No significant differences in motility between control and monthly injected fish were found.

Sperm samples collected from captive white bass and wild Florida striped bass were cryopreserved in 0.5 mL freezing straws using three cryoprotectants. Cryopreserved samples were stored in liquid nitrogen vapors. A portion of the straws were shipped on dry ice to ISU, thawed, and motility evaluated and compared to motilities of extended sperm. Extended samples from both species had a significantly higher motility than the cryopreserved samples; motility was reduced by about 50% with cryopreservation. Extended white bass sperm held in refrigerated storage for approximately 30 days exhibited a similar reduction in motility. There were no significant differences between motilities of cryopreserved samples from both species. The remainder of the straws were later used in fertility tests with white bass eggs stripped from captive females. No significant differences in percent hatch were detected among the three cryoprotectant treatments. Hatch from eggs was 26.1 to 52.8% and 40.2 to 85.0% of hatch from eggs fertilized with fresh extended semen for cryopreserved white bass and striped bass sperm, respectively. The results indicated that although motility was significantly reduced with cryopreservation, reasonably good health was still obtained. However, cryopreserved sperm can be stored indefinitely. Therefore, if *Morone* sperm must be stored prior to use for longer than 30 days, cryopreservation appears to be the best option.

Larval Rearing

SIUC researchers found that both hybrid striped bass crosses at a 2-5 g size range readily convert from zooplankton to formulated feed. Over 90% of the fish converted to formulated feed within two days as compared to 70-85% after seven days for largemouth bass which were trained in a "side-by-side" study. Preliminary results indicate that white bass and reciprocal-cross hybrids can make the switch between day 21 and 28 after hatch. Original cross hybrids can generally be switched at day seven after hatch. Researchers at SIUC, Ohio State University, and University of Wisconsin-Milwaukee have been attempting to rear white bass larvae from hatch to fingerling. To date, less than 5% survival rates have been experienced at all three stations after 30 days. Poor survival has also been experienced by researchers in South Carolina (Hadley et al. 1994). Additional trials are underway in both the NCR and in South Carolina.

Rearing Techniques

Much information exists on rearing techniques for the original cross hybrid, striped bass female × white bass male = palmetto bass (Stevens 1966, 1967; Tatum et al. 1966; Bayless 1972; Bishop 1975; Bonn et al. 1976; Harrell 1984). In the past 20 years there have been several research and development programs examining the aquaculture potential of striped bass and its hybrids in different systems (see review by Carlberg et al. 1984; Smith et al. 1985). These studies have focused mainly on the use of the palmetto bass. However, the reciprocal cross hybrid, white bass female × striped bass male = sunshine bass, grew faster and had higher survival rates than the striped bass or the palmetto bass when reared in indoor recirculating systems (Smith et al. 1985).

In Illinois, sunshine bass (white bass female × striped bass male; 100 ± 5 g each) were stocked at equivalent densities into earthen ponds, rectangular cages within those ponds, round and rectangular cages in a single pond, and round and rectangular indoor tanks equipped with biofilters. Performance was best in the open ponds due to natural foods. Fish performance in round and rectangular confinements was similar. Performance in all systems was comparable to reports for the palmetto bass (striped bass female × white bass male) and striped bass (Kelly and Kohler, submitted manuscript).

There have been numerous evaluations of hybrid striped bass production in cages, most of which have been conducted on the East Coast (cf, Williams et al. 1981; Woods et al. 1983). One of the more recent studies was conducted in Indiana (Swann et al. In press). In that study, hybrids were grown at densities of 100/m^3 and grew at rates similar to published results from eastern researchers. Those densities are still in use in Indiana. However, maximum stocking density has apparently not been explored in cage culture of hybrid striped bass.

Diet Development

Dietary research with hybrid striped bass has been conducted at a relatively rapid pace, primarily at Purdue and Texas A&M Universities. Those studies have focused on appropriate existing diets (Brown et al. 1993), optimal protein and protein to energy ratios (Brown et al. 1992; Nematipour et al. 1992a), optimum ratio of lipid to carbohydrate (Nematipour et al. 1992b), essential amino acid requirement studies (Griffin et al. 1992; Griffin et al. 1994a, b; Keembihetty and Gatlin 1992, 1993) and vitamin requirements (Griffin et al. In press). Those studies have provided the necessary information for formulating diets specifically for the hybrid. Several new diets are available, but none have been evaluated on a production scale in recirculating systems.

Extension

Since 1989, the Southern Regional Aquaculture Center (SRAC) has produced numerous extension fact sheets and at least three videotapes on various aspects of hybrid striped bass culture in the south, and on spawning induction techniques in warm water fish in general. In addition, similar informational materials have been produced by the Cooperative Extension Services or Sea Grant Programs of a number of southern and Atlantic Coast states. However, to our knowledge, little if any research-based techniques-centered educational materials, presented in an extension format (fact sheets, videotapes, etc.), exists on the applied reproductive biology of white bass, the artificial propagation of the reciprocal-cross hybrid striped bass in the NCR, or the preservation and transport of viable striped bass or white bass semen.

ANTICIPATED BENEFITS

The overall goal of this collaborative project is to enhance hybrid striped bass aquaculture in the NCR. Hybrid striped bass are consistently identified as a high priority species within the NCR and consistently ranked as a preferred species to eat (unpublished data from Purdue University). Out-of-season spawning of white bass has been achieved in an ongoing NCRAC-sponsored project. The development of intensive larval culture techniques for this species will allow for its full domestication. The development of techniques for semen storage (cryopreservation and extended) preclude the need for maintaining large numbers of male striped bass brood stock. The logical next step is to conduct field trials of several strains of white bass and hybrid striped bass in various culture systems. Existing producers need to improve the economics of hybrid striped bass production by increasing stocking densities and improving feeds. The break-even production cost of hybrids grown in cages is $2.29 to $3.45/kg (Riepe et al. 1992). Those values were based on a stocking density of 100/m^3 and feed costs of $0.55/kg. As production of hybrids increases on a regional and national scale, market price will likely decrease. Thus, this research will help maintain current profit margins as production increases. The knowledge gained from this study should be of immediate use by the aquaculture industry. The extension component of the study will assure that research information gets to the industry in a user-friendly form. Although the proposed project is not directly interregional with respect to physical performance, lines of communications have, and will continue to be maintained with the Hybrid Striped Bass Grower's Association and other researchers, specifically: Harrell, Woods, and Zohar at the University of Maryland; Smith and Jenkins at the South Carolina Department of Natural Resources; and Hodson and Sullivan at North Carolina State University.

Progress to Date

The objectives are new to NCRAC; thus, there has been no progress from previously funded NCRAC projects. Progress of previous work is described in **RELATED CURRENT AND PREVIOUS WORK**.

OBJECTIVES

To address the problems that face commercial production of hybrid striped bass which were identified by the IAC of the NCRAC, a joint research and extension project is being proposed. Objectives of the project are as follows:

1. Examine fry (phase I) to fingerling (phase II) production of three strains of white bass and three strains of hybrid striped bass (sunshine bass) in ponds with and without lights and vibrating feeders.

2. Conduct field testing of fingerling (phase II) to advanced fingerling (phase III) production of three strains of sunshine bass in various culture systems.

3. Extension component:

a. Coordinate selection of various culture systems and implement field testing (fingerling to advanced fingerling to food size).

b. Write an initial culture manual using the information generated by all the hybrid striped bass research sponsored by the NCRAC.

c. Produce associated fact sheets, bulletins, and a video for hybrid striped bass research in the NCR.

PROCEDURES

Fry and Fingerling Production (Objective 1)

The studies conducted under this objective will involve researchers from SIUC, UW-Madison, and the University of Nebraska-Lincoln (UNL). SIUC researchers will evaluate white bass and hybrid striped bass strains in pond trials. UW-Madison and UNL researchers will evaluate fry production of white bass and hybrid striped bass, respectively, in ponds using lights and vibrating feeders. Due to funding constraints, the studies are not designed to comprehensively evaluate strains, but rather to provide sufficient data to discern whether major differences in performance occur between strains. Comprehensive strain evaluation might be proposed in the future if preliminary data indicate it would be warranted, and provided that the IAC would consider such research to be a priority.

SIUC

White bass brood stock originating from the Illinois River, Lake Erie, and North Carolina will be obtained and spawned using standard procedures (Kohler et al. 1994). Reciprocal-cross hybrid striped bass (sunshine bass) larvae will be obtained from Arkansas, Iowa, and South Carolina. Twenty-four 0.04-ha earthen ponds will be filled one week prior to stocking and fertilized with cottonseed meal at 350 Kg/ha in a single application and inorganic fertilizer at 25 Kg/ha twice weekly for five weeks. An additional application of cottonseed meal will be administered once weekly at 25 Kg/ha starting in week four. Each source of white bass and hybrid striped bass larvae will be stocked at approximately day four after hatch in quadruplicated ponds at 250,000 to 500,000 larvae/ha. All fish will be fed a #1 crumble of a high protein salmon starter at 5-10 Kg/ha/d when fish have attained approximately 25 mm in length. Fingerlings will be harvested 30 to 45 days after stocking by seining and draining the ponds. Fingerlings will be placed in tanks, graded using a bar grader, and trained to eat pelleted foods containing 45-50% crude proteins. Survival will be determined at pond harvest and again after feed training.

UW-Madison and UNL

Researchers at UW-Madison and UNL will evaluate the use of lights and vibrating feeders to enhance the production of fingerling white bass and sunshine bass in ponds. These evaluations will be done at minimal cost by using existing ponds and feeding systems in both Wisconsin and Nebraska. The studies done by UW-Madison will examine purebred white bass, while those in Nebraska will focus on sunshine bass. No strain comparisons will be performed.

Because of the limited funding available for this component of the project, controlled multi-replicate experiments comparing fingerling production in ponds with and without lights and automatic feeders may not be possible. However, the data collected, coupled with our observations on the behavior and feeding responses of the fish reared at two different locations, will provide us with sufficient information to determine the general effectiveness of these systems at improving the production of fingerling white bass and sunshine bass in Wisconsin and Nebraska, respectively.

The studies done by UW-Madison will use one or two of the 0.25-0.5 ha production ponds at the UW-Madison Aquaculture Program's main research facility at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin. Prior to and after stocking, the ponds will be fertilized with a combination of soybean meal, phosphoric acid, and urea at concentrations that have proven to be successful at this hatchery for stimulating heavy plankton blooms. White bass fry will be obtained from one of two available sources. Fry produced by investigators at

SIUC will be used if sufficient numbers are available. Alternatively, fry will be produced in Wisconsin using brood fish captured from Lake Mendota, Dane County, Wisconsin, during the spawning season (mid-May). The ponds will then be stocked at approximately 250,000 fry/ha.

Dissolved oxygen levels and temperatures in the ponds will be measured in the morning at depths of 0.3 and 1.2 m. The growth of the fish will be monitored by measuring samples of fish captured from the ponds at regular intervals (e.g., about weekly). The lights and vibrating feeders will be activated when the mean fish size in the ponds reaches 10-14 mm TL. The behavior of the fish in response to the lights and feeders will be observed on a nightly basis. The pond feeding will be continued until a strong feeding response is observed in a large number of fish, or until fish reach 25-35 mm TL, at which time they will be harvested.

The ponds will be harvested using a combination of methods, including a light trap system (Manci et al. 1983), small fyke nets, and pond draw-down to a harvesting basin. The number of fish harvested from the ponds will be estimated gravimetrically, and the mean weights and lengths of fish from the ponds will be determined from subsamples.

To estimate the percentage of fingerlings that were feed-trained in the ponds, three 110-L cylindrical flow-through rearing tanks at the Lake Mills laboratory will be stocked with fingerlings at one fish/L. There, the fish will be raised for a period of two weeks, using general protocols and fish husbandry procedures similar to those described by Malison and Held (1992). In brief, the rearing tanks will be provided with tempered water (23 ± 0.5°C at a flow rate of 4 L/min), airstone aeration, and continuous illumination using submerged lights. The fish will be fed five times daily by hand, and their feeding behavior carefully observed. Accurate records on survivorship, mortalities, and cannibalism will be kept. Cumulatively, the procedures used for this feeding trial should provide an accurate assessment of the efficacy of using submerged lights and vibrating feeders for raising fingerling white bass in ponds.

Studies by UNL investigators to evaluate the use of lights and vibrating feeders to enhance the production of fingerling reciprocal-cross hybrid striped bass in ponds will be done in cooperation with the Nebraska Game and Parks Commission at the Calamus State Fish Hatchery, near Burwell, Nebraska. UNLess otherwise indicated, pond stocking, management, and final harvesting procedures will be those normally employed by the Game and Parks Commission to produce reciprocal-cross hybrid fingerlings. In brief, eggs to produce the hybrids will be taken from female white bass captured in the spring from one of several reservoirs in Nebraska (e.g., Johnson Lake, Lake McConaughy, Sutherland Reservoir). Sperm will be obtained from male striped bass captured and transported to the Calamus hatchery from reservoirs, probably in Oklahoma. The eggs will be fertilized, then incubated in McDonald jars until hatching. The ponds will be filled with water and fertilized with alfalfa pellets and a liquid high-phosphorus fertilizer two to three days before stocking. The ponds will be stocked with fish three to four days after hatching at a rate of 500,000 fry/ha, and will be fertilized on a regular basis (generally two or three times weekly) throughout the project. Present plans are to use six adjacent 0.20-ha ponds of nearly identical geometries to conduct the Calamus studies. Three ponds will be used as experimental controls and will not be fed a formulated feed. The other three ponds will each be equipped with nine feeding stations, each with an electronically controlled vibrating feeder and a submerged light adjacent to the feeder. The geometries of these feeding stations differ somewhat from those developed by UW-Madison, but the concept is the same. The UNL feeding stations are controlled by an electronic system that can provide feed at almost any time interval for whatever duration desired. Present plans are to activate the feeding stations about every two or three hours for a period of 30-40 minutes. 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 they are in operation. The feeding systems will be first activated when the fish reach 10-14 mm TL. The initial diet fed will be Silver Cup Salmon Starter (Sterling H. Nelson and Sons, Inc., Murray, Utah).

Dissolved oxygen levels and water temperatures will be measured, and the behavior and growth of fish in the ponds will be monitored, as described for the UW-Madison studies. In addition, to better determine the time of onset and degree of ingestion of the formulated diet, the latter will be mixed with a fluorescent marker pigment, and the mixture fed to the ponds for 24 hours, about a week after the pond feeder 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 immediately after these feeding periods. This technique provides a more sure method of discriminating between formulated diet ingested and natural food, during examination of the guts of sampled fish. Fish will be harvested from all the ponds over the same time period when the fish in the control ponds reach about 25-32 mm TL, using pond draw-down to a harvesting basin. The number and size of fish harvested from each pond will be determined in the same manner as described for the UW-Madison studies. The evaluation of post-harvest feeding success by the reciprocal-cross hybrid striped bass fingerlings will also be done in a manner similar to that described for the UW-Madison studies on white bass, except the hybrid fingerlings will be evaluated using 0.61-m-wide × 6.1-m-long × 0.61-m-deep indoor raceway tanks that will not be equipped with submerged lights.

Advanced Fingerling Production (Objective 2)

The studies conducted under this objective will involve SIUC, Purdue, South Dakota State University (SDSU), and several private producers. Studies will be conducted in ponds, traditional raceways, floating raceways, cages, and water recirculating systems.

SIUC

Pelleted food trained white bass and hybrid striped bass will be: (1) stocked back in the same ponds where they originated at approximately 25,000 fingerlings/ha, (2) shipped to SDSU for raceways studies, and (3) shipped to Mid-Continental Fisheries for floating raceway studies. Standard feeding practices will be used to complete phase II production. Survival, feed conversion, and overall production will be determined for phase II production. Depending on the results of the first year, phase III production will be implemented in year 2 or phase I and II will be repeated. Dressed and fillet proportions, and composition will be determined following harvest.

Purdue

Research at Purdue will be under the direction of Paul Brown in conjunction with three private producers (Lyons Enterprises, Morocco, Indiana; Shirley Fish Farm, Lafayette, Indiana; and Advanced Aquaculture Technologies, Syracuse, Indiana). Density studies will be conducted at the first two sites, and feed evaluations will be conducted at the third site as well as the research laboratories at Purdue.

Cages are already in place at each of the field sites and have been used in previous years to produce hybrids. Juvenile fish will be acquired in the spring of 1996 from Keo Fish Farms and transported to each site using procedures established at Purdue. Fish will be stocked at densities of 100, 150 and 200/m^3 in triplicate. Initial weights will be recorded. The study duration will be approximately 180 days. Feed fed during the study will be purchased locally and will be one of the better feed formulations identified in previous studies (Brown et al. 1993). Feed consumption will be measured and recorded. At the end of the study, final numbers and weights of fish will be determined for calculation of weight gain, feed conversion ratio and survival.

Studies conducted in the second year will depend on results from the first year, but it is anticipated that those studies will be further refinement of maximum stocking density. For example, if a density of 200/m^3 does not reduce response parameters when compared to lower densities, then densities will be increased to 250 and 300/m^3. If density does have a significant impact on response of fish reared at the highest density, then closer gradations in density will be evaluated in the second year. All procedures will be similar between years.

Water quality monitoring will be routinely conducted at each site. Every attempt will be made to maintain water quality within acceptable levels for hybrids. Emergency equipment is in place at Morocco.

The feed evaluation will use relatively standard techniques except that only two dietary treatments will be evaluated during a given cycle (8-10 weeks) and they will not be replicated at the production site. It is simply not feasible to jeopardize production at a commercial facility with experimentation of this nature. Two individual tanks will be used. Tanks currently hold 3500 fish each; thus, sample and groups size are dramatically higher than in most production studies. This experimental approach is currently being used to evaluate a new diet manufactured in this region. We anticipate continuing these studies using new data being developed at Purdue and Texas A&M. Those studies are designed to continue quantifying nutritional requirements of hybrid striped bass and use of regionally available feed ingredients.

Weight gain, feed conversion ratio and hepatosomatic index (HSI) will be determined as response parameters. Excessive liver weights have been identified as an unacceptable loss during processing of fish. Between 200 and 300 fish will be individually measured and weighed prior to and after the study. HSI values will be determined from 10 fish per tank.

In addition to the commercial scale study, a separate, but smaller scale study will be conducted in established experimental recirculating systems using the same diets at Purdue. This direct comparison will provide important information regarding extrapolation of small scale studies to large commercial operations. Methods used in those studies will be similar to those previously conducted (Brown et al. 1993).

SDSU

Comparative growout trials for three strains of reciprocal hybrid striped bass will be conducted for phase II to phase III. The study will be conducted in a replicated tank system at the Northern Plains Biostress Laboratory. Phase II fish, supplied by SIUC, will be transported to SDSU and stocked in an indoor flow-through system comprised of twelve 500-L rectangular tanks. Each strain will be stocked into a minimum of four replicate flow-through tanks at similar densities. Fish will be offered a commercial diet formulated specifically for hybrid striped bass (East Texas Feed, Inc., Mineola) three times per day. Feed will be dispensed by mechanical feeders actuated by an electronic timer. Approximately 15 randomly-selected fish from each tank will be sampled weekly to obtain length and weight measurements. Rations will be adjusted weekly to maintain levels approaching satiation. Performance characteristics (e.g., growth, conversion, condition, survival) of each strain will be evaluated. Basic water quality (i.e., total ammonia, nitrites, pH and dissolved oxygen) will be determined several times weekly during the evaluation. Dissolved oxygen will be maintained near saturation with supplemental aeration. Lighting (~ 20 lux) will be controlled by an electric timer to provide a normal photoperiod. Trials will continue until each strain reaches a marketable size. Dressed and fillet proportions, and composition will be determined following harvest.

Extension (Objective 3)

The studies conducted under this investigation will involve researchers/extensionists from ISU, SIUC, U-Milwaukee and UNL.

The development of educational materials on the applied reproductive biology, propagation, and culture of white bass and the reciprocal-cross hybrid striped bass will be primarily the responsibilities of Chris Kohler of SIUC, Joe Morris of ISU, Terry Kayes of UNL, and Fred Binkowski of UW-Milwaukee, though other members of the Work Group may provide assistance when needed. All four of these principal investigators have had experience with striped bass or hybrid striped bass culture; and Morris, Kayes, and Binkowski all have extension appointments at their respective institutions, and are all members of the NCRAC Extension Work Group.

Kohler, Morris, and Binkowski will be primarily responsible for the collation of information and development of the manual and all related printed materials.

Kayes will coordinate the development of an education videotape which will expand on selected topics in the manual or other printed materials that will particularly benefit from audio-visual demonstrations of practical procedures or highly specialized techniques. The videotape will have a duration of 15-30 minutes; be produced primarily for use in a workshop or classroom setting, or for library loan; and will complement the appropriate printed materials. The videotape will be scripted by Kayes, working in collaboration with Kohler, Morris or other members of the Work Group as appropriate, as well as with a designated professional videotape producer of the UNL Institute of Agriculture and Natural Resources Communications and Computing Services (or an associated agency or service).

Present plans are to do all of the videotaping, scripting, video graphics, editing, and final copying of the videotape for distribution in Year 1 of the project, though there may well be some overlap into Year 2. The principal emphasis of the videotape will be on the following techniques: (1) determination of the sex of potential brood fish, (2) gamete viability assessment and artificial propagation, and (3) the short- and long-term (cryopreservation) of semen and semen transport. Depending on time and the availability of funds, videotaping may also be done of the procedures employed to domesticate wild adult white bass for use as brood fish. The various techniques will be videotaped primarily at the research facilities of SIUC, though some videotaping may also be done at other university or private facilities in Iowa or Indiana. Editing and final production of the videotape will be done at the UNL.

Implementation of Field Testing

All field testing for phase II production conducted at private producer facilities will be coordinated through each state's NCRAC extension contact.

Hybrid Striped Bass Culture Guide

SIUC and ISU

A hybrid striped bass culture guide will be produced consisting of various chapters based on information garnered from research generated by all the hybrid striped bass research generated by NCRAC. Because the Managing Editors (Kohler and Morris) have been associated with this project since its inception, Kohler - Chair and Morris - Extension Liaison, this guide represents an opportunity to generate a document of user-friendly information for the industry.

Each chapter will also have a two to four page synopsis consisting of bullet statements.

The managing editors will: (1) develop a list of chapters, (2) select authors for each chapter, (3) approve list of reviewers for each chapter, (4) monitor progress and provide editing, and (5) approve final copy of chapters

Calendar for Hybrid Striped Bass Culture Workshop/Guide

Date	**Action**
September 1995	Peer reviewers selected; chapters, authors discussed and selected
October 1995	Authors notified of their selection
May 1996	Authors submit first draft
June 1996	Manuscripts sent out for review
August 1996	Reviews returned and sent back to authors
November 1996	Authors' revision returned to managing editors
January 1997	First technical editing; manuscripts returned to authors
March 1997	Manuscripts returned to managing editors
May 1997	Second technical review
August 1997	**ABSOLUTE DEADLINE**

Associated Fact Sheets, Bulletins, and Videos

UW-Milwaukee

UW -Milwaukee researchers will contribute to the proposed culture manual by providing unique information on the intensive culture of white bass utilizing modifications of the "green tank" live food rearing strategies that they have previously used to rear yellow perch and other larval size species through early first feeding phases. Their work to date indicates that such techniques can bring white bass through the earliest feeding green tank phase and successfully habituate them to feeding on *Artemi*a nauplii and starter diets, but that the required period of "green tank" feeding is much more prolonged than that required for yellow perch. However, white bass have been exceedingly difficult to rear to a larger size. Extensive mortality is prolonged through the post larval and early juvenile phases of rearing. As they continue to investigate early feeding strategies with this species during the second year of the ongoing hybrid striped bass project, they will make further modification of these techniques. The goal is to develop and improve methods that will provide practical production alternatives to extensive pond rearing of white bass larvae. The use of green tank foods to bring white bass to the point where they are supported with brine shrimp nauplii will be a significant foundation from which to make such improvements. The development of practical alternative strategies to extensive pond production of white bass fingerlings will diversify the options open to potential producers of domesticated white bass brood stocks, and enhance the development of hybrid striped bass culture in the region.

This proposed NCRAC funding will support the effort required to transfer this information into extension type formats suitable for the initial culture manual and a fact sheet on the potential utility of early intensive feeding strategies toward the ultimate goal of complete domestication and captive rearing of white bass brood stock for the production of hybrid striped bass.

FACILITIES

SIUC

An indoor recirculated-water culture system will be used for brood stock maintenance and spawning. Currently, six 9463-L systems, each containing six 1325-L circular tanks, are in operation at the SIUC wet lab facility. Two of these systems will be devoted to the proposed study for the full duration. One system is housed in a greenhouse allowing for a natural photoperiod. Black plastic tents are placed over three tanks to block natural light. These tanks are equipped with artificial lights set on timers to achieve the desired photoperiod for the compressed cycle. The natural- and compressed-cycle systems are maintained on separate biofilters and have individual temperature controls.

Field facilities include eighteen newly renovated 0.06-ha ponds contiguous to campus. At the nearby SIUC Touch of Nature Facility, 90 ponds have recently been constructed. The Touch of Nature site includes a large water retention pond, several deepwater wells, and all-weather roads. Graduate student living quarters and various storage facilities are situated on the site. Twenty-five ponds will be allocated to this study.

UW-Madison

Studies done by the UW-Madison Aquaculture Program will be conducted at the Program's wet and analytical laboratories at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin. The Hatchery has over thirty 0.25-0.5 ha fingerling production ponds, several of which are equipped with lighting and feeding systems described under **RELATED CURRENT AND PREVIOUS WORK**. The wet laboratory has an ample supply of temperature-regulated (10 to 30±0.5 °C) well or carbon-filtered city water, and over 100 tanks ranging in size from 110-750 L. The Program also has all of the necessary equipment to capture and transport brood fish and fingerlings and collect and incubate eggs. This equipment includes a live-haul truck, two boats, 11 trap nets, and numerous McDonald jars and other types of egg incubators.

UNL

Objective 1

The Nebraska studies to evaluate fry (phase I) to fingerling (phase II) production of reciprocal-cross hybrid striped bass in ponds with and without lights and vibrating feeders will be done by UNL investigators, in cooperation with the Nebraska Game and Parks Commission, at the Calamus State Fish Hatchery, a 24-ha facility located immediately downstream of the 2,023-ha Calamus Reservoir in north central Nebraska. Physical resources available at "the Calamus" include: 11 0.20-ha and 40 0.40-ha fish production ponds; 8 1.8-m-wide × 20-m-long × 1.2-m-deep and 162.4-m-wide × 27-m-long × 1.2-m-deep outdoor raceways; 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); 10 0.61-m-wide × 6.1-m-long × 0.61-m-deep and 8 0.91-m-wide × 6.1-m-long × 0.61--m-deep indoor raceways; and numerous hatchery troughs, egg incubators, and 1.2-, 1.5- and 1.8-m-diameter cylindrical rearing tanks. Ten 0.20-ha and at least 11 0.40-ha ponds in close proximity to the main hatchery buildings can be readily equipped with the feeding systems to be evaluated, or used as experimental controls. Water resources at the Calamus 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. A very large pure-oxygen supply system is in place at the Calamus, and oxygen supplementation in individual tanks and raceways can be achieved through the use of sealed packed-columns. The UNL and Nebraska Game and Parks Commission together at the Calamus hatchery have all the live-haul trucks, facilities, and equipment needed to transport fish; artificially propagate and hatch eggs from brood stock captured in the field; stock, fertilize, manage, and harvest ponds; and monitor water quality and other critical environmental factors. The UNL has already fabricated six prototype pond feeding systems utilizing lights and vibrating feeders, and can readily fabricate more in a variety of different geometries and sizes.

Objective 3

Production of the videotape on the applied reproductive biology of striped bass and white bass, including artificial propagation and sperm cryopreservation techniques, 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 extension professionals and researchers at SIUC, ISU, and possibly Purdue. 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 and laboratory 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.

<u>Purdue</u>

The two field sites for the density studies are 8.2 and 4.1 ha, respectively. Each has a maximum depth of approximately 12.5 m. The recirculating system facilities are proprietary, but has a history of producing hybrid striped bass. Facilities at Purdue University include a new 7400 ft^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. Hybrid striped bass have been housed at the facility since opening in January 1993.

<u>SDSU</u>

The indoor fish culture facilities (140 m^2) located at the Northern Plains Biostress Laboratory are equipped with a variety of fish holding/rearing systems. The system to be used for this particular evaluation consists of twelve 500-L rectangular tanks supplied with municipal water that is dechlorinated by sodium thiosulfate injection. This is a hard wellwater supply (300 mg l^{-1} $CaCO_3$) that provides stable temperatures of 23 - 25 °C. A minimum of 12 of these tanks will be allocated to this study.

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	Robert J. Sheehan Southern Illinois University-Carbondale	Aquaculture
Indiana	Paul B. Brown Purdue University	Aquaculture/Nutrition
Iowa	Joseph E. Morris Iowa State University	Aquaculture/Extension
Nebraska	Terrence Kayes University of Nebraska-Lincoln	Aquaculture/Extension
South Dakota	Michael L. Brown South Dakota University	Aquaculture
Wisconsin	Fred P. Binkowski University of Wisconsin-Milwaukee	Aquaculture/Extension
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PROPOSED HYBRID STRIPED BASS BUDGET FOR
SOUTHERN ILLINOIS UNIVERSITY-CARBONDALE

(Kohler and Sheehan)

Objectives 1 - 3

	Year 1		Year 2		Year 1	Year 2
A. Salaries and Wages	No.	FTEs	No.	FTEs		
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)	2	0.20	2	0.20	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals						
c. Graduate Students	2	1.00	2	1.00	$22,500	$26,500
d. Prebaccalaureate Students	1	0.50	1	0.50	$ 5,000	$5,000
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$27,500	$31,500
B. Fringe Benefits					$0	$0
C. **Total Salaries, Wages and Fringe Benefits**					$27,500	$31,500
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$5,500	$5,500
F. Travel - Domestic (*Including Canada*)					$4,000	$4,000
G. Other Direct Costs					$2,500	$2,500
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$39,500	$43,500
				TOTAL PROJECT COSTS	$83,000	

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

BUDGET JUSTIFICATION FOR SOUTHERN ILLINOIS UNIVERSITY-CARBONDALE

(Kohler and Sheehan)

Objective 1

A. **Salaries and Wages.** Two graduate assistants (0.45 FTE) and a student worker (0.25 FTE) will be required each year to spawn and maintain brood fish, fertilize fish ponds, feed fish, conduct water quality analyses, sample zooplankton, harvest fish, and train fish to pelleted feed.

E. **Materials and Supplies.** Expendable supplies such as fish feed, fertilizers, chemicals, seines, etc.

F. **Travel-Domestic.** Truck rental at $300/month/yr × 3 ($900/yr) trips for obtaining brood stock/fry; ($500/yr) professioinal meetings for paper presentation ($350/yr).

G. **Other Direct Costs:** Computer costs, report preparation, graphics, telecommunications, equipment repair, etc.

Objective 2

A. **Salaries and Wages.** Two graduate assistants (0.45 FTE) and a student worker (0.25 FTE) will be required each year to feed fish, conduct water quality analyses, control weed problems, harvest fish, date reduction, etc.

E. **Materials and Supplies.** Expendable supplies such as fish feed (major cost), chemicals, seines, etc.

F. **Travel-Domestic.** Truck rental at $300/month/yr × 4 ($1200/yr); incidental travel to obtain/ deliver fingerlings ($300/yr); professional meetings for paper presentation ($500/yr).

G. **Other Direct Costs.** Computer costs, report preparation, graphics, telecommunications, equipment repair, etc.

Objective 3

A. **Salaries and Wages.** Two graduate assistants (0.10 FTE) will assist in working with private producer(s) to implement field testing and will assist in data acquisition/analyses.

E. **Materials and Supplies.** Incidental supplies needed to assist private producer(s) and/or for culture manual.

F. **Travel-Domestic.** Travel to work with private producer(s); travel to work with co-editor/authors on culture manual.

G. **Other Direct Costs.** Computer costs, manual preparation, graphics, telecommunications, etc.

PROPOSED HYBRID STRIPED BASS PROJECT BUDGET
FOR UNIVERSITY OF WISCONSIN-MADISON

(Malison)

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	0.03			$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals	1	0.14			$3,200	
c. Graduate Students						
d. Prebaccalaureate Students						
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$3,400	$0
B. Fringe Benefits (32% of 2f)					$1,000	$0
C. **Total Salaries, Wages and Fringe Benefits**					$4,400	$0
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$300	$0
F. Travel - Domestic (*Including Canada*)					$300	$0
G. Other Direct Costs					$0	$0
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$5,000	$0
TOTAL PROJECT COSTS					$5,000	

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

BUDGET JUSTIFICATION FOR UNIVERSITY OF WISCONSIN-MADISON

(Malison)

A. Salaries and Wages. Salaries are needed for personnel to conduct the pond feeding trial and collect and collate data.

E. Materials and Supplies. Supplies needed include fish food, fertilizers, general wet-laboratory and office and record keeping supplies needed for the trial.

F. Travel. Travel funds will be used to attend the NCRAC Hybrid Striped Bass Work Group meeting(s).

PROPOSED HYBRID STRIPED BASS BUDGET FOR UNIVERSITY OF NEBRASKA-LINCOLN

(Kayes)

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	0.09	1	0.03	$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	0.14			$2,540	$0
Total Salaries and Wages					$2,540	$0
B. Fringe Benefits (25% of 2f)					$635	$0
C. **Total Salaries, Wages and Fringe Benefits**					$3,175	$0
D. Nonexpendable Equipment					$1,000	$0
E. Materials and Supplies					$1,500	$0
F. Travel - Domestic (*Including Canada*)					$1,750	$0
G. Other Direct Costs					$2,575	$0
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$10,000	$0
TOTAL PROJECT COSTS					$10,000	

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

BUDGET JUSTIFICATION FOR UNIVERSITY OF NEBRASKA-LINCOLN

(Kayes)

Objective 1

A. Salaries and Wages. A technician (0.08 FTE) is required in Year 1 to assist with the fabrication, set-up, maintenance, and testing of the pond ond feeding systems to be evaluated.

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

E. Materials and Supplies. About $800 for hardware will be required to repair and/or replace vital components of the feeding systems, and to maintain them for the entire evaluation period. About $200 will be needed for miscellaneous supplies. The Nebraska Game and Parks Commission will pay all pond fertilization and feed costs.

F. Travel. The UNL component of the project will require considerable in-state travel between the UNL campus and the Calamus State Fish Hatchery, near Burwell, a round-trip distance of about 400 miles. Both short and long-term stays at the hatchery by UNL researchers 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 are $2,100. 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 down to $1,250.

G. Other Direct Costs. Funds are needed in Year 1 for electronics and machine shop services, computer and graphic arts services, photographic processing, telecommunications, postage, shipping, and photocopying expenses related to the project.

Objective 3

A. Salaries and Wages. A technician (0.06 FTE) is required in Year 1 to help with the preparation of video graphics, and to assist with the coordination, staging, and shooting of videotape segments at various field and laboratory sites in Illinois, and probably Iowa and/or Indiana.

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

E. Materials and Supplies. About $500 is needed in Year 1 for videotape, and photographic, art and computer-graphics supplies.

F. Travel. The production of an effective techniques-centered videotape on the applied reproductive biology of striped bass and white bass, including artificial propagation and sperm cryopreservation techniques, will require extensive travel from UNL to different videotaping sites in Illinois, and probably Iowa and/or Indiana. Present plans are to do all of the videotaping in Year 1 of the project. Estimated travel costs are $600 for fleet vehicle rental (including mileage charges), and $900 for lodging and meals - calculated on the basis of 10-13 d total time required for two people for vehicle travel, field coordination, set-up, and videotaping at the sites selected.

G. Other Direct Costs. The production of the videotape will be done in collaboration with professional staff of the UNL IANR Communications and Computing Services, and 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) $680; editing, video-graphics production, and dubbing (at $50.00-$80.00/h) $1,020.

PROPOSED BUDGET FOR PURDUE UNIVERSITY

(P. Brown)

Objective 1

	Year 1		Year 2		Year 1	Year 2
A. Salaries and Wages	No.	FTEs	No.	FTEs		
1. No. of Senior Personnel & FTEs[1]						
a. (Co)-PI(s)						
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals						
c. Graduate Students					$11,200	$11,500
d. Prebaccalaureate Students . . .					$2,000	$2,000
e. Secretarial-Clerical						
f. Technical, Shop, and Other . . .						
Total Salaries and Wages					$13,200	$13,500
B. Fringe Benefits					$107	$109
C. **Total Salaries, Wages and Fringe Benefits**					$13,307	$13,609
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$3,000	$2,500
F. Travel - Domestic (*Including Canada*)					$1,500	$1,500
G. Other Direct Costs					$193	$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

(P. Brown)

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, coordination with private producers, initial and final weighings of fish at the field sites, conducting the laboratory portion of the project, and data analysis.

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

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

PROPOSED BUDGET FOR
SOUTH DAKOTA STATE UNIVERSITY

(M. Brown)

Objective 2

	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	0.78	1	0.31	$8,000	$3,200
d. Prebaccalaureate Students	1	0.13	1	0.13	$1,100	$1,200
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$9,100	$4,400
B. Fringe Benefits					$170	$80
C. **Total Salaries, Wages and Fringe Benefits**					$9,270	$4,480
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$2,350	$950
F. Travel - Domestic (*Including Canada*)					$650	$300
G. Other Direct Costs					$0	$0
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$12,270	$5,730
TOTAL PROJECT COSTS					$18,000	

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

BUDGET JUSTIFICATION FOR SOUTH DAKOTA STATE UNIVERSITY

(M. Brown)

A. Salaries and Wages. One graduate research assistant and one undergraduate student worker will assist the principal investigator with system monitoring and maintenance, fish care, and data collection.

E. Materials and Supplies. Expendable budget items include: feed, chemicals, and basic aeration and plumbing supplies.

F. Travel. These funds will be used for transporting fish from SIUC and also to provide partial support for transportation, meals, and lodging for annual NCRAC planning and work group meetings.

PROPOSED EXTENSION BUDGET FOR IOWA STATE UNIVERSITY

(Morris)

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	0.05	1	0.05	$0	$0
b. Senior Associates						
2. No. of Other Personnel (Non-Faculty) & FTEs						
a. Research Assoc./Postdoc						
b. Other Professionals	1	0.??	1	0.??	$800	$1,000
c. Graduate Students						
d. Prebaccalaureate Students	1	0.??	1	0.??	$600	$600
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$1,400	$1,600
B. Fringe Benefits (3% of 2b)					$168	$192
C. **Total Salaries, Wages and Fringe Benefits**					$1,568	$1,792
D. Nonexpendable Equipment					$0	$0
E. Materials and Supplies					$200	$200
F. Travel - Domestic (*Including Canada*)					$500	$250
G. Other Direct Costs					$232	$258
TOTAL PROJECT COSTS PER YEAR (*C through G*)					$2,500	$2,500
TOTAL PROJECT COSTS					$5,000	

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

BUDGET JUSTIFICATION FOR IOWA STATE UNIVERSITY

(Morris)

A. Salaries, Wages and Fringe. Secretarial/clerical and technical editor wages.

E. Materials and Supplies. General office supplies.

F. Travel. Expenses to SIUC: 2 trips in 95/96 and 1 trip in 96/97.

G. Other Direct Costs. Telecommunications, photocopying and duplication and mailing costs.

PROPOSED HYBRID STRIPED BASS 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						
c. Graduate Students						
d. Prebaccalaureate Students					$3,000	
e. Secretarial-Clerical						
f. Technical, Shop, and Other						
Total Salaries and Wages					$3,000	$0
B. Fringe Benefits (33% of 2b)					$0	$0
C. **Total Salaries, Wages and Fringe Benefits**					$3,000	$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*)					$3,000	$0
TOTAL PROJECT COSTS					$3,000	

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

BUDGET JUSTIFICATION FOR UNIVERSITY OF WISCONSIN-MILWAUKEE

(Binkowski)

A. Salaries and Wages. A prebaccalaureate student will be hired to assist in clerical and technical editing.

CULTURE TECHNOLOGY OF HYBRID STRIPED BASS

Budget Summary for Each Particpating Institution at $90.3K for First Year

	SIUC	UW-MADISON	UNL	PURDUE	SDSU	ISU	UW-MILWAUKEE	TOTALS
Salaries and Wages	$27,500	$3,400	$2,540	$13,200	$9,100	$1,400	$3,000	$60,140
Fringe Benefits	$0	$1,000	$635	$107	$170	$168	$0	$2,080
Total Salaries, Wages and Benefits	$27,500	$4,400	$3,175	$13,307	$9,270	$1,568	$3,000	$62,220
Nonexpendable Equipment	$0	$0	$0	$0	$0		$0	$0
Materials and Supplies	$5,500	$300	$1,500	$3,000	$2,350	$200	$0	$12,850
Travel	$4,000	$300	$2,750	$1,500	$650	$500	$0	$9,700
Other Direct Costs	$2,500	$0	$2,575	$193	$0	$232	$0	$5,500
TOTAL PROJECT COSTS	$39,500	$5,000	$10,000	$18,000	$12,270	$2,500	$3,000	$90,270

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

	SIUC	UW-MADISON	UNL	PURDUE	SDSU	ISU	UW-MILWAUKEE	TOTALS
Salaries and Wages	$31,500	$0	$0	$13,500	$4,400	$1,600	$0	$51,000
Fringe Benefits	$0	$0	$0	$109	$80	$192	$0	$381
Total Salaries, Wages and Benefits	$31,500	$0	$0	$13,609	$4,480	$1,792	$0	$51,381
Nonexpendable Equipment	$0	$0	$0	$0	$0	$0	$0	$0
Materials and Supplies	$5,500	$0	$0	$2,000	$950	$200	$0	$8,650
Travel	$4,000	$0	$0	$2,000	$300	$250	$0	$6,550
Other Direct Costs	$2,500	$0	$0	$391	$0	$258	$0	$3,149
TOTAL PROJECT COSTS	$43,500	$0	$0	$18,000	$5,730	$2,500	$0	$69,730

RESOURCE COMMITMENT FROM INSTITUTIONS[1]

State/Institution		Year 1	Year 2
Souther Illinois University-Carbondale			
Salaries and Benefits: SY @ 0.20 FTE		$13,000	$15,000
Waiver of Overhead		$17,000	$17,000
	Total	$30,000	$32,000
University of Wisconsin-Madison			
Salaries and Benefits: SY @ 0.03 FTE		$1,886	$0
TY @ 0.12 FTE		$1,000	$0
Supplies, Expenses, and Equipment		$3,150	$0
	Total	$6,036	$0
University of Nebraska-Lincoln			
Salaries and Benefits: SY @ 0.09 and 0.03 FTEs (Year 1 and 2)		$6,058	$2,019
Supplies, etc.		$6,305	$1,108
	Total	$12,363	$3,127
Purdue University			
Salaries and Benefits: SY @ 0.05 FTE		$4,200	$4,800
Supplies, Expenses, Equipment, and Waiver of Overhead		$15,000	$15,000
	Total	$19,200	$19,800
South Dakota State University			
Salaries and Benefits: SY @ 0.05 FTE		$2,500	$2,750
Supplies, Expenses, and Equipment		$3,000	$3,000
	Total	$5,500	$5,750
Iowa State University			
Salaries and Benefits: SY @ 0.05 FTE		$2,486	$2,850
Supplies, Expenses, Equipment, and Waiver of Overhead		$1,100	$1,100
	Total	$3,586	$3,950
University of Wisconsin-Milwaukee			
Salaries and Benefits: SY @ 0.10 FTE		$9,432	$0
	Total	$9,432	$0
	Total per Year	$86,117	$64,627
	GRAND TOTAL	$150,744	

[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

Michael L. Brown, South Dakota State University

Paul B. Brown, Purdue University

Terrence B. Kayes, University of Nebraska-Lincoln

Christopher C. Kohler, Southern Illinois University-Carbondale

Jeffrey A. Malison, University of Wisconsin-Madison

Joseph E. Morris, Iowa State University

Robert J. Sheehan, Southern Illinois University-Carbondale

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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), 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., J.J. Sedmark, and S.O. Jolly. 1993. An evaluation of *Pfaffia* yeast as a pigment source for salmonids. Aquaculture Magazine, March/April 1993:1-4.

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 bioenergentics model for analysis of food consumption patterns by bloater in Lake Michigan. Transactions of the American Fisheries Society 123:344-357.

Miller, T., L. Crowder, J. Rice, and F.P. Binkowski. 1992. Body size and the ontogeny of the functional response in fishes. Canadian Journal of Fisheries and Aquatic Sciences 49:805-812.

Miller, T., L. Crowder, and F.P. Binkowski. 1990. Zooplankton size dynamics and recruitment success of bloater in Lake Michigan. Transactions of the American Fisheries Society 119:484-491.

Sommer, C.V., F.P. Binkowski, M.A. Schalk, and J.M. Bartos. 1986. Stress factors that can affect studies of drug metabolism in fish. Veterinary and Human Toxicology 28(1):45-54.

Binkowski, F.P., and S.I. Doroshov, editors. 1985. Proceedings of North American sturgeons: biology and aquaculture potential. Kluwer Academic Publications, Dordrecht, Netherlands.

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EDUCATION

B.S. Arkansas Tech University, 1986
M.S. Texas A&M University, 1989
Ph.D. Texas A&M University, 1993

POSITIONS

Assistant Professor (1994-present), South Dakota State University
Instructor/Research Associate (1991-1993), and Research Assistant (1987-1991), Texas A&M University
Research Technician (1985-1986), Arkansas Tech University

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society: Dakota Chapter; Texas Chapter; Continuing Education Committee (National); Small Impoundments (Southern Division); Pond Management (Texas Chapter); Fish Culture, Fisheries Management, Education, and Physiology Sections
Alpha Chi
Gamma Sigma Delta

SELECTED PUBLICATIONS

Brown, M. L., F. Jaramillo, Jr., and D. M. Gatlin, III. 1993. Dietary phosphorus requirement of juvenile hybrid striped bass, *Morone chrysops* ♀ × *M. saxatilis* ♂. Aquaculture 113:355-363.

Brown, M. L., D. M. Gatlin, III, and B. R. Murphy. 1993. Nondestructive measurement of hybrid striped bass body composition with electrical conductivity. Aquaculture and Fisheries Management 24:585-592.

Brown, M. L., Gh. R. Nematipour, and D. M. Gatlin, III. 1992. Dietary protein requirement of juvenile sunshine bass at different salinities. Progressive Fish-Culturist 54:148-156.

Nematipour, Gh. R., M. L. Brown, and D. M. Gatlin, III. 1992. Effects of dietary carbohydrate:lipid ratio on growth and body composition of hybrid striped bass. Journal of the World Aquaculture Society 23:128-132.

Nematipour, Gh. R., M. L. Brown, and D. M. Gatlin, III. 1992. Effect of dietary energy:protein ratio on growth characteristics and body composition of hybrid striped bass, *Morone chrysops* ♀ × *M. saxatilis* ♂. Aquaculture 107:359-368.

Brown, M. L., and B. R. Murphy. 1991. Standard-weight (*Ws*) development for striped bass, white bass, and hybrid striped bass. North American Journal of Fisheries Management 11:451-467.

Brown, M. L., and B. R. Murphy. 1991. Relationship of relative weight (W_r) to proximate composition of juvenile striped bass and hybrid striped bass. Transactions of the American Fisheries Society 120:509-518.

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EDUCATION

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

POSITIONS

Associate Professor 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

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.

Wetzel, J.E., II and P.B. Brown. 1993. Growth and survival of juvenile *Orconectes virilis* and *O. immunis* at different temperatures. Journal of the World Aquaculture Society 24:339-343.

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* x *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.

VITA

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EDUCATION

B.A. Chico State College, 1968
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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
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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.

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Associate Director (1991-present) and Assistant Director (1988-1991), Fisheries Research Laboratory, Southern Illinois University-Carbondale

Research Associate (1980-1981), Department of Zoology, Southern Illinois University-Carbondale

Assistant Professor (1980), Department Fisheries and Wildlife Science, Virginia Polytechnic Institute & State University

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society: Culture, Management, Introduced, Education and International
World Aquaculture Society (USA Chapter)
Sigma Xi
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SELECTED PUBLICATIONS

Kohler, C.C. In press. Captive conservation of endangered fish. *In* E.F. Gibbons, J. Demarest, and B.S. Durrant, editors. Captive conservation of endangered species. State University of New York Press.

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POSITIONS

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SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

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

SELECTED PUBLICATIONS

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

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Graduate Research Assistant (1986-1988), Mississippi State University
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SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society; Iowa Chapter: Education, Fish Culture, Early Life History, Computer Users, and Fish Management
Iowa Aquaculture Association
World Aquaculture Society
Phi Kappa Phi
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SELECTED PUBLICATIONS

Bryan, M.D., J.E. Morris, and G.J. Atchison. 1994. Methods for culturing bluegill in the laboratory. Progressive Fish-Culturist 56:217-221.

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SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

American Fisheries Society: Early Life History, Exotic Fishes, Fish Culture, Fisheries Educators, and Water Quality

SELECTED PUBLICATIONS

Bodensteiner, L.R., R.J. Sheehan, W.M. Lewis, and P.S. Wills. In press. Effects of long-term repetitive formalin treatments during winter on channel catfish fingerlings. Journal of Aquatic Animal Health.

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