



# **S-83 Annual Report 1980**

## **Freshwater Food Animals**

Southern Cooperative Special Report  
June 1981



## COOPERATING AGENCIES AND PRINCIPAL LEADERS

### Agricultural Experiment Stations:

### Representative\*

Alabama .....	R. T. Lovell
Arkansas .....	S. H. Newton
Georgia .....	Kaine Bondari
Kentucky .....	D. W. Johnson
Louisiana .....	J. W. Avault, Jr.
Mississippi .....	Roland Regan
North Carolina .....	W. W. Hassler
Puerto Rico .....	R. C. Cortes-Maldonado
South Carolina .....	J. W. Foltz
Tennessee .....	J. L. Wilson
Texas .....	R. R. Stickney
Virgin Islands .....	James Rakocy

### Others:

Memphis State University .....	B. A. Simco
Oak Ridge National Laboratory .....	Mike McGee
Tennessee Valley Authority .....	Carl Madewell

### U.S. Department of Agriculture:

Economics Research Service .....	Shelby Holder
Southern Regional Research Center .....	Don Freeman

### U.S. Department of Commerce:

National Marine Fisheries Service .....	Richard Raulerson
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### U.S. Department of the Interior:

Fish Farming Experimental Station .....	Harry K. Dupree
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**University of Southwestern Louisiana** ..... Mark Konikoff

### Administrative Advisor

Southern Director .....	R. Dennis Rouse
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### SEA Representative

SEA — USDA .....	Clyde E. Richards
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\*Voting representatives. Other participants listed in Attachment #1.

# S-83

## FRESHWATER FOOD ANIMALS<sup>1</sup>

Edited By R. T. LOVELL, Chairman  
Technical Committee

### PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS

#### Objective I, Production

##### A. Nutrition

**Alabama.** Channel catfish fed rations of 15 percent extruded (floating) and 85 percent pelleted (sinking) diets in ponds grew as well and had the same feed conversion rate as fish fed 50:50, 100:0, or 0:100 ratios of extruded to pelleted diets. Only 15 percent of the extruded diet in the ration gave the same management benefits but was 17 percent cheaper than feeding an all-extruded diet.

Channel catfish synthesized as much as 1.9 nanograms per gram body weight per day of vitamin B<sub>12</sub> by intestinal bacteria. Addition of an antibiotic or omission of cobalt from the diet suppressed vitamin synthesis. Use of radiolabelled B<sub>12</sub> indicated synthesized vitamin B<sub>12</sub> was absorbed directly from the gut and utilized by the fish.

**Mississippi.** Amino acid availability values have been determined for the following feed ingredients commonly used in catfish feeds: corn, wheat middlings, rice bran, rice mill feed, soybean meal, peanut meal, cottonseed meal, meat-and-bone meal, and menhaden fish meal. Channel catfish are more sensitive, apparently more than poultry, to antinutritional factors in soybean meal. Studies are being conducted to determine the pathological effects of the trypsin inhibitors and flavones in soybean meal on catfish.

Nutritionally balanced catfish diets containing up to 20 percent duckweed (Family *Lemnaceae*) produced as much weight gain as a commercial catfish diet. Cottonseed meal in catfish diets at levels of 20 percent and above caused suppression of growth rate; lower levels had no effect.

**South Carolina.** A feeding regime for channel catfish based on water temperature and body size was tested again during 1980. Average weight gain after 174 feeding days was 270 grams and feed conversion averaged 1.20. Catfish continued to feed regularly until water temperature was 10 degrees C. When water temperature exceeded 25 degrees C daily growth was essentially linear, averaging 1.27 millimeters per day.

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<sup>1</sup> Supported by Allotments of the Regional Research Fund, Hatch Act, as Amended August 11, 1955.

**Texas.** Semipurified diets with varying lipid sources and percentages revealed no significant differences in channel catfish fingerling growth over the lipid range from 6 to 14 percent, at a mean temperature of 22 degrees C, over a 20-week experiment. Fatty acid composition revealed that there were no significantly different patterns among diets with the same lipid source, but there were differences among lipid sources.

The basic nutritional requirements and nutritional physiology of *Macrobrachium rosenbergii*, with respect to protein were determined, giving rise to information on the protein-energy requirements of that species.

**U.S. Fish and Wildlife Service (Fish Farming Experimental Station).** Golden shiners stocked at 5 grams per liter in 70-liter circular tanks were fed at rates of 1.5, 3, and 6 percent of body weight in three equal portions daily for 60 days. Increasing feeding rate from 1.5 to 3 percent increased weight gain, but increasing feeding rate from 3 to 6 percent did not improve gain.

## **B. Breeding and Genetics**

**Alabama.** Realized heritability for body weight in a wild strain of channel catfish was 0.21. This resulted in a 17 percent increase in growth rate through one generation of selection for fish selected and cultured in ponds at 7,500 per hectare. This growth difference developed during the fingerling growth period and late in the grow-out period. Fry and fingerlings from select brood within this strain had higher survival than fry and fingerlings from random brood. Heritability is also being studied in two domestic strains. At 11 months of age, progeny from select brood averaged 150 grams and were growing 15-20 percent faster than those from random brood. The select and control fry of the domestic lines had no difference in survival when stocked in ponds. In the wild strain and one of the domestic strains, brood selected for growth rate also had higher fecundity. When the wild strain was stocked at 11,120 per hectare, selects only grew 4 percent faster than the control population. Selection therefore may only be appropriate for the environment in which the selection is made.

The reproductive advantage that 3-year-old crossbred channel catfish exhibited over pure-line channel catfish was not maintained as 4-year-olds. Pure-line brood fish were more likely to breed with their own strain than other strains. However, crossbred embryos had higher hatchability, and fry were hardier. Reciprocal crossbred channel catfish fingerlings did not grow at the same rate.

Experiments with channel ♀ x blue ♂ and channel catfish fingerlings indicated large genetic x environment interactions exist. The principal factors causing the interactions were stocking densities and dissolved O<sub>2</sub> levels.

Only crossbred channel catfish females hybridized with blue catfish males. The following parameters appear very important: time of stocking, hormone injection, genotype, and size of fish. Eradication of the olfactory organs of brooders did not affect hybridization rate.

Channel ♀ x blue ♂ brooders readily spawned but hatchability and fry survival were extremely low. Channel ♀ x white ♂ and blue ♀ x white ♂ hybrids would not spawn.

Large variations of the sex ratios in individual spawns of *Tilapia nilotica* and *T. aurea* indicate sex determination is not a simple 1-locus system. Sex reversed males were potent, allowing a workable monosex production system. One out of four sex-reversed grass carp males (gynogentic) produced milt and was able to fertilize eggs.

**Georgia.** One generation of bidirectional selection for body weight and size uniformity in channel catfish has increased body weight and total length at 40 weeks of age by 22.2 percent and 9.2 percent, respectively. The rates of decline in the downward line were 18.7 percent for body weight and 4.1 percent for total length. Family coefficient of variation for 40-week body weight in the upward line was also 7 percent less than in the downward line. Fingerlings produced from 5-year old brood channel catfish weighed 20 percent less and were 8 percent shorter in total length than fingerlings produced from 3-year old brood fish. Multiple-trait selected fingerlings were 10.4 percent heavier and 3.3 percent longer than unselected control fingerlings at 40 weeks. One generation of inbreeding with channel catfish resulted in 7.4 percent and 5.9 percent growth depression at 16 and 40 weeks of age, respectively.

A study concerning the effects of albinism on growth of channel catfish indicated that normal fingerlings were 13 percent and 20 percent larger than their full-sib albinos at 16 and 28 weeks of age, respectively. The albinos, however, possessed the ability to compensate in growth at 40 and 70 weeks of age.

**Louisiana.** Fifteen channel catfish families from the Yazoo strain and eight from the LSU strain were tested for genetic variability in sensitivity to low dissolved oxygen ( $1.1 \pm 0.1$  milligram per liter). Fry of both strains, ranging from 2 to 10 days of age, were administered low dissolved oxygen shock tests for 10-hour periods following 12-hour acclimation. There was no difference between the LSU and Yazoo strains in mortality. No differences were detected among age groups of fry (3 and 4; 5 and 6; 7 and 8; and 9 and 10 days old). There were highly significant ( $P < 0.01$ ) and significant ( $P < 0.05$ ) intraclass correlations among the families which led to high heritability estimates for resistance to low dissolved oxygen. Heritability estimates ranged from  $0.9 \pm 0.3$  to  $1.7 \pm 0.1$ ). Based on this study, one could probably select among 2 to 10-day-old channel catfish fry for resistance to low dissolved oxygen.

**Memphis State University.** Chromosomal and electrophoretic studies of *Ctenopharynogodon idella*, *Aristichthys nobilis* and their F<sub>1</sub> hybrid showed that both parental species had similar karyotypes and a diploid number of 48. The *C. idella* x *A. nobilis* hybrid was triploid with 72 chromosomes. Analysis of the hybrid karyotype suggested that the most likely method of triploidization was retention of a polar body. Electrophoretic analysis of eleven enzyme systems revealed that both parental genomes were functional in the triploid hybrid. Lactate dehydrogenase and liver esterase were the most useful enzymes for distinguishing the triploid hybrid from their parents and for studying gene expression in the F<sub>1</sub> hybrid.

Two presumptive gonadotropic cell types have been identified in the pituitary of channel catfish. These two cell types have different patterns of annual change and are thought to have different roles in the control of fish reproduction. Exposure of fish to increased photoperiods and elevated temperature in winter resulted in an increase in the gonadosomatic index (GSI) and an elevation of plasma sex hormones. However, increased temperature alone resulted only in an increase in GSI and did not alter plasma sex hormone levels. Photoperiod and temperature are both involved in the spring maturation of the reproductive system. Fish without eyes but with an intact pineal can detect the length of the photoperiod. Removal of the pineal from blinded fish destroys this ability.

**Mississippi.** Selection of catfish for weight gain, gain in dressout percentage, and decreased percent fat with 25 percent for high selection and 25 percent for low selection was completed. Fish will be mated at 2 years of age in an attempt to decrease age at maturity.

**North Carolina.** Striped bass semen was cryopreserved at freezing rates from -1 to -30 degrees C per minute using four previously developed extenders. Dimethylsulfoxide (5 percent of media) was used as a cryoprotectant. Results of fertilization experiments indicated that the freezing rate needs to be at least -5 degrees C per minute for acceptable results, but more rapid rates (up to 30 degrees C per minute) did not appear to provide additional improvement. Mass production of striped bass fry using cryopreserved sperm is feasible, but is not yet as efficient as using fresh sperm. Two pond experiments, utilizing six 1-acre ponds and six 0.5-acre ponds, indicated no significant differences in survival or growth between fish produced using fresh sperm and fish produced with cryopreserved sperm.

**Texas.** Electrophoretic patterns of several species of freshwater shrimp were elaborated and the genetic implications of them were addressed.

**TVA.** Small mesh nylon hapas (1.2 meter x 1.2 meter x 2.7 per meter, 0.13-centimeter mesh) were suspended in ponds, stocked with brood tilapia, and evaluated as fry production units. Three hybrid crosses, each at three density/sex ratio combinations were tested to determine optimum conditions for maximizing fry production. A second test was designed to compare relative fry production in both hybrid and within-line crosses. The method shows promise of being a cost-effective method for mass producing either hybrid or within-line fry.

**U.S. Fish and Wildlife Service (Fish Farming Experimental Station).** Studies on the hybridization of the bighead carp male with the grass carp female revealed that the offspring had a 3 N chromosome number, whereas the usual hybrid had a 2 N chromosome number, indicating that the triploid (3 N) animal is usually sterile.

More than 125 bighead carp x grass carp hybrids were examined for triploidy. Chromosome squashes confirmed a count of 72 in the hybrid and 48 in the parent species. Muscle, kidney, and liver isozyme analyses confirm hybridization. Blood smears confirm that the nucleus diameter is greater in the hybrid fish. All chemical analyses confirmed triploidy. Morphological differences in the hybrids and the parent species make the separation of these fishes quite easy.

Additional methods for verification of the hybrid from the parent species were investigated. The LDH isoenzyme of grass carp consisted of five wide distinct bands. The hybrid had several more (eight?) bands but these were narrow and not distinct. The bighead carp also had narrow band isoenzymes, but the number was less ( $5 \pm 1$ ) than the hybrid.

### C. Water Quality

**Alabama.** Stirring of catfish ponds, to more fully utilize the daytime oxygen surplus, and emergency aeration were compared. The emergency aerated pond was stocked at the rate of 7,400 fish per hectare and the stirred pond was stocked at 10,000 fish per hectare. From 1 to 5 specially designed water blenders provided the circulation in one pond and a tractor p.t.o.-driven paddlewheel provided the emergency aeration. The heavier stocking density in the stirred pond would have made it more susceptible to oxygen depletion; however, the aeration energy costs were still more (\$103) for emergency aeration than for stirring (\$71).

Studies of channel catfish ponds on fish farms in western Alabama revealed a direct correlation between feeding rates and deterioration of water quality. Off-flavor problems in fish were usually worse in fish from ponds with feeding rates of 60 to 110 kilograms per hectare per day than in fish from ponds with lower feeding rates. In general, off-flavor was more intense in fish from ponds with heavy phytoplankton blooms. The blue-green algae *Lyngbya* sp. was abundant in several ponds where fish were rated as having extreme off-flavor.

An enzyme immunoassay developed for detecting *Edwardsiella* sp. from catfish compared favorably with the fluorescent antibody test in laboratory experiments.

Phagocytes were separated from whole channel catfish by isopycnic centrifugation on PVP coated colloidal silica. These phagocytes were used in a luminol-dependent phagocytic chemiluminescent assay to determine the effect of temperature on the cellular immune response in channel catfish.

Standard aeration tests were conducted on a tractor-powered paddlewheel aerator. The most oxygenation was provided when the paddlewheel was rotated at 108 rpm with the lower, center blade submerged to a depth of 53 centimeters.

Silver carp in catfish ponds changed algae dominance from blue-green to green, and decreased the number of emergency aerations, but made catfish harvest more difficult.

**Louisiana.** Catfish were stocked into ponds at rates of 7,500, 15,000, and 22,000 per hectare. All ponds received aeration each day from 0200 hours until 1 hour after sunset. In control (unaerated) ponds catfish were stocked at 7,500 per hectare. Fish in all ponds were fed a commercial ration. Production of catfish in kilograms per hectare was: 2,717 at a stocking of 7,500; 3,474 at 15,000; and 5,277 at 22,000. In non-aerated ponds production was 1,870 kilograms per hectare.

**Memphis State University.** Sublethal water levels of ammonia and nitrite and decreased oxygen concentration each resulted in an elevation of plasma concentrations of cortisol in channel catfish. However, cortisol concentrations did not increase in catfish exposed to nitrite with chloride ions present, supporting the hypothesis that chloride ions prevent the entrance of nitrite into the fish.

**U.S. Fish and Wildlife Service — Fish Farming Experimental Station.** Fish can be successfully produced in reuse systems utilizing biological filters. However, failure to convert toxic ammonia- and nitrite-nitrogen to the less toxic nitrate form is a major problem in these systems. Past studies indicated that nitrification could be maintained in the systems by draining recycled water; however, there was no increase in fish production. The facilities can be maintained in a "fixed" condition by completely draining and refilling every 4 weeks.

Four aeration devices were compared in intensively stocked and fed catfish ponds. The devices included a sparger, submersible pumps, paddlewheels, and airlift pumps. The airlift pumps allowed for the most weight gain. They were economically feasible for continuous aeration but the other aerators weren't.



## D. Fish Health

**Alabama.** Golden shiners infected with golden shiner virus yielded virus from kidney, liver, and spleen. Virus titers were higher at 28 degrees C than 23 degrees C.

Largemouth bass, bighead carp, *Tilapia* sp., and golden shiners could not be experimentally infected with *Edwardsiella* sp., the causative agent of enteric septicemia of catfish.

Adult channel catfish from a population with a history of CCV infected offspring had antibody titers from 0 to 1.14 against 100 TCID<sub>50</sub> of CCV per 0.1 milliliter in mid-April. Females were injected with Betamethazone (immunosuppressent) at 0.25 and 0.125 milligram per kilogram and 3 weeks later spawned CCV antibody titers did not change. CCV was not isolated from internal organs of the test fish immediately after spawning, but indirect FA application to frozen sections of ovarian tissues revealed what appeared to be foci of CCV antigen. Also, primary cell cultures from ovarian tissues showed positive fluorescent foci of CCV antigen. Transmission electron microscopy of gonadal tissue revealed no CCV particles.

Efforts to perfect the application of FA procedures for detection of CCV are continuing using goat anti-CCV serum in both the direct and indirect method. Results are inconsistent in CCV infected cell cultures and fish. Preliminary experimental infections in sub-adult channel catfish resulted in isolation of CCV from gonads, kidney and spleen at 72 hr. PI but not from liver or brain. At 144 hr. PI, CCV was isolated only from gonads. Indirect FA procedures failed to demonstrate virus antigen in any tissues.

**Memphis State University.** Channel catfish skin mucus demonstrated an immunological response. Agglutinating antibody and bactericidal activity to *Salmonella paratyphi* were found in the mucus after intraperitoneal injection of bacteria. By immunodiffusion in gel, catfish skin mucus gave a precipitin line of identity with catfish 14S serum macroglobulin against rabbit anti-catfish 14S serum indicating the presence of secretory IgM in the mucus. Parenteral immunization (intraperitoneally) can thus yield specific IgM antibody in the mucus. Lysozyme was also demonstrated in the mucus as well as lymphocytes.

Elevated cortisol concentrations may increase disease susceptibility. Increased cortisol concentrations due to handling resulted in a short term decrease followed by a long term increase in white blood cells as measured by leucocrit determinations. However, no change in plasma antibody titers was apparent. Cortisol incorporated into the diet of catfish caused a decrease in growth rate but elevated liver tyrosine amino transferase activity.

**South Carolina.** Work on identification and confirmation of parasites from American eels (*Anguilla rostrata*) in Cooper River, S.C. is continuing. New host records were identified for the protozoan *Trypanosoma granulorum*; monogenean *Gryodactylus anguillae*; trematodes *Stephanostomum imparaspine*, *Opecoeloides fimbriatus* and *O. vitellosus*; cestode, *Bothrimonus sturionus*; and crustacean *Ergasilus cerastes*. New distribution records for parasites found in the southeastern region of the United States include the protozoans *T. granulorum* and *Myxidium giardi*; monogenean *G. anguillae*; cestode *B. sturionus*; acanthocephalan *Fessisentis friedi* and crustacean *E. celetis*.

**Tennessee.** A terramycin-resistant strain of *Edwardsiella tarda* was isolated from infected fish; this is the first report of this strain in channel catfish.

**U.S. Fish and Wildlife Service (Fish Farming Experimental Station).** Identification procedures were developed for *Mitrospora cyprini* which causes "kidney bloater" in goldfish. Copper oxychloride at 0.2, 2, and 20 ppm caused premature excystment of *Ichthyophthirius*, which appears to produce noninfective pretomites *in vitro*. Neither Furacin®, copper Myxin®, nor R05-0037 (Hoffman-LaRoche) eradicated *Aeromonas salmonicida* in goldfish. However, Furacin applied to the water at 40 ppm for 4 hours, followed in 3 days with 20 ppm for 4 hours was more effective than the others in reducing mortality and healing lesions. Dimilin at 0.01 ppm, Masoten at 0.25 ppm, and dichlorovous at 0.25 ppm killed the parasite *Lernaea*.

## E. Culture Systems

**Alabama.** *Tilapia aurea* cultured in cages at stocking rates of 400, 800, 1,200, and 1,600 per m<sup>3</sup> for 92 days gained an average of 127, 124, 114, and 100 grams, respectively. The fish fed their daily ration in one feeding gained 16 percent less than those fed the same amount in two feedings. Male golden hybrid tilapia (*T. hornorum* x *T. mossambica*) gained significantly more than male *T. aurea*, but female goldens gained significantly less than female *T. aurea*, in cages.

Over a 3-year period, trapping experiments in a 10-hectare catfish pond yielded 1,996 kilograms per hectare per year of which 75 percent was caught by trapping and 25 percent upon draining the pond. Feed conversion was 2.0. Similar results were obtained in 1-hectare ponds where production was approximately 3,000 kilograms per hectare. During 1980 one pond stocked at 10,000 per hectare (improved genetic stock) and equipped with water destratification equipment yielded 4,000 kilograms per hectare and 1.5 feed conversion.

**Arkansas.** Yields of over 224 kilograms per hectare, by multiple harvests, of mosquitofish and additional yields of 1,122 kilograms per hectare of food fishes have been harvested from polyculture combinations. *Gambusia* were maintained best by using a high exchange rate (5.7 liters per minute) of fresh water circulation and by adding 0.2 percent NaCl to holding tanks with mechanical agitation of the water.

Bigmouth x black and black x bigmouth buffalo hybrids were compared with bigmouth parentals when reared in polyculture with channel catfish, grass carp, and largemouth bass over a two-season period in 0.1-hectare ponds. Stocking rates per hectare were 2,500 catfish, 30 grass carp, 100 bass, and 250 buffalo fish. Yields and greatest total fish production were achieved with the polyculture combinations. Parental bigmouth buffalo appeared to be most satisfactory for this polycultural combination (over buffalo hybrids) with channel catfish as the primary species.

A fish-row crop rotation project was initiated in July, 1980. All construction aspects of 19 ponds were completed, as well as an 800 foot<sup>2</sup> feed chemical storage building by midwinter. A winter feeding study with fingerling channel catfish was conducted during November-March, 1981.

**Louisiana.** No differences in production were found when crawfish were grown in tanks planted with untreated rice and rice treated before and after planting with various pesticides. No pesticide residues were found in the flesh. Sizes of harvested crawfish in ponds with rice stubble standing, stubble baled and added back, and stubble disced under were 19, 18, and 17 grams, respectively. Sizes of crawfish in ponds flooded in September and flooded in October were 92 and 83 millimeters, respectively. Yields of crawfish from ponds not planted in rice but fed cattle pellets was 881 kilograms per hectare, from rice ponds fed cattle pellets fall through spring was 2,130 kilograms per hectare, from rice ponds fed cattle pellets in spring only was 2,016 kilograms per hectare, and from rice ponds not fed was 1,273 kilograms per hectare.

Six types of traps presently used in the industry and three new designs are being evaluated for harvest efficiency in three commercial ponds during 1980-81 crawfish season. Concomitantly, trap placement, trap density, frequency with which traps are emptied and manipulation of environmental parameters, such as water circulation, are being investigated. Seven commercial crawfish ponds are being sampled biweekly with dip nets, seines, and small and large mesh traps during 1980-81 season to quantitate growth, mortality, and recruitment patterns of crawfish populations. Seasonal changes in vegetation cover and plant species composition are being determined.

Prawns were stocked into ponds at rates of 25,000 per hectare, 50,000 per hectare, and 25,000 per hectare plus channel catfish fry at 75,000 per hectare. Ponds were also stocked with catfish fry only at 75,000 per hectare. All ponds were fed a commercial catfish feed. Prawn survival (22

percent) and production (265 kilograms per hectare) were greatest in ponds stocked at 25,000 per hectare. This production was much lower than that in 1979. Overall, catfish survival was 33 percent and production was 595 kilograms per hectare.

**North Carolina.** Blue tilapia (*Sarotherodon aureus*) were grown to edible size (211 grams) in backyard fish tanks in approximately 6 months. There was no significant difference in the growth rates of blue tilapia and hybrid tilapia. Water temperatures were modified by using saran shaders and tank temperatures were modified by using saran shaders and tank placement during the summer. Plastic insulation and solar exposure were used to maintain winter temperatures. Wind-proof covers were also devised for the tanks. Water recycling was accomplished by floating trickling filters at the tank surface. Ammonia control was effected by using clinoptilolite in an improvised, air-lift filter.

**Tennessee.** In a high-density, flow-through system, growth and condition of catfish were significantly reduced in polyculture treatments with tilapia as compared to monoculture treatment. Correlation of species densities (3:1, 6:1, 12:1 tilapia/catfish) and growth of catfish resulted in a significant negative relationship. Tilapia growth and condition were unaffected except at the highest stocking density. Water quality parameters were similar between the treatments, except for dissolved oxygen levels which at times were lower in the polyculture treatments.

**Texas.** Mariculture experiments were performed in heated brackish effluent of a power plant. Blue crabs were grown in individual cages for soft shelled crab production. Expenses were high. Time between molts will have to be shortened for this method to be economical. Crabs were susceptible to gas bubble disease when kept in gas-saturated water. *Fundulus grandis* (locally called mud minnows) were evaluated for salt water bait. Production was as high as 882 kilograms per hectare and wholesale price was about \$14.30 per kilogram. The blue shrimp (*Penaeus stylirostris*) was stocked July 17-18 and harvested December 6-7. Production was as high as 1,244 kilograms per hectare. Because of slower growth and reduced survival, economic returns did not increase appreciably as stocking density was raised from 5 to 10 to 15 shrimp per square meter. Behavior studies of channel catfish cultured in variable depth cages indicated that the fish avoid both the surface and deepest water in cages. Water depths occupied by the water column increased with cage depth.

Polyculture studies with freshwater shrimp and tilapia revealed depressed growth when the two were stocked together, but, in general, feeding on the basis of estimated fish biomass will yield a secondary shrimp crop without additional feed. Overwintering of large numbers of tilapia is

being conducted to determine if the technique is feasible for use in central Texas. Plastic- and fiberglass-covered ponds as well as indoor overwintering facilities are being compared. A closed, recirculating water system is also being evaluated.

**TVA.** Both primary productivity and net production of tilapia were higher in ponds fertilized with untreated swine manure than in ponds receiving treated (anaerobic digestion) manure. The treated manure (digested effluent) had less C and N.

The giant freshwater prawn, *Macrobrachium rosenbergii*, was cultured with tilapia from May to October to evaluate its potential in fed or organically fertilized (swine manure) pond cultures. Prawn yields ranged from 0 to 290 kilograms per hectare. Survival figures ranged from 0 to 65 percent.

In December 1979, 6-inch rainbow trout fingerlings were stocked in raceways at 148 fish per  $m^3$  to evaluate production. Trout were harvested 97 days after stocking at 21.8 kilograms per  $m^3$ .

Nine 16.5- $m^3$  concrete raceways were stocked in late April with channel catfish fingerlings at three stocking densities. The study demonstrated that more than 370 kilograms of channel catfish per  $m^3$  can be produced in a 7-month growing season with a feed conversion of 1.5. A supplemental oxygenation system might be economically feasible in a high-density catfish production unit and allow production at densities up to 1,000 fish per  $m^3$ . Water quality parameters of the raceway effluent were within the limits established by regulatory agencies.

**Virgin Islands.** A research facility has recently been completed for studies on recirculating fish culture and hydroponics (6 systems) and on tilapia fingerling production in pools (34 plastic pools).

## Objective II, Economics

**Mississippi.** A Microcomputer program designed to provide information for management decision-making has been developed. This system computes daily feeding rates by pond and projects feeding days to harvest. It also stores water quality information needed to assess fish health. The program will handle up to five ages of fish in each pond and is designed for 100 ponds. The program will produce "firm" summaries when desired.

**TVA.** An economic analysis of a tilapia overwintering facility at the Browns Ferry Nuclear Plant was conducted. Capacity is 90,000 fingerlings averaging 40 grams. Fixed costs totalled \$56,839. Emergency backup facilities contributed 32 percent to the total cost. Variable costs in the first year totalled \$27,563. Revenues from the sale of fingerlings at \$0.20 each amounted to \$20,160 the first year. Analysis showed an internal rate of

return of 5 to 10 percent. Profit could be improved by overwintering small fingerlings or brood stock and with other uses of the facility during summer.

### **Objective III, Product Development and Quality Assurance**

**Alabama.** A total of 59 collections of catfish processing waste (head, skin, viscera) from the major processing plants and representing production ponds from Alabama, Mississippi, and Arkansas was analyzed for a-BHC, heptachlor, DDE, DDT, dieldrin, endrin, and toxaphene. None of the pesticide concentrations in any sample exceeded the action levels allowed for human foods, indicating the waste should be safe to use in commercial fish feeds.

Off-flavored catfish collected from processing plants during April-June, 1980, were evaluated by a trained sensory panel for quality and intensity of off-flavor. Only six of the 35 samples had the geosmin flavor. The most prominent flavor was "fecal" (sewage or manure); others were "rancid", "paint", "diesel", and "algae". Extracts from the fish are being analyzed for compound identification.

**Mississippi.** The procedure for canning tuna-style channel catfish was refined, further data on heat processing developed, and work was initiated on a consumer acceptance study.

**Tennessee.** The feasibility of using freshwater mussels as a food source is being examined. Replicate samples of the washboard variety of mussel are being examined for composition, microbial profile, and quality of surrounding water.

**TVA.** A market study of farm-raised tilapia was conducted in six supermarkets in northwest Alabama. Retail prices ranged from \$1.39 to \$2.09 per pound. The price range which yielded the highest net revenue to the store was \$1.69-\$1.89 per pound. Farm-raised tilapia were well received by consumers and at about the same price range as wild catfish.

### **USEFULNESS OF FINDINGS**

Information from this research is presented through journals, trade and Experiment Station literature, trade and technical meetings, and state and federal government extension agents. Four state-of-the-art cooperative bulletins have been prepared by the S-83 Technical Committee (Processing; Diseases; Nutrition and Feeding; and Breeding and Genetics), and two are in preparation (Water Quality; Culture Systems). Scientific data provided during the 9 years of this project (S-83) will be useful to industry and government in development of aquaculture in this country.

**WORK PLANNED FOR NEXT YEAR**

All participant stations will continue their research. This project expires next year. A proposal for revising the project for continuation of this research for an additional 5 years has been approved.

## APPENDIX I

### OTHER PARTICIPATING TECHNICAL COMMITTEE MEMBERS

#### Agricultural Experiment Stations

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Louisiana	Robert P. Romaine J. V. Huner	Larry De la Bretonne Michael R. Miltner Mark Konikoff
Mississippi	G. R. Ammerman J. E. Waldrop R. P. Wilson Robert P. Busch	H. R. Robinette Edwin Robinson W. E. Poe Craig S. Tucker
North Carolina	J. M. Kerby M. I. Huisk	
South Carolina	A. G. Eversole L. L. Bauer	
Tennessee	Tom K. Hill	
Texas	D. H. Lewis R. W. Brick G. Finn	R. K. Strawn W. Griffin
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<b>Tennessee Valley Authority</b>	J. J. Maddox R. Snipes Chas. Collins B. Carroll L. Behrends	A. Smith David Sample Bob Nelson J. C. Roetheli K. Granneman
<b>U.S. Department of Agriculture</b>	J. P. Cherry Shelby Holder	H. G. Geiger Bille Hougart
<b>U.S. Department of Commerce</b>	J. W. Ayers	
<b>U.S. Department of the Interior</b>	D. Greenland Mayo Martin Drew Mitchell Nick Parker	Glenn Hoffman Thomas Brandt Dewey Tackett Kenneth Randolph



## APPENDIX 2

### PUBLICATIONS

#### Alabama

- ACRE, R. G. and C. E. BOYD. 1980. Water Chemistry of Alabama Ponds. Ala. Agr. Exp. Sta., Auburn Univ., Auburn, Bull. 522. 35 p.
- BOWSER, P. R. and J. A. PLUMB. 1980. Fish Cell Lines: Establishment of a Line from Ovaries of Channel Catfish. *In Vitro*. 16:265-268.
- BOWSER, P. R. and J. A. PLUMB. 1980. Channel Catfish Virus: Comparative Replication and Sensitivity of Cell Lines from Channel Catfish Ovary and the Brown Bullhead. *J. Wildl. Dis.* 16(3):451-454.
- BOWSER, P. R. and J. A. PLUMB. 1980. Growth Rates of a New Cell Line from Channel Catfish and Channel Catfish Virus Replication at Different Temperatures. *Can. J. Fish. & Aquat. Sci.* 3(5):871-873.
- BOYD, C. E. and M. L. CUENCO. 1980. Refinements of the Lime Requirement Procedure for Fish Ponds. *Aquaculture* 21:293-299.
- BOYD, C. E., J. A. STEELY, and E. W. MCCOY. 1980. Frequency of Low Dissolved Oxygen in Ponds for Commercial Culture of Channel Catfish. *Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies* 33:591-597.
- BUSCH, C. D. and C. A. FLOOD, JR. 1979. Pond Water Movement can Improve Natural Aeration. *Ala. Agr. Exp. Sta. Highlights of Agricultural Research* 26(1):8.
- HOLLERMAN, W. D. and C. E. BOYD. 1980. Nightly Aeration to Increase Production of Channel Catfish. *Trans. Amer. Fish. Soc.* 109:446-452.
- HUNT, D. and C. E. BOYD. 1980. Alkalinity Losses Resulting from Ammonium Fertilizers Used in Fish Ponds. *Trans. Amer. Fish. Soc.* 110:81-85.
- LOVELL, R. T. 1980. Fish Culture in the United States. *Science* 206:1368.
- LOVELL, R. T. 1980. Utilization of Catfish Processing Waste. *Ala. Agr. Exp. Sta. Auburn Univ. Bull. S 21*. 19 p.
- LOVELL, R. T. 1980. S-83 Annual Report: Freshwater Food Animals. *So. Coop. Ser. Sp. Rep.*, June, 1980. 20 p.
- LOVELL, R. T. 1980. Effects of Feeding Full-Fat Soybean Meal on Growth and Flesh Quality in Catfish. *Aquaculture* 6(3):39.
- LOVELL, R. T. 1980. Nutritional Value of Fish. *Aquaculture Mag.* 6(5):45.
- LOVELL, R. T. 1980. Effects of Feed on Sensory Quality of Fish. *Aquaculture Mag.* 6(6): 41.
- LOVELL, R. T. 1980. Combination Feeding of Extruded and Pelleted Diets for Catfish. *Highlights of Agric. Res., Ala. Agr. Exp. Sta. Auburn Univ.* 27(4):3.
- LOVELL, R. T. 1980. Computer Formulation of Fish Feeds. *Aquaculture Mag.* 6(4):36.

- LOVELL, R. T. 1980. Factors Affecting Food Consumption by Channel Catfish. Proc. Annu. Conf. Southeast. Fish Wildl. Agencies 540-546.
- LOVELL, R. T. 1980. Nutrient Requirements of Tilapia. Aquaculture 7(1):42.
- LOVELL, R. T. 1980. Feeding Extruded and Pelleted Fish Diets. Aquaculture Mag. 6(2):38.
- METZGER, R. J. and C. E. BOYD. 1980. Liquid Ammonium Polyphosphate as a Fish Pond Fertilizer. Trans. Amer. Fish. Soc. 109:563-570.
- MITCHELL, A. J. and J. A. PLUMB. 1980. Toxicity and Efficacy of Furnace on Channel Catfish Infected Experimentally with *Aeromonas Hydrophila*. J. Fish. Dis. 3:93-99.
- MUSIG, Y. and C. E. BOYD. 1980. Comparisons of Orthophosphate and Polyphosphate as Fertilizer for Fish Ponds. Aquaculture 20:135-138.
- SCHWEDLER, T. E. and J. A. PLUMB. 1980. Fish Viruses: Serologic Comparison of the Golden Shiner and Infectious Pancreatic Necrosis Viruses. J. Wildl. Dis. 16:597-599.
- SCOTT, A. L. and W. A. ROGERS. 1980. Histological Effects of Prolonged Sublethal Hypoxia on Channel Catfish. J. Fish. Dis. 3:305-316.
- SHELTON, W. L., and R. R. STEPHENS. 1980. Comparative Embryology and Early Development of Threadfin and Gizzard Shad. Prog. Fish-Cult. 42(1):4-41.
- TAVE, D., A. S. MCGINTY, J. A. CHAPPELL and R. O. SMITHERMAN. 1980. Evaluation of Hybrid Catfish for Alabama Fee-Fishing Ponds. Highlights of Agric. Res., Ala. Agr. Exp. Sta. Auburn Univ. 27(2):11.
- WALTERS, G. R. and J. A. PLUMB. 1980. Environmental Stress and Bacterial Infection in Channel Catfish. J. Fish. Biol. 17:177-185.

### Arkansas

- LYNCH, TERESA. 1980. Arkansas Institution Initiating Full Fisheries Biology Curriculum this Year. Aquaculture Mag. 6(3):34-38.
- NEWTON, SCOTT H. 1980. Status of Cage Culture in Arkansas. Aquaculture Mag. 7(1):32-36.
- NEWTON, S. H. 1980. Catfish Farming with Chinese Carps. Arkansas Farm Research Journal, 29(1):8.
- NEWTON, S. H., WALTER, R. ROBINSON, and CALVIN J. HASKINS. 1980. Evaluation of a Full-Fat Soybean Ration for Channel Catfish Production in Cages. Ark. Acad. of Sci., Vol. 34.
- HASKINS, CALVIN J. and SCOTT H. NEWTON. 1980. Potential for Utilizing Scrap Processed Cheese as a Major Catfish Ration Component. Ark. Acad. of Sci., Vol. 34.

### Georgia

- BONDARI, K. 1980. Genetic Experiments in Channel Catfish. Aquaculture Magazine 6(4):38-39.

- BONDARI, K. 1980. Cage Performance and Quality Comparisons of Tilapia and Divergently Selected Channel Catfish. Proc. Ann. Conf. S. E. Assoc. Fish and Wildlife Agencies (In press).

### Louisiana

- AVAULT, J. W., JR. 1980. Water Temperature. Aqua. Mag. 6(4):41.
- AVAULT, J. W., JR. 1980. Six Tons of Catfish with Aeration in One Acre of Water. Aqua. Mag. 7(1):44.
- AVAULT, J. W., JR. (editor). 1980. Proc. 11th Annu. Meeting World Mariculture Soc., Louisiana: LSU Div. of Cont. Educ. 611 pp.
- AVAULT, J. W., JR. 1980. The Bare Bones of Crawfish Farming. Aqua. Mag. 6(6):42-43.
- AVAULT, J. W., JR. 1980. Salt, a Useful Tool in Aquaculture. Aquaculture. Aqua. Mag. 6(3):40-41.
- AVAULT, J. W., JR. 1980. Fishery Products from Aquaculture and Capture Fisheries, p. 142-155. In H. Cole and W. N. Garrett (editors) Animal Agriculture. San Francisco: W. H. Freeman and Co. 39 p.
- AVAULT, J. W., JR. 1980. Management of Aquatic Species, p. 658-674. In H. H. Cole and W. N. Garrett (editors) Animal Agriculture. San Francisco: W. H. Freeman and Co. 739 p.
- AVAULT, JAMES, W., JR. 1980. Aquaculture, in Fisheries Management, Robert T. Lackney and Larray A. Nielson, editors, pp. 379-411. John Wiley and Sons, New York.
- CHEAH, M. L., J. W. AVAULT, JR. and J. B. GRAVES. 1979-80. Some Effects of Rice Pesticides on Crawfish. Louisiana Agr. 23(2):8-9 & 11.
- CHEAH, M. L., J. W. AVAULT, JR., and J. B. GRAVES. 1980. Acute Toxicity of Selected Rice Pesticides to Crayfish *Procambarus clarkii*. Progr. Fish-Culturist. 42(3):169-171.
- CHIEN, Y. H., and J. W. AVAULT, JR. 1980. Production of Crayfish in Rice Fields. Progr. Fish-Culturist. 42(2):67-70.
- CHIEN, YEW-HU, and JAMES W. AVAULT, JR. 1980. Effects of Flooding Dates and Type Disposal of Rice, *Oryza sativa*, Straw on the Crawfish, *Procambarus clarkii* (Girard), Culture in Rice Fields (abstract only). In Abstracts of Fish Culture Section of the American Fisheries Society. 1980:14.
- HUNER, J. V., M. MILTNER, R. A. BEAN, and J. W. AVAULT, JR. 1980. Survival and Reproduction of Blue Tilapia, *Tilapia aurea*, in Ponds Stocked with Bowfin, *Amia calva*, to Serve as Predators. In Res. Work. Sum. of Papers Catfish Farmers of Amer. Annu. Conf. 1980:40-41.
- HUNER, J. F., G. PERRY, JR., M. MILTNER, R. A. BEAN and J. W. AVAULT, JR. 1980. Preliminary Studies into the Polyculture of Giant Malaysian Prawns, *Macrobrachium rosenbergii*, and Channel Catfish Fingerlings, *Ictalurus punctatus*, in Louisiana. In Res. Work. Sum. of Papers Catfish Farmers of Amer. Annu. Conf. 1980:44-45.
- JOHNSON, W. BARNES, and JAMES W. AVAULT, JR. 1980. Some Effects of Poultry Manure Supplementation to Rice/Crawfish Experimental

- Earthen Ponds (abstract only). In Abstracts of Fish Culture section of the American Fisheries Society. 1980:15.
- MILTNER, MICHAEL, and JAMES W. AVAULT, JR. 1980. An Evaluation of Rice (*Oryza sativa*) and Japanese Millet (*Echinochloa frumentacea*) as Forage for Red Swamp Crawfish (*Procambarus clarkii*) (abstract only). In Abstracts Fish Culture Section of the American Fisheries Society. 1980:15.
- PLEMMONS, B. and J. W. AVAULT, JR. 1980. Six Tons of Catfish per Acre. Louisiana Agr. 23(4):6, 7, and 9.
- PLEMMONS, B. and J. W. AVAULT, JR. 1980. Use of Aeration to Increase Catfish Production. In Res. Work. Sum of Papers Catfish Farmers of Amer. Annu. Conf. 1980:12-13.
- WITZIG, JOHN F., JAMES W. AVAULT, JR. and JAY V. HUNER. 1980. Insect Dynamics in a Crawfish Pond with Emphasis on Predaceous Insects (abstract only). In Abstracts of Fish Culture Section of the American Fisheries Society. 1980:14.

#### Memphis State University

- BECK, M. L., C. J. BIGGERS, and H. K. DUPREE. 1980. Karyological Analysis of *Ctenopharyngodon idella*, *Aristichthys nobilis*, and their F<sub>1</sub> Hybrid. Trans. Amer. Fish. Soc. 109:433-438.
- HUEY, D. W., B. A. SIMCO, and D. W. CRISWELL. 1980. Nitrite-Induced Methemoglobin Formation in Channel Catfish. Trans. Amer. Fish. Soc. 109:558-562.
- OURTH, D. D. 1979. Immune Response to Bacterial Immunization of Channel Catfish Maintained in a Recirculating Water-Reuse System. Research Report No. R73, 22 pp. OWRT, U. S. Depart. Interior., Wash. D.C.
- OURTH, D. D. 1980. Secretory IgM, Lysozyme and Lymphocytes in the Skin Mucus of the Channel Catfish, *Ictalurus punctatus*. Dev. Comp. Immunol. 4:65-74.
- SIMCO, B. A. and K. B. DAVIS. 1980. High Density Culture of Channel Catfish. Aquaculture Magazine 6(5):34, 52.
- TOMASSO, J. R., C. A. GOUDIE, B. A. SIMCO, and K. B. DAVIS. 1980. Effects of Environmental pH and Calcium on Ammonia Toxicity in Channel Catfish. Trans. Amer. Fish. Soc. 190:229-234.
- TOMASSO, J. R., M. I. WRIGHT, B. A. SIMCO, and K. B. DAVIS. 1980. Inhibition of Nitrite-Induced Toxicity in Channel Catfish by Calcium Chloride and Sodium Chloride. Prog. Fish-Cult. 42:144-146.

#### Mississippi

- ROBINETTE, H. R., M. W., BRUNSON, and E. J. DAY. 1980. Use of Duckweed in Diets of Channel Catfish. Proc. Southeast Assoc. Game and Fish Comm.
- WALDROP, J. E. and R. D. SMITH. 1980. An Economic Analysis of Producing Pond-Raised Catfish for Food in Mississippi: A January

- 1980 Update. Dept. of Ag. Economics Research Report No. 103, July, 1980.
- WILSON, R. P., E. H. ROBINSON, and W. E. POE. 1980. Amino Acid Supplementation of Practical Type Diets for Channel Catfish. Presented 9th Annual Fish Feed and Nutrition Workshop. Univ. of Washington, Seattle.
- WILSON, R. P., W. E. POE, and E. H. ROBINSON. 1980. Apparent and True Amino Acid Availabilities of Common Feed Ingredients for Catfish Feeds. Presented 9th Annual Fish and Nutrition Workshop. Univ. of Washington, Seattle.
- WILSON, R. P., E. H. ROBINSON, and W. E. POE. 1980. Antinutritional Factors in Catfish Feeds. Presented 9th Annual Fish Feed and Nutrition Workshop. Univ. of Washington, Seattle.

#### North Carolina

- GARDNER, MARK B. 1980. Mechanisms of Size Selectivity by Planktivorous Fish: a Test of Hypotheses. M. S. accepted by *Ecology*.

#### South Carolina

- HINTON, M. J. and A. G. EVERSOLE. 1980. Toxicity and Tolerance Studies with Yellow-Phase Eels: Five Chemicals. *Prog. Fish-Cult.* 42(4):201-203.
- CRANE, J. S. and A. G. EVERSOLE. 1980. Ectoparasitic Fauna of Glass and Black Eels of American Eel (*Anguilla rostrata*). *Proc. World Maricult. Soc.*

#### Tennessee

- HILTON, R. and J. L. WILSON. 1980. Terramycin-Resistant *Edwardsiella tarda* in Channel Catfish. *Prog. Fish Culturist* 42(3):159.

#### Texas

- BURNS, R. P., and R. R. STICKNEY. 1980. Growth of *Tilapia aurea* in Ponds Receiving Poultry Wastes. *Aquaculture*, 20:117-121.
- CHAMBERLAIN, G. W., W. H. NEILL, P. ROMANOWSKY, and K. STRAWN. 1980. Vertical Responses of Atlantic Croaker to Gas Super-Saturation and Temperature Changes *Trans. Amer. Fish. Soc.* 109:737-750.
- CUENCO, M. L., and R. R. STICKNEY. 1980. Reliability of an Electrode and a Water Analysis Kit for Determination of Ammonia in Aquaculture Systems. *Trans. Am. Fish. Soc.* 109:571-576.
- HENDERSON-ARZAPALO, A., R. R. STICKNEY, and D. H. LEWIS. 1980. Immune Hypersensitivity in Intensively Cultured *Tilapia* Species. *Trans. Am. Fish. Soc.* 109:244-247.

- MCGEACHIN, R. B. 1980. Production of *Tilapia aurea* in Simulated Lagoons Receiving Laying Hen Wastes. Ph.D. Dissertation, Texas A & M University. 71 p.
- ROMANOWSKY, P. and K. STRAWN. 1979. Vertical Distribution of Caged Estuarine Fish in Thermal Effluent Subject to Gas Supersaturation. Proc. 33rd Ann. Conf. Southeastern Assoc. Fish. and Wildlife Agencies. 33:466-483.
- WILLIAMS, G. E., III and K. STRAWN. 1980. Effects of Power Plants on Penaeid Shrimp. Pp. 261-308, in Power Plants-Effects on Fish and Shellfish Behavior. C. H. Hocutt, J. R. Stauffer, Jr., J. E. Edinger, W. Hall, Jr. and R. P. Morgan, II, editors. Acad. Press. NY, NY.
- YINGST, W. L., III and R. R. STICKNEY. 1980. Growth and Survival of Caged Channel Catfish (*Ictalurus punctatus*) Fingerlings on Diets Containing Various Lipids. Prog. Fish-Cult. 42:24-26.

### U.S. Virgin Islands

- NAIR, AYYAPPAN. 1981. Fish Culture and Hydroponics in the Virgin Islands. Bull. Ann. Agr. Food Fair Virgin Islands. 11:87-88.

### Tennessee Valley Authority

- BEHREND, L. L. 1980. Recycling Livestock Wastes via Fish Culture. Aquaculture Magazine, 7(1):38.

### U.S. Fish and Wildlife Service (Fish Farming Experimental Station)

- BECK, M. L., C. J. BIGGERS and H. K. DUPREE. 1980. Karyological Analysis of *Ctenopharyngodon idella*, *Aristichthys nobilis*, and their F<sub>1</sub> Hybrid. Transactions American Fisheries Society. 109:433-438.
- GUIDICE, JOHN. 1980. Fish Farming Line. Aquaculture Magazine 6(2):52.
- HENDRICKSON, GARY and G. L. HOFFMAN. 1979. Formation of the Host Cyst and Associated Pathology of *Ornithodiplostomum ptychocheilus* (Trematode: Strigeoidea) in *Pimephales promelas*. American Society of Parasitology., Program and Abstracts p. 68.
- HOFFMAN, G. L. 1979. National Fish Parasite Center. Aquaculture Mag. 6(1):40.
- HOFFMAN, G. L. 1979. Book Review: Roberts, R. J. (ed) Fish Pathology, Bailliere Tindall, London, 318 pp, J. of Parasitology. 65(5):731.
- HOFFMAN, G. L. 1980. Asian Tapeworm, *Bothriocephalus acheilognathi* Yamaguti, 1934, in North America. Invited paper in honor of Prof. Dr. H. H. Reichenbach-Klinke's 65th birthday. Fisch and Umwelt 8:69-75.
- HOFFMAN, G. L. 1980. Parasites of North American Freshwater Fishes. University of California Press, Berkeley, California, 486 pp. Fourth Printing.

- HOFFMAN, G. L. 1980. Parasitic Diseases of Laboratory Fishes and their Control. *Synapse* 13(3):16-20.
- HOFFMAN, G. L. and A. J. MITCHELL. 1980. Exotic *Mitraspora cyprini* and *Sphaerospora carassii* (Protozoa: Myxosporida) of Goldfish now in the U.S. — Abstract from 1980 Meeting of the American Society of Parasitologists, 82 pp.
- LUNDE, M. N., S. J. EDWARDS, G. L. HOFFMAN, R. A. KNIGHT, L. MARIGOLIS, and K. G. POWERS. 1980. Translations of Parasitological Articles Reported During 1978 and 1979. *J. Parasitology*. 66(3):559-563.
- MARIGOLIS, L., S. J. EDWARDS, G. L. HOFFMAN, R. A. KNIGHT, M. N. LUNDE, and K. G. POWERS. 1978. Parasitology Translation Reported Mainly During 1976 and 1977 *J. Parasitology*. 64(6):1107-1114.
- MARTIN, J. MAYO. 1980. What the Label May not Tell You About Aquatic Herbicides. *Aquaculture Mag.* 1(3):43-45.
- MARTIN, J. MAYO. 1980. Innovative Pond Design. *Aquaculture Mag.* 6(4):40.
- MARTIN, J. MAYO. 1980. Coping with Adhesive Eggs. *Aquaculture Mag.* 6(6):40.
- MARTIN, J. MAYO. Brown Blood Syndrome. *Aquaculture Mag.* 6(2):49.
- MARTIN, J. MAYO. 1979. Interstate Shipment of Fish. *Aquaculture Mag.* 5(6):26-27.
- MARTIN, J. MAYO. 1979. Extension/Training in Extension Work. *Aquaculture Mag.* 6(1):37-38.
- MARTIN, J. MAYO., D. GREENLAND, and D. TACKETT. 1980. How to Cheaply Improve Water for Hatching Fish Eggs. *Aquaculture Mag.* 6(5):35.
- MITCHELL, A. J. and J. A. PLUMB. 1980. Toxicity and Efficacy of Furanace on Channel Catfish *Ictalurus punctatus* (Rafinesque) Infected Experimentally with *Aeromonas hydrophila*. *J. Fish Disease* 3(2):93-99.
- MITCHELL, A. J. and G. L. HOFFMAN. 1980. Important Tapeworms of North American Freshwater Fishes. U.S. Fish and Wildlife Service, Fish Disease Leaflet 59, 18 pp.
- PLUMB, J. A., P. R. BOWSER, J. M. GRIZZLE, and J. A. MITCHELL. 1979. Fish Viruses: A Double-Stranded RNA Icosahedral Virus from a North American Cyprinid. *J. Fish. Res. Board of Canada* 36:1390-1394.
- RAIKOVA, E. V., V. CH. SUPPRESS, and G. L. HOFFMAN. 1979. The Parasitic Coelenterate, *Polypodium hydriforme* Ussov, from the Eggs of the American Acipensiform, *Polyodon spathula*. *J. Parasitology*. 65(5):804-810.
- SNIESZKO, S. F., G. L. HOFFMAN, and P. E. MCALLISTER. 1979. Fish Diseases. Chapter in *Wildlife Conservation, Principles and Practices* (eds: R. D. Teague, E. Decker), The Wildlife Society, Washington, D.C. 280 pp.

*Information contained herein is available to all persons without regard to race, color, sex, or national origin.*