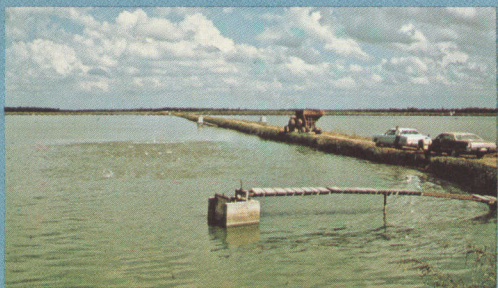


SOUTHERN COOPERATIVE  
SPECIAL REPORT  
MAY, 1982



# S-83 Annual Report 1981

Freshwater Food Animals

## COOPERATING AGENCIES AND PRINCIPAL LEADERS

### Agricultural Experiment Stations:

Station	Representative
Alabama .....	R.T. Lovell
Arkansas .....	S.H. Newton
Georgia .....	Kaine Bondari
Kentucky .....	D.W. Johnson
Louisiana .....	J.W. Avault, Jr.
Mississippi .....	R. Regan
North Carolina .....	W.W. Hassler
Puerto Rico .....	A.S. McGinty
South Carolina .....	J.W. Foltz
Tennessee .....	J.L. Wilson
Texas .....	R.R. Stickney
Virgin Islands .....	J. Rakocy

### Others

Memphis State University .....	B.A. Simco
University of Southwestern Louisiana .....	M. Konikoff
Oak Ridge National Laboratory ....	M. McGee
Tennessee Valley Authority .....	C. Madewell

### U.S. Department of Agriculture

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

### U.S. Department of Commerce

National Marine Fish Service.....	R. Raulerson
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### U.S. Department of the Interior

Fish Farming Experiment Station ..	H.K. Dupree
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### Administrative Advisor

Southern Director .....	G.A. Buchanan
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### SEA Representative

SEA-USDA .....	C.E. Richards
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On the Cover: Sequence showing production, harvesting, processing, and marketing of catfish.

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

# S-83

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

Edited by ROBERT R. STICKNEY, Secretary  
Technical Committee

### PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS

#### Objective I, Production

##### A. Nutrition

**Alabama.** Two feeding experiments were conducted to determine if fishmeal could be replaced in feeds for catfish. Test diets were prepared containing 0 to 12 percent fishmeal. As fishmeal was removed, soybean meal, dicalcium phosphate, and animal fat were increased in isocaloric, isonitrogenous diets which met all known nutrient requirements. When catfish were fed to satiation, no fishmeal was necessary to produce maximum growth.

Intestinal bacteria in *Tilapia nilotica* were found to synthesize up to 10 ng of vitamin B12 per gram of body weight daily. This compares with only 1.9 ng/day in channel catfish which have a shorter gut. *T. nilotica* did not require a dietary source of vitamin B12 for normal growth and hematopoiesis, but catfish did.

Grass carp (*Ctenopharyngodon idella*) stocked at 25,000/ha in ponds were fed several concentrated diets for 5 months. The diets were equal in nutrients but varied in ingredients. A pelleted diet containing 20 percent alfalfa meal provided better growth than diets containing 40 percent alfalfa.

**Mississippi.** Fish fed a basal diet containing 0.004 percent magnesium developed deficiency signs such as poor growth, anorexia, sluggishness, muscle flaccidity and high mortality. The dietary magnesium requirement was determined to be 0.04 percent of the dry diet.

The dietary requirement of fingerling channel catfish for phosphorus was determined to be 0.4 percent apparent available phosphorus. The apparent availability of phosphorus from soybean meal was found to be 29 percent for channel catfish. Preliminary

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<sup>1</sup>Supported by allotments of the Regional Research Fund Hatch Act as amended August, 1955.

studies have been conducted to show the essentiality of dietary zinc and manganese by fingerling channel catfish.

A packing procedure was prepared for tuna-style canned catfish. Retorting for 59 minutes at 250° F for a 307 x 113 tin or aluminum can resulted in a commercially sterile product. A consumer test in 50 homes in New York showed that 60 percent liked tuna-style canned catfish as well as or better than the tuna usually consumed.

Weight gains of fish fed diets containing 70, 85, and 100 percent of the lysine requirement showed a direct correlation with available lysine and showed significant differences ( $\alpha=0.1$ ).

**South Carolina.** Testing of a feeding regime for channel catfish, *Ictalurus punctatus*, which takes into account water temperature and body size, was completed. Three years of data collected from experimental ponds indicate that food conversion averaged 1.20. Marketable-size channel catfish were produced despite a sub-optimal thermal environment.

**Tennessee.** A study was initiated at the University of Tennessee to determine the digestibility of high energy and high protein feedstuffs by channel catfish. The feedstuffs used included soybean meal, peanut meal, corn gluten meal, fish meal, tankage, blood meal, poultry by-product meal, corn oil, safflower oil, coconut oil, poultry oil, tallow, lard, and margarine.

**Texas.** Growth curves for channel catfish reared on commercial feeds in ponds for three growing seasons were completed. Relative growth rate was slower in older fish, but the doubling time did not change substantially after the fish were of fingerling size. Fish averaged over 2 kg at the end of the study. The fish were reared from the time they could accept floating feed until the end of the study on a diet which contained no fish meal. Animal protein was supplied by meat and bone meal.

Fry diets were formulated and tested during the 1981 spawning and fry-rearing season. Fish on casein diets, used for comparison, performed well. Fish on practical diets with 48 percent crude protein did not perform as well as a fish on a commercial trout starter diet which contained in excess of 50 percent protein, so starter diets formulated for the 1982 season will have higher initial protein levels.

An experiment was initiated to determine the fatty acid requirements of channel catfish. Fish were fed a fat-free diet for several weeks, then placed on diets containing no fat or stearic acid in

combination with oleic, linoleic or linolenic acid. One fish oil control diet and two containing each of the purified fatty acids were also used. *Aeromonas* sp. infections in several tanks led to termination of the feeding trial after 10 weeks on the experimental diets. Preliminary data analysis indicates that no significant growth differences occurred as a function of diet (all had 6 percent lipid). Histological changes in skin and liver did occur; however, fatty acid and proximate composition analyses are underway. But preliminary fatty acid patterns on fish reared on fish oil and those on a fat-free diet for 3 months showed significant differences.

## B. Breeding and Genetics

**Georgia.** Male and female brood channel catfish, selected for 40-week body weight in the positive and negative directions from the mean, were crossed in all four possible combinations to study the growth of the offspring. A randomized control line was also propagated. Fingerlings produced from the two divergent lines (positive male x positive female and negative male x negative female) differed in 40-week body weight and total length by 41 and 13 percent respectively. The negative male x positive female combination produced fingerlings comparable in growth to those of the positive male x positive female line but significantly superior to those of the reciprocal, positive male x negative female line.

Five strains of channel catfish (Auburn, Kansas, Minnesota, Marion, and Tifton) were compared for growth and survival under two culture conditions. Results indicated a strong genetic variability among strains for many economically important traits. A study of the abnormal characteristics of channel catfish demonstrated that totally tail-less catfish grew less than half as much as normally-tailed fish and should be selected against. A comparative study of inbred and randomized channel catfish indicated that genetic divergence between two lines was associated with a differential response to temperature regime.

**Tennessee.** Genetic studies have been conducted with hybrids produced by crossing female grass carp, *Ctenopharyngodon idella*, with male bighead carp, *Aristichthys nobilis*, at Memphis State University. Electrophoretic and chromosomal analyses of offspring produced in 1980 yielded diploid, triploid and gynogenetic individuals. Electrophoretic analysis of protein systems of the gynogenetic offspring indicated that no paternal genes were present. Thus, sperm from *A. nobilis* occasionally stimulated the eggs to begin

developing but did not fuse with the pronucleus and participate in embryo formation.

Both diploid and triploid hybrids occurred in the same spawn when the two species were artificially hybridized. The reproductive status of the hybrids is not presently known.

Diploid hybrids are more likely to be deformed and stunted than triploids. This makes them less suitable for use in aquatic weed control.

**Tennessee Valley Authority.** Breeding and genetics studies were conducted at the TVA's waste heat tilapia overwintering facility to ascertain the feasibility of inducing tilapia broodstock (four species) to spawn early as a result of photoperiod manipulation. By late February, all four species were exhibiting breeding behavior, and spawning occurred in all species by mid-March. Invariably, early spawning occurred only after water temperature (condensor cooling water from Browns Ferry Nuclear Plant) was above 24° C, and the photoperiod was greater than 11 hours.

Inbreeding F-1 stocks of the red-gold hybrid (*Tilapia hornorum* female x *T. mossambica* male, reddish orange mutant) resulted in the production of F-2 progeny of several different color phenotypes. Based on uniform coloration of the F-1 hybrids and segregation of at least six different phenotypes in the F-2 generation, it is hypothesized that the red-gold coloration is a dominant trait which is regulated by two or three genes.

Crossbreeds derived from breeding red-gold hybrids with the cold-tolerant *T. aurea* will form the nucleus for development of a strain of cold-tolerant, red-gold tilapia.

**U.S. Fish and Wildlife Service.** Mechanized facilities are being developed to reduce the labor required in performing strain evaluation and selection studies for channel catfish. Tanks of 230 l capacity were evaluated for growing catfish fry to 100-150 g. The tanks were stocked with 500, 750 or 1,000 fry/tank and the fish were fed a mixture of dry feed and beef liver. The tanks were supplied with 23 C. water at a rate which led to one exchange hourly. Fish stocked at 500, 750, and 1,000 per tank averaged 48, 41, and 32 g, respectively, after 90 days. Survival averaged 99 percent.

Maximum loading of 850 l tanks in which the goal is to rear the fish from 100-150 g up to 500 g has been 141 kg. Above that level, dissolved oxygen problems occur, even if supplemental oxygen is added.

Groups of grass carp x bighead carp hybrids from 3 spawning years are being maintained in order to determine whether the fish will reproduce. Fish obtained from the State of Arkansas 1979 spawns are approximately 1 kg in size; those of the same year class obtained from a commercial producer are about 2 kg. No determination of reproductive ability has yet been possible. Morphological characteristics which can be used to distinguish the triploid and diploid grass carp have not been found, though 20 such characters were measured on fish of known genetic characteristics.

### C. Water Quality

**U.S. Fish and Wildlife Service.** Surface water drained from agricultural lands on which common insecticides and herbicides had previously been applied was studied. Nalcolyte 8102, a liquid coagulant commonly used in water treatment, was applied at the rate of 20 ppm. Pesticide levels were reduced to well below EPA permissible levels for domestic water supplies as a result. However, the extreme clarity of the treated water led to problems with aquatic vegetation growth and the quantity of chemical used was expensive, though not prohibitively so.

A series of 18, 0.05 ha ponds were stocked and managed according to current recommendations for catfish. Nalcolyte is being applied and has been found to reduce water turbidity considerably when used at 2-8 ppm. Pesticide levels were below EPA maximums.

A test was conducted to determine if an ammonia absorbing resin could be used to remove toxic levels of ammonia from a water system until bioconversion was established. Results indicated that the resin did remove toxic ammonia. By week 23 of the study, the fish in five of six control tanks had died, but fish in only one of six tanks equipped with the resin died.

Water exchange rates of 1.0, 1.5, and 2.3 times per hour were tested in 0.55 m diameter tanks containing golden shiners. Feed was offered at 3 percent of body weight daily in three equal feedings at 8-hour intervals for 70 days. Survival was hardly affected by water exchange. Average weight at stocking was about 3 g, and at harvest the fish averaged 4.5 g. Standing crop at harvest ranged from 25 to 27 g/l. There was some correlation between water exchange and weight gain, but the difference did not appear to be significant.

### D. Fish Health

**Alabama.** A total of 322 fish disease cases were accepted. Of those, 18 (5.6 percent) were viral, 77 (23.9 percent) bacterial, 3 (0.9

percent) fungal, 42 (13.1 percent) parasitic and 182 (56.5 percent) were classified miscellaneous.

A golden shiner ovary cell strain was established which is in its seventh passage. The cells are susceptible to the golden shiner virus.

Pathogenesis of *Edwardsiella ictaluri* was studied in channel catfish. Pathogenesis occurred in most tissues and hematological changes occurred.

Etomidate was evaluated as an anesthetic on three species of warmwater cultured fish under a variety of conditions. The pathogenicity of non-hemolytic *Streptococcus* group B was studied in bullminnows. There was a significant difference in the number of bacteria isolated from livers and spleens; there was a significant increase in bacteria isolated between 24, 48, and 72 hours post-injection.

Positive Ames tests on water samples indicated that a chemical carcinogen was present in chlorinated sewage effluents. Cutrine Plus was evaluated for use as a possible parasiticide. The pathogenic effects of *Cleidodiscus robustus* on gills of bluegill were determined. An attempt is being made to determine serological specificity of the interlamellar form of *Henneguya*.

Adult channel catfish were experimentally infected with channel catfish virus (CCV), 5 months before and immediately prior to spawning. Each fish was bled 1 and 2 months after injection and when spawned. Certain fish were injected with betamethazone prior to spawning. Thirty-three percent had CCV neutralized titers of 1:10 or greater upon injection. Titers did not increase. Virus was not isolated from internal organs, eggs, fry or fingerlings produced by these fish.

Two-year old channel catfish, injected with CCV and held at 28° C, were assayed for virus. CCV was isolated from the anterior and posterior kidney of one fish 4 days after injection. A total of 18 injected fish and nine control fish were assayed. Electron microscopy of the tissues is underway.

Techniques for the determination of CCV specific lymphocyte stimulation have been developed. Lymphocyte stimulation in the presence of inactivated CCV will be determined by comparing the uptake of labeled leucine in those cells with cells incubated in CCV-free media.



The accepted specific epitaph of the etiological agent of "enteric septicemia" of catfish is *Edwardsiella ictaluri*. The fluorescent antibody test and an enzyme-linked immunoassay test were developed to identify *E. ictaluri*, *E. tarda*, *Flexibacter columnaris*, *Aeromonas salmonicida* and some *A. hydrophila*. These tests will identify the organism in 15-20 minutes, compared with 24 to 48 hours for conventional tests.

Development of the fluorescent antibody test for CCV detection is continuing. The most recent goat anti-CCV serum had a neutralization titer of over 1:320 against 100 TCID<sub>50</sub> for CCV.

Channel catfish developed methemoglobinemia during chronic exposure to nitrite. Several hematological changes occurred during prolonged nitrite exposure, but no histological changes were found.

A preliminary experiment was conducted to determine if one, two or three vaccinations of *Edwardsiella ictaluri*, at weekly intervals elicited a greater agglutinating anti-body response in channel catfish held at 26°C. Channel catfish responded antigenically better to the single vaccination than to the higher numbers. Highest titers were 1:80, 28 days past single injection, compared with 1:20 for two injections and 1:40 for three. Using these preliminary data, vaccination and immunological protective studies will be initiated.

**Louisiana.** Three exotoxins produced by *Aeromonas hydrophila* in a defined medium were demonstrated to be lethal to channel catfish fingerlings. A heat-labile hemolysin was demonstrated to have a 48-hour median lethal dose (LD<sub>50</sub>) of 15.7 ug/fish. In addition, a heat-labile protease had a 48-hour LD<sub>50</sub> of 106.25 ug/fish. Partial purification of the three toxins and subsequent injection into laboratory rabbits resulted in the production of antiserum to each of the toxic fractions, which was then used to develop toxin neutralization assays for each. Using cross neutralization, the hemolysins from 17 isolates of *A. hydrophila* were shown to be neutralized by the monovalent antiserum. In addition, the monovalent antisera against heat-labile protease neutralized the protease of four heterologous *A. hydrophila* isolates and the monovalent antisera against heat-stable protease neutralized both the heat-labile and heat-stable activities of four other isolates.

**South Carolina.** Work continued on the identification and confirmation of parasites found on yellow-stage American eels (*Anguilla rostrata*) trapped from the Cooper River, South Carolina. One or

more of 22 helminth species representing four classes were found on 214 infested eels. Larval nematodes (*Contracaecum* sp.) predominated, infesting 95 percent of eels examined. Seasonal, size, and age-related variations were observed in the levels of trematode and cestode parasites.

Elver-stage American eels infested with the protozoan parasite, *Trichodina* sp., were treated experimentally with salt (NaCl) and potassium permanganate (KMnO<sub>4</sub>). Dip treatments of KMnO<sub>4</sub> were more effective in controlling *Trichodina* than was NaCl. An application of 100 mg/l KMnO<sub>4</sub> for 10 minutes appeared to be safe and effective.

**Tennessee.** Channel catfish were immunized over a 4-month period with four intraperitoneal injections of bovine serum albumin (BSA) in complete Freund's adjuvant at Memphis State University. The catfish anti-BSA antibody was purified by affinity chromatography and subjected to sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE). Two immunoglobulin heavy chains were demonstrated by these two methods. The molecular weights of the two immunoglobulin heavy chains were 56,000 and 72,000. The molecular weight of the single light chain was 23,000. Antibody activity was determined by direct hemagglutination testing. Characterization of the two affinity-purified immunoglobulin heavy chains by Sephadex G-200 gel filtration demonstrated that both immunoglobulin heavy chains were present in the 14S fraction. The presence of anti-BSA antibody in the 7S fraction was not demonstrated by SDA-PAGE or by indirect hemagglutination testing.

Intraperitoneal immunization of channel catfish with *Salmonella paratyphi* in Freund's complete adjuvant produced persistent agglutinating antibody titers of hundreds of thousands during a 1-year response. Bactericidal activity of two high-titered sera averaged 30 percent and 20 percent. Post-immunization bactericidal activity varied little and remained within 10 percent of pre-immunization bactericidal activity. Fresh channel catfish serum from unimmunized catfish exhibited 100 percent bactericidal activity against *S. paratyphi*. Lysozyme was present in fresh channel catfish serum at 1.8 ug/ml serum or 34 ng lysozyme/mg protein.

A bacterial exotoxin neutralization response by fish IgM antibody has not been demonstrated in any fish species. Channel catfish were immunized intraperitoneally with alum-adsorbed tetanus toxoid. Immune serum demonstrated 1.28 AU/ml of antitoxin neutralization and gave an indirect hemagglutination (IHA) titer of

1:65,536. After 2-mercaptoethanol (2ME) reduction of immune serum, no antitoxin neutralization remained but IHA serum titer of 1:4,096 was present. After Sephadex G-200 gel filtration of the catfish immune serum, the antibody gave no antitoxin neutralization but an IHA titer of 1:512 was found. After 2ME reduction, neither the 14S or 7S demonstrated antitoxin neutralization, but minimal IHA titers of 1:16 and 1:4, respectively, were still found. Immunological identity by precipitation in 1 percent agar gel was demonstrated between catfish immune serum, 14S and 7S globulins using rabbit anticatfish 14S serum. The catfish immune serum and the 14S and 7S globulins did not precipitate tetanus toxoid by immunodiffusion in 1 percent agar gel.

**U.S. Fish and Wildlife Service.** A continually growing reference collection of preserved specimens of parasites and diseased organisms and a reference collection of prepared slides is being maintained. A card catalog index of parasites and hosts and a comprehensive library of freshwater fish parasites is also maintained at the Stuttgart, Arkansas facility.

Menensin killed all the free-swimming forms of *Ichthyophthirius* theronts at concentrations ranging from 0.01 to 10 ppm. Foccal was effective in killing all theronts in 1 hour at concentrations as low as 0.1 ppm, as was Duter at 0.01 ppm, Dowicil at 10 ppm, NaCl at 10 ppm, Cutrine at 2 ppm and methyl violet 2B at 0.05 ppm. Karamex, RO5 (experimental product of Hoffman-LaRoche) and Emtryle (25 percent dimetridazole) at concentrations as high as 10 ppm did not kill theronts *in vitro*.

Concurrat and Dronkit appear promising as fish anthelmintics, but Masoten at concentrations as high as 100 g/kg active of body weight of fish had little effect on *Capillaria catostomi*, a nematode which attacks golden shiners. An undescribed species of *Epistylis* which attacks catfish and centrarchids was effectively treated with a 3-hour bath in 1.5 percent NaCl. The tapeworm, *Corlallotaenia parva*, which has been diagnosed in channel catfish, was obtained and its occurrence and damage documented.

Dimilin was found to kill copepodites of *Lernaea* in static tests at concentrations of 0.01 and 0.1 ppm. The chemical did not appear to affect adult *Lernaea*. Masoten also killed the larvae, but not the adults. Abate will kill copepodites *in vitro* at 1 ppm, but should be tested in ponds.

## E. Culture Systems

**Alabama.** A modified hydroponics system was maintained until late April 1981 in a solar greenhouse. A common garden variety of tomato was planted in gravel above a fish growing tank. A continuous flow of effluent was pumped through the gravel and back into the tank. The tomatoes grew well, set a moderate crop of fruit which developed normally, and had good color, size, and flavor. Plants were set in February and matured fruit was obtained in April.

Three types of circulating systems for fish holding were installed in a solar greenhouse in September. All tanks were covered with a rubber-type (non-water absorbing) insulation. All systems were stocked with two species of tilapia (*Tilapia nilotica* and *T. aurea*) on October 19-28, 1981. Water temperature of the fish holding tanks was continuously recorded. Outside air temperature and that within the greenhouses were recorded daily. During the period October through December, 1981, water temperatures within the greenhouse ranged from a high of 43°C to a low of -2°C. Monthly operational costs (electrical) were \$10.21, \$81.79, and \$93.75 for October, November, and December, respectively.

**Arkansas.** Nine 0.1 ha ponds (mean depth 1 m) were stocked with 300 channel catfish each on May 30, 1981. During June, 25 bigmouth buffalo, five grass carp, and 2.3 kg of fathead minnows were added to each pond. The catfish were fed 5 days a week for 115 feeding days over a 158-day period. All fish were harvested during mid-November, 1981. The ponds will be placed into rotation with crops in coming growing seasons.

Catfish survival averaged 88 percent while average total fish production was 1,119 kg/ha. Average individual weight increases were 0.39 kg for catfish, 0.42 kg for buffalo, and 1.77 kg for grass carp. Catfish average feed conversion ratio was 1.5 for all nine ponds.

Fingerling catfish harvested in March, 1981 after being fed during the winter gained 18 and 25 percent when fed 35 and 25 percent protein rations, respectively. Feeding rate was based upon water temperature. Non-fed fish lost 3 percent of their initial body weight during the same period.

Twelve ponds in Cleveland, Lincoln, and Jefferson counties, Arkansas were stocked with channel catfish, largemouth bass, grass carp, fathead minnows, and bigmouth buffalo. Four of the ponds were fertilized, while in four others the catfish were fed in addition to the ponds being fertilized. Floating cages stocked with 200 catfish

fingerlings each were placed in the remaining four ponds at the rate of 2-3 cages/ha. All caged fish were fed *ad libitum* five to seven times weekly by pond owners. Caged catfish survival ranged from 87 to 99 percent, net production from 58 to 73 kg/cage and food conversion ratio from 1.24 to 1.88.

Mosquitofish production under monoculture produced yields of 426 kg/ha compared with 113 kg/ha in polyculture ponds. Mosquitofish consumption by predaceous fishes such as largemouth bass and sunfish increased directly with predator fish. Filter-feeders and herbivores did not consume mosquitofish during predator/prey studies.

Channel catfish predation on mosquitofish was minimal until the catfish reached 3-4 cm; predation then became significant but decreased after the fish reached 4-6 cm. Cannibalism by mosquitofish females on newly hatched offspring indicated that 95 percent of the young may be preyed upon under certain conditions.

Transportation and holding technique studies revealed that mosquitofish survival was higher when fish were held at the rate of 0.2 kg of fish in each 3.8 l of water with a water exchange rate of 13 times per hour than in static conditions. In the latter case, best results were obtained at half the above stocking rate. Pure oxygen bubbled at the rate of 2 l/minute was more conducive to mosquitofish survival than aeration provided by mechanical agitators during transport.

**Louisiana.** Postlarval prawns, *Macrobrachium rosenbergii*, were stocked into brackish water ponds at rates of 12,355/ha, 24,710/ha and 37,065/ha. The shrimp subsisted only on natural food organisms. Production after 163 days ranged from 115 to 314 kg/ha. Individual weights ranged from 11 to 15 g. In a second experiment, postlarval prawns were stocked into brackish water ponds at rates of 24,710/ha, 49,420/ha and 74,130/ha. All ponds were offered an experimental commercial ration on a daily basis. Production after 140 days was 409 kg/ha, 616 kg/ha, and 510 kg/ha and average weights were 21 g, 17 g, and 12 g at the three respective stocking densities. In a third experiment, postlarval prawns were stocked into brackish water ponds and fed daily for 140 days after which average production for stocking densities of 1.24, 2.5, 5.0, and 7.5/m<sup>2</sup> were 243, 353, 651, and 798 kg/ha, respectively. Average shrimp weight was 32.5, 22.7, 19.4, and 16.5 g, respectively.

Channel catfish fingerlings averaging 2.5 g were stocked into ponds at two rates. Later, tilapia hybrids (*Tilapia hornorum* x

*Tilapia mossambica*) averaging 35 g were stocked at two rates into some ponds while others did not receive tilapia. The ponds were harvested 224 days after catfish and 115 days after tilapia stocking. Catfish stocked at 11,115/ha with tilapia at 5,557/ha (highest density) showed highest production (2,488 kg/ha catfish and 835 kg/ha tilapia). However, catfish were smaller (0.34 kg) than in the other treatments. In another catfish study, fingerlings averaging 15 cm were stocked at four rates into ponds on September 24 to determine if they would grow during winter. The fish were fed daily *ad libitum* and harvested on June 10 the following year. In general, the fish did not reach the minimum harvestable size of 340 g.

Crawfish harvesting was investigated in ponds with electricity and/or push trawling. Laboratory studies revealed that specific galvanotaxic responses in crawfish depended on differential current density, pulse rate and width, crawfish position with respect to the electrical field, the physiological state of the animals, their size, and ambient temperature. Optimum pulse characteristics were 0.23 ma/cm<sup>2</sup>, four pulses/sec and 41.5 msec pulse width. In ponds, electro-trawling was very effective in harvesting crawfish. Catch efficiency was affected more by vegetation density than by crawfish abundance.

Four experimental baits for crawfish were developed and compared with the standard bait - gizzard shad. The baits all contained the same carrier: 33 percent fish meal, 43 percent cottonseed meal and 14 percent soya flour. The attractant varied with each bait: catfish oil, blood meal, powdered eggs or no attractant. The bait with catfish oil trapped better than any of the others and was better than shad in both cold and warm water. All other baits, with the exception of blood meal, caught more crawfish than did shad. The cost of ingredients in each bait were: catfish oil, \$0.35; blood meal, \$0.39; powdered eggs, \$1.43; no attractant, \$0.33; shad, \$0.35.

Investigations of catch efficiency of crawfish traps and trap density in commercial harvesting operations indicated that (1) crawfish catch tripled as the number of funnel entrances per trap increased from one to three, (2) black-colored traps caught 15 percent more crawfish than galvanized traps, (3) "stand-up" traps caught no more crawfish than did "pillow" traps, and (4) crawfish catches at 100, 75, and 50 traps/ha were 3.2, 2.6, and 1.7 times greater, respectively, than the catch at 25 traps/ha. Maximum catch was obtained by emptying traps at 6-hour intervals. Optimum economic catch was attained with 75 traps/ha emptied every 6 hours.

**Puerto Rico.** Sixteen 1 m<sup>3</sup> floating cages suspended in a 0.67 ha pond were stocked with *Tilapia aurea* fingerlings (15 g) at densities of 250, 500, 750, or 1,000 fish/cage. Total number of fish in the pond was 14,925/ha. Cages were suspended in each of four, 0.13 ha ponds and stocked with 250 or 1,000 fish/cage, resulting in densities of 1,923 and 7,693 fish/ha, respectively. All fish were fed a 32 percent protein ration four times daily at 4 percent of body weight initially. Feeding rate was gradually reduced to 2 percent of body weight daily by harvest after 168 days.

Mean total weights of fish were 57, 94, 131, and 169 kg/cage for 250, 500, 750, and 1,000 fish/cage, respectively, in the 0.67 ha pond, and 71 and 189 kg/cage for fish at 250 and 1,000 fish/cage, respectively, in the 0.13 ha ponds. Growth increased as density per unit area of pond surface decreased. Production increased and average size and food conversion efficiency decreased as fish density increased. There appeared to be a maximum carrying capacity for cage volume as well as for pond surface area; an interaction between those factors is hypothesized.

**Tennessee.** A study was initiated at the University of Tennessee to determine the feasibility of using solar and/or composting to heat water for culture of warmwater fish in small operations. The main emphasis was to provide relatively inexpensive methods of waste heat utilization to extend the growing season in areas where catfish production is marginal.

**Texas.** Closed recirculating water systems, indoor running water tanks and ponds over which inexpensive greenhouses were constructed were all evaluated with respect to their potential for overwintering tilapia. All of the systems worked well and none were found to show large diurnal fluctuations in water temperature when well water was pumped through them.

A recirculating water system developed for tilapia overwintering was found to be well suited for the rearing of red drum (*Sciaenops ocellatus*) in low salinity (3-50/00) water. Initial results indicated that red drum would readily consume prepared feeds, grew as rapidly or more rapidly than channel catfish under similar conditions, and underwent handling with little damage. Results indicated that red drum require low salinity or relatively hard water if disease problems are to be avoided.

Research with polyculture of freshwater shrimp (*Macrobrachium rosenbergii*) in combination with tilapia (*Tilapia aurea*) indicated that additional production can be realized when the two

species are reared in communal ponds. It was further demonstrated that the culture animals could be efficiently fed by estimating the weight of fish present and providing them with feed at 3 percent of body weight daily. Supplemental fertilization was also important for promoting rapid growth of both species.

Depth distribution of caged channel catfish cultured in a heated discharge canal was negatively correlated to gas saturation and light. Fish did better in 1.83 than in 3.66 m deep cages.

An automatic feeder was developed for use in conjunction with fry rearing troughs. The feeder is inexpensive, will feed several times daily, and requires filling only once every 24 hours.

**Tennessee Valley Authority.** Six, 17.4 m<sup>3</sup> concrete raceways were stocked in April with 15 to 18 cm channel catfish fingerlings to determine the feasibility of using a supplemental oxygenation system in high density raceway culture in association with power plant waste heat. All raceways were not harvested prior to this report, but data collected indicate that production can be increased by at least 2.5 times with the use of supplemental oxygen. Other production parameters were also enhanced. It was found that densities of 40 kg/m<sup>3</sup> required supplemental oxygen for optimum growth.

Hybrid striped bass x white bass fingerlings were cultured in a raceway receiving heated water. Sinking food was preferred over floating pellets. The fish grew from 3.13 to 113.5 g in 117 days in water that averaged 27 C. Feed conversion ratio was 1.94. Survival was 87.3 percent. Density at harvest was 8.97 kg/m<sup>3</sup>.

**Virgin Islands.** *Tilapia aurea* broodfish were stocked at 10, 20, and 30 fish in nylon happas (3 x 1.3 x 1.3 m) suspended in circular pools (4 m diameter and 1.3 m deep). The treatments were replicated twice with a constant sex ratio of four females to each male. Feeding at 1 percent of body weight caused water quality deterioration at the higher stocking rates and emergency aeration was occasionally required. Fry were collected at 2-week intervals after an initial acclimation period of 1 month. After three collections, total production for stocking rates of 10, 20, and 30 brood fish per happa was 2,224, 1,418, and 3,564 fry, respectively.

Tilapia fry were stocked in another study at 250, 500, 750, 1,000, 1,250, and 1,500 fish per pool in circular (4 m diameter, 1 m deep) tanks for outgrow to 5 g fingerlings. The treatments were replicated three times. The fry were fed a commercial feed at 15 percent of initial body weight for 3 weeks followed by weekly feed adjust-



ments to ultimately reduce feeding rate to 5 percent of body weight daily.

A model closed recirculating water system, consisting of three oil barrels and 370 l of water, produced 9.3 kg of tilapia and 10.4 kg of vegetables in a 3.5-month period. Lettuce, pok-choy, Chinese cabbage, tomatoes, eggplant and green peppers were cultured. The system was modified and another yield trial initiated. Six additional large recirculating systems are under construction. A 1,900 l clarifier was designed and constructed from inexpensive materials. It is cylindrical with a conical bottom (60° slope) to facilitate sludge removal.

### OBJECTIVE II, ECONOMICS

**Texas.** Value of the crop for *Penaeus stylirostris* increased little as stocking rate increased from 10 to 15 m<sup>3</sup> because postlarval cost per kg of shrimp harvested increased as growth and survival decreased. Also, larger shrimp produced at the lower stocking rate brought a higher price per kg.

The rearing of *Fundulus grandis* for bait on the upper Texas coast would be profitable at present wholesale prices. A \$0.10 blue crab more than half-way through the molt cycle can be turned into a \$1.25 soft shell crab within an average of 4 days by proper use of eye-stalk ablation.

**Tennessee Valley Authority.** Economic evaluations were conducted for the 1979 and 1980 catfish production seasons at the Gallatin aquaculture project. The 1979 study produced a 1.3 pound fish from a 7-inch fingerling. The 1980 study produced a 0.7 pound large stocker fingerling (for the fee-fishing market) from a 4-inch fingerling. Neither of these production scenarios proved to be economically viable under conditions experienced at Gallatin.

Other production scenarios were evaluated in a "paper study." Production of 4-inch fingerlings from sac fry appeared to be extremely favorable with internal rates of return above 100 percent for several production situations involving raceway designs and lengths of growing season. This culture mode should be substantiated by actual production and marketing experience in the near future.

### OBJECTIVE III, PRODUCT DEVELOPMENT AND QUALITY ASSURANCE

**Alabama.** An off-flavor described as "sewage" was found to be one of the most prominent off-flavors in pond-raised catfish. Envi-

ronmental conditions in ponds from which fish with this flavor came are being evaluated to determine the cause of the flavor. This flavor occurs most frequently in heavily fed ponds.

Diets containing various levels (1.5 to 4.5 percent) of supplemental fat (soybean oil) added to satisfy dietary energy requirements were fed to catfish in ponds during two, 6-month growing seasons (1980 and 1981). Dietary fat did not affect dressing percentage or amounts of fat in the whole body, offal or dressed flesh.

Acid hydrolysis was compared with solvent extraction for measuring fat in various feedstuffs. Either extraction by the Goldfish method was satisfactory for plant feedstuffs and pelleted or meal-type feeds, but underestimated the fat in heat-processed feeds such as extruded (floating) fish feeds. Acid hydrolysis was a more reliable method for the latter types of feed.

A gas chromatograph was purchased and is being equipped for quantitative identification of musty, muddy flavor compounds in catfish. Standards for two musty, muddy odorous compounds, geosmin, and 2-methyl-isoborneol, are being synthesized. Taste thresholds of those compounds, determined with sensory panels, will be compared with instrumental analyses.

**South Carolina.** Small tilapia (*Tilapia mossambica*) which were undesirable for human consumption were tested as a substitute fish meal. Fish that were fed a control and a plant substituted diet did not differ in terms of growth rate or chemical composition. The data indicated that *T. mossambica* produced for use as plant control agents would be a suitable fish meal source.

**Tennessee.** Work is progressing at the University of Tennessee to evaluate freshwater mussels as a human food source. Samples of the washboard variety were collected from four places at four times when mussels were being harvested for shell. Analyses have shown levels of 40 percent protein and 25 percent ash (largely complex silicates) along with 2 percent fat and the balance carbohydrates on a dry weight basis. Broad spectrum pesticide analyses revealed low levels of persistent chlorinated hydrocarbons and one sample had 3.2 ppm Thiodan I. Microbiological tests showed reasonable total counts and very few or no indicators of human pathogens. Amino acid distribution implies protein of good nutritive value. Preliminary evaluation of foods prepared with mussels were encouraging.

**Tennessee Valley Authority.** Labor efficiencies of two small-scale tilapia processing operations were documented. The crew of one

plant processed about 1,400 kg over a 6-week period and achieved rates of 10.42 kg per man-hour and 32.7 fish per man-hour on the processing line. Dressout averaged 64 percent. The crew of another plant achieved rates of 16.25 kg per man-hour and 69.4 fish per man-hour. The higher figure in fish per man-hour is approximately the same as that found in catfish processing plants which use hand labor. It was estimated that the minimum quantity of tilapia required to support a small processing plant designed to meet health department specifications would be about 40,000 kg/year over a 5-year period.

Staff assisted in the organization of a catfish producer and processor association in north Alabama. Assistance was also provided in the development of baitfish production and distribution systems in the Tennessee Valley, in diagnosing and treating disease and water quality problems of regional fish farmers, and in coordinating marketing efforts of producers of complementary seafood products.

#### USEFULNESS OF FINDINGS

Information generated from this research has been made available to other researchers through publication in scientific journals, Experiment Station literature and trade magazines. Commercial producers have obtained the information through trade magazines and extension agents affiliated with state and federal government. Recommended changes in fish diets resulting from nutritional research have been adopted by feed manufacturing companies and adjustments in fish farm management have been made as a result of recommendations from the subcommittees involved with water quality and water systems. Other subcommittees have also made important contributions in the areas of processing, off-flavors, food technology, and the development of new products. Economists have developed production models and balance sheets which have been helpful to prospective and operating fish farmers as well as lending institutions. Four cooperative bulletins have been prepared by the S-83 Technical Committee (Processing, Diseases, Nutrition and Feeding, Breeding and Genetics) and two additional reports (Water Quality and Culture Systems) are nearing completion after recent updating of the original rough drafts. In the 10 years of its existence, the S-83 project became well known throughout the South by researchers and the private sector. Contributions from research conducted under the auspices of the project have changed the way that freshwater food animals are produced in the southern United States.

### WORK PLANNED FOR NEXT YEAR

The S-83 project was officially terminated on September 30, 1981. A new regional project, S-168, Warmwater Aquaculture, was approved as of October 1, 1981 and is fully operational. The new project is an expansion of the S-83 project with increased consideration of estuarine species. Emphasis will be continued on aquatic animals utilized for human consumption. The intensity will not be reduced in the new project, but should actually show considerable increase because of increased numbers of contributing institutions and accelerating interest in aquaculture. A series of bulletins featuring treatment of species other than channel catfish which were considered in the S-83, Freshwater Food Animals program will be initiated.

## APPENDIX I OTHER PARTICIPATING TECHNICAL COMMITTEE MEMBERS

### Agricultural Experiment Stations

#### Alabama

R.O. Smitherman	C.E. Boyd
J.A. Plumb	E.M. McCoy
W.A. Rogers	C. Busch

#### Arkansas

D.L. Gray	C. Haskins
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#### Georgia

E.E. Brown	E.B. Shotts
J.B. Gratzek	J.L. Chessness
G.J. Musick	J.A. Joyce

#### Louisiana

R.P. Romaine	L. De la Bretonne
J.V. Huner	M.R. Miltner

#### Mississippi

G.R. Ammerman	R.P. Busch
J.E. Waldrop	H.R. Robinette
R.P. Wilson	W.E. Poe

#### North Carolina

J.M. Kerby	M.I. Huish
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#### Puerto Rico

A.S. McGinty	
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#### South Carolina

A.G. Eversole	
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#### Tennessee

T.K. Hill	
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Texas	
D.H. Lewis	R.K. Strawn
G. Finne	E.H. Robinson
W. Griffin	
Virgin Islands	
A. Nair	
Oak Ridge National Laboratory	
M. Olszewski	H. Bigelow
M. McGee	
Tennessee Valley Authority	
J.J. Maddox	A. Smith
R. Snipes	D. Sample
C. Collins	B. Nelson
B. Carroll	J.C. Roetheli
L. Behrends	K. Granneman
U.S. Department of Agriculture	
J.P. Cherry	H.G. Geiger
S. Holder	B. Hougart
U.S. Department of Commerce	
J.W. Ayers	
U.S. Department of the Interior	
D. Greenland	G. Hoffman
M. Martin	D. Tackett
D. Mitchell	K. Randolph
N.C. Parker	T. Brandt

## APPENDIX II

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