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PROGRESS IN SHRIMP MARICULTURE IN THE UNITED STATES[1/]

by

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Shrimp at present are not reared for commercial production in the United States. There are, however, numerous governmental, academic, and commercial organisations engaged in shrimp mariculturel research, and the pace of research has accelerated in the last 2 years. As a result, we can probably expect some commercial production in the near future.

The main impediment to research on shrimp production in ponds and natural impoundments-has been a lack of postlarvae for stocking. This problem is all but solved. The Akima International Development Corporation and our Laboratory now possess the technology required to produce large quantities of post-larvae and undoubtedly others will have it soon.

At our Laboratory in Galveston, we have reared through the larval stages and beyond, the three major commercial species of Penaeus of the United States - the brown (Penaeus aztecus aztecus), the white (P. setiferus), and the pink shrimp (P. duorarum duorarum). Several less important species of shrimp, including Sicyonia brevirostris and Xiphopeneus kroyeri, as well as the stone crab (Menippe mercenaria) also have been cultured.

We have developed means of hatching and culturing to postlarvae large numbers of shrimp at almost any time of the year. At present, we obtain about 50 000 postlarvae from the spawn of a single female in about a 1 000-l culture tank. Three of these tanks are shown in Figure 1. Because it takes only about 14 days from spawning to postlarvae, one such culture unit could produce many thousands of post-larvae in a year.

Laboratory experiments indicate that, with carefully controlled conditions, the number of post-larvae can be increased to more than 50 000 per culture tank. Survival of brown shrimp larvae is increased by holding nauplii at 24°C and then, as development progresses, gradually increasing the temperature to 32°C.

The density and quality of food are also important in determining the number of larvae that can be cultured in a given volume of water. Survival appears to be greatest when food is maintained at or slightly below optimum levels. Excess food seems to cause mortality, whereas food levels somewhat below optimum appear to cause a decline in the rate of growth, but not extensive mortality.

Postlarvae are hardy and can be transported easily from one place to another. For shipment, they are gradually adjusted to water of about the same salinity and temperature as that of the recipient location. They are then placed in plastic bags with this adjusted water and supplemental oxygen is added. The bags are sealed and placed in styrofoam boxes which are then sealed. For experimental use about 80 000 postlarval brown shrimp were flown by private plane from Galveston, Texas, to Grande Terre Island, Louisiana, in boxes containing as many as 10 000 shrimp in 8 l of water. Although transport time was 6 h, mortality was estimated at less than 1 percent. The same technique has been used to ship, by commercial airline, postlarval brown shrimp from Galveston, Texas, to Tallahassee, Florida, and pink shrimp postlarvae from Miami, Florida, to Galveston, Texas. One box, containing 5 000 post-larval brown shrimp, was in transit 17 h with negligible mortality. This experience suggests that when shrimp culture is proven to be economically feasible, a few hatcheries may serve the needs of many shrimp farms. Research, however, has not yet reached the stage where we would recommend hatcheries other than for experimental purposes, but the day for the commercial hatchery may not be too far in the future.

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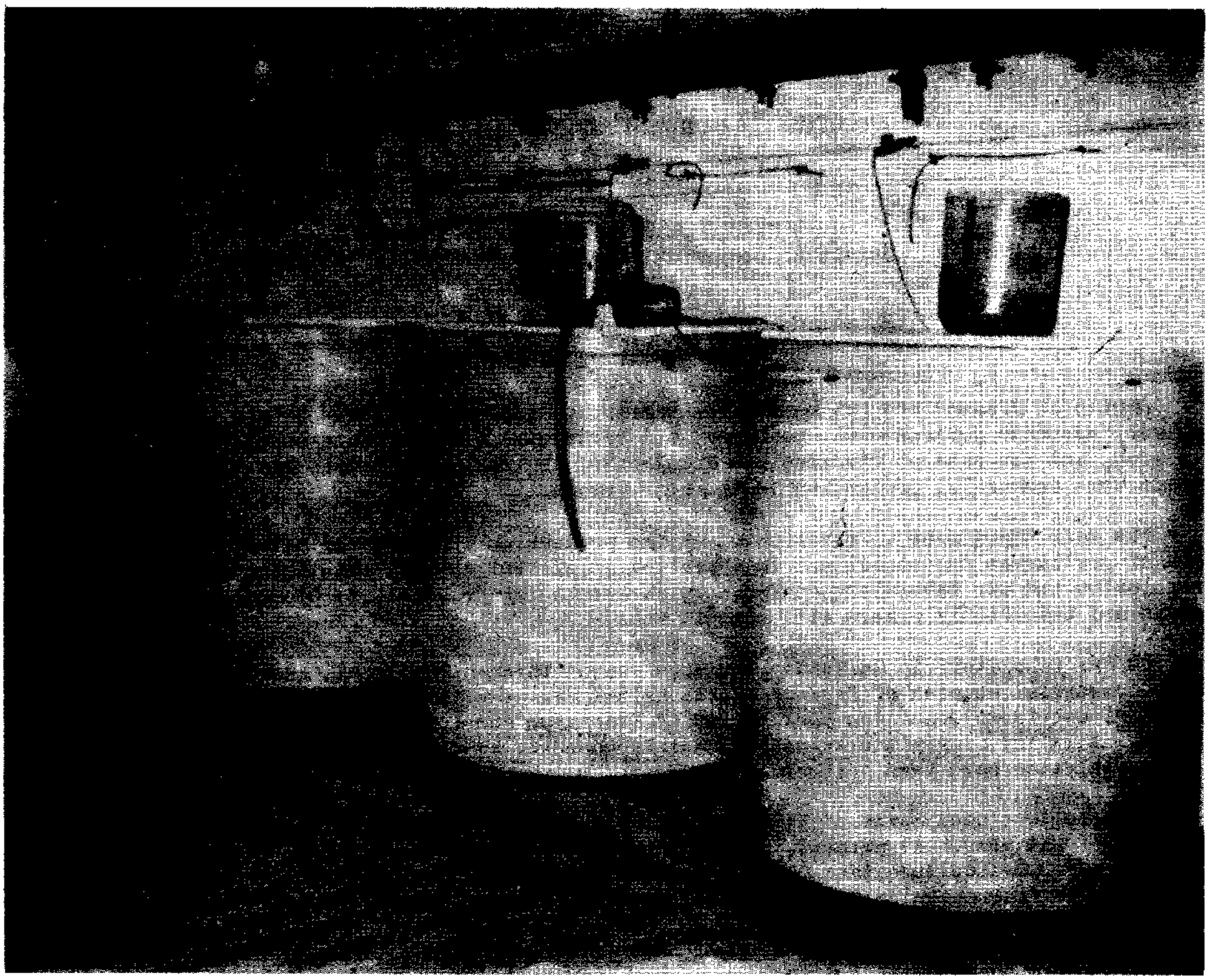

Fig. 1 Three tanks of 1 000-l capacity in which larval shrimp are reared at the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas

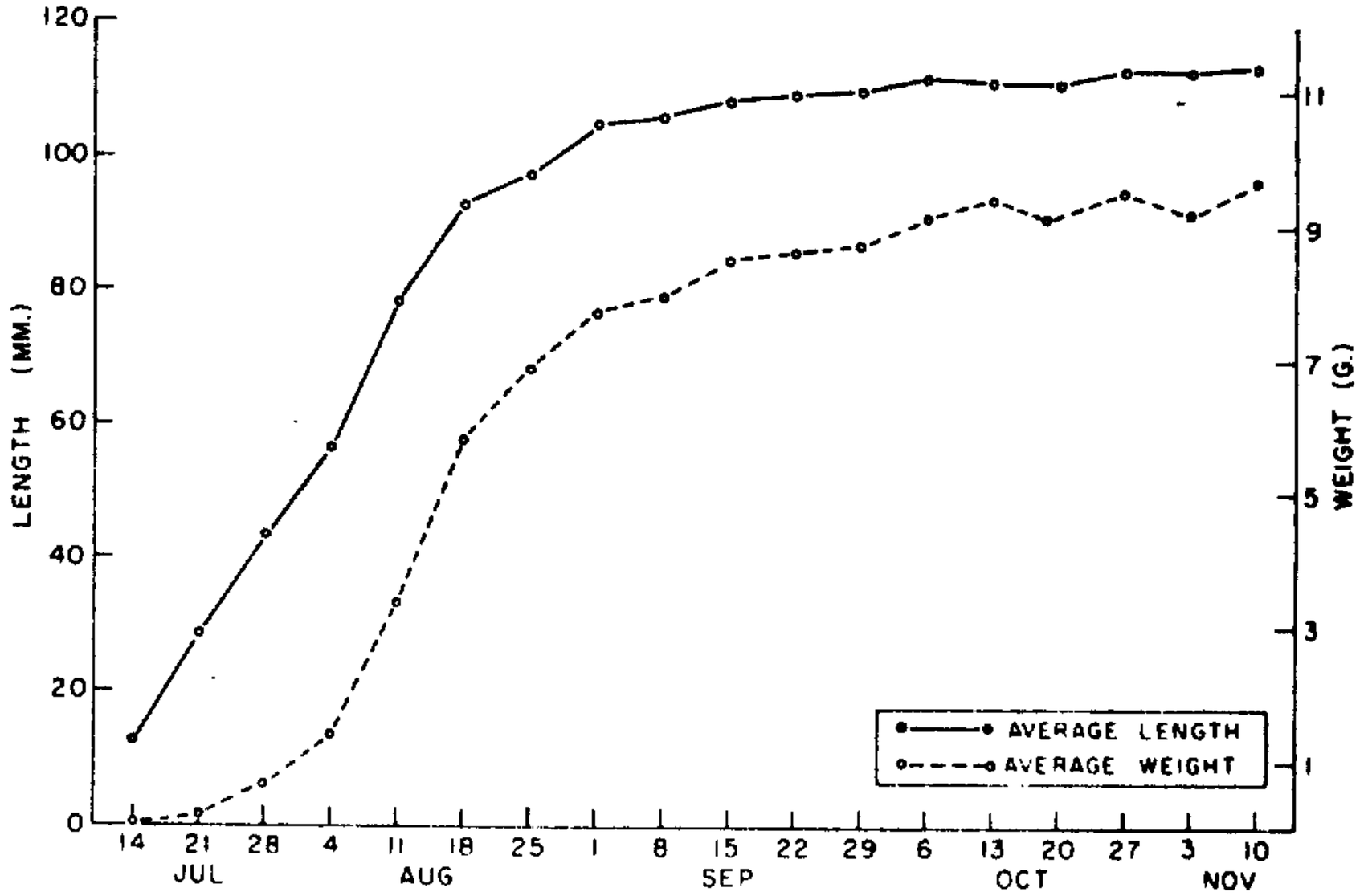

Fig. 2 Growth of white shrimp over a 4-mo period in 1966

Progress in our research to culture shrimp in ponds also has been encouraging. At our Laboratory, we have demonstrated that postlarvae can be grown rapidly in ponds to subadult size without supplemental feeding. For 3 consecutive years, shrimp growth was similar to that shown in Figure 2. The shrimp in this experiment were white shrimp that had been spawned in the laboratory. Placed in the pond as 12 mm postlarvae at about 38 000 to the pound, they grew to 92 mm or about 78 to the pound (heads-on) in 5 weeks. Growth above this size, however, was slow.

Supplemental feeding will accelerate growth of the larger shrimp, but their growth still does not approach that of wild shrimp. Foods such as cornmeal and pelleted rabbit and trout foods have been used in ponds, but have supported little or no growth in laboratory experiments. Shrimp, nevertheless, can be grown to a large size in ponds. We now have one pond containing 1-year-old shrimp that average 21 shrimp to the pound, heads-on.

Survival rates of 90 percent or above can be expected with proper pond management. One of the biggest problems facing those doing pond-culture work has been mortalities caused by oxygen deficiencies, but this problem should not be hard to solve. We have installed an aeration system in our ponds that apparently has eliminated this problem.

With our present knowledge and with supplemental feeding, yields of about 560 kg per ha of 31- to 40-count heads-on shrimp should be possible in growing periods of 100 to 120 days. In the south-eastern United States, it should be possible to harvest two such crops a year for an annual yield of about 1 100 kg per ha which, when sold for human consumption, would be worth about $890 per ha. With only a slight improvement in weight gains, 26- to 30-count heads-on shrimp could be obtained and the annual yield would increase to about $1 000 per ha. This figure would be comparable to catfish farming where annual yields are presently averaging about $970 per ha.

Culture of shrimp as live bait for sport fishing could be more profitable. As stated previously, postlarvae can be reared to bait size (about 80 mm) in 4 to 6 weeks. If a shrimp farmer took advantage of the heated effluent from power plants, he could culture shrimp throughout the year. With controlled temperature conditions and adequate facilities, it might be possible to harvest at least six, 450-kg-per-ha crops of bait per year. Bait shrimp in Texas usually sells for a minimum of $1.45 per kg wholesale, but during the winter they are worth as much as $5.50 per kg wholesale.

If calculated at the lower figure, the value per ha per hear would be about $3 900. The demand for bait shrimp is limited, but those culturing bait shrimp probably would develop knowledge that could be applied to the culturing of shrimp for human consumption.

After this somewhat optimistic presentation on shrimp culture, perhaps we should look at some of the cost aspects and at some of the problems about which little is known and much research is needed. You undoubtedly have already noticed that, although we have given some yield estimates, we have not presented any cost estimates. They were omitted deliberately because practically all shrimp cultural efforts in the United States are still in the experimental stage, particularly with respect to pond culture. In the near future, we will develop some cost estimates on larval culture, but cost estimates on pond culture probably will have to come from the other agencies involved in this research; we do not have the necessary pond facilities. Pond costs should include not only the production costs, such as pond construction, water supply, and feeding, but also harvesting and marketing costs as well as cost of land. Another cost not to be overlooked involves the economic and sociological effects that extensive pond culture might have on existing fisheries.

At our present stage of development the problems we are encountering in our research undoubtedly are more basic and of greater importance than are cost estimates. A list of some of these problems, but not their order of importance, follows:

(i) We still depend on wild stocks for a supply of ripe shrimp. Methods of inducing shrimp to mature and spawn under controlled conditions should be developed as well as techniques for regulating the time of spawning so that eggs can be obtained when they are required.

(ii) An economical prepared food that will support the rapid growth of shrimp in ponds is needed, as is a food that contains nutrients suitable for allowing shrimp to develop to sexual maturity in confinement.

(iii) The cycling and orderly control and improvement of natural shrimp foods in ponds should be known to determine whether it would be more economical to provide either natural or prepared foods, or a combination of both.

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(iv) We must consider the possibilities of shrimp parasites and diseases. Little is known about them, but most certainly they will present problems when shrimp are maintained in confinement.

(v) We have the great and completely unexplored domain of genetical research to create rapid-growing and disease-resistant strains.

(vi) Finally, because a pond contains depth in addition to a surface and a bottom, the monoculture of bottom-living shrimp should not be the ultimate objective. Eventually, we must be able to grow organisms for human consumption throughout the entire water column.

For the most part, we have limited the material presented to work accomplished and some of the thoughts we have at our Laboratory. Our organization, however, is not the only one working on shrimp mariculture. Within the next year, at least 12 governmental agencies or universities will be conducting research on this problem in the United States. At least four private concerns are now in operation and others are planning to start in the near future. We have attached, as an appendix, a list of these organizations and, as far as they were obtainable, their objectives and facilities.

APPENDIX

Organizations in the United States Involved in Research on Shrimp Mariculture

A. Governmental and University

1. Bears Bluff Laboratories, Route 1, Box 39, Wadmalaw Island, South Carolina 29487.

Research objectives are: (a) to experiment with different types of food to find the most economical for use in shrimp culture; (b) to develop the proper technique for spawning shrimp in captivity with emphasis on the use of hormones to stimulate sexual development; and (c) to culture diatoms to be used as food for larval shrimp.

The Laboratory has 11 ponds from 0.04 to about 1 ha. Most are being used for shrimp culture. A large greenhouse contains six 2.6 x 3.6 m, eleven 340-l tanks, and two 2 268-l circular tanks. Four of the large tanks have heat exchangers for temperature control.

2. Bureau of Commercial Fisheries Biological Laboratory, Building 302, Fort Crockett, Galveston, Texas 77550.

BCF research on shrimp mariculture is centred at the Galveston Laboratory. Objectives of this research are: (a) to develop methods to induce shrimp to spawn under controlled conditions; (b) to improve methods of larval culture; (c) to develop a processed food that will support rapid growth under controlled conditions; (d) to develop methods to control or modify environmental factors for maximum production of natural shrimp foods; (e) to breed selective strains of fast-growing shrimp that are tolerant of low temperatures and resistant to disease; (f) to establish experimental populations of shrimp in estuaries to determine the feasibility of bolstering or renewing natural populations; and (g) to control undesirable predators, competitors, and parasites.

Research facilities include a recirculating sea-water system that houses a prototype hatchery, a greenhouse for algal culture, a circulating sea-water system, five 0.02-ha ponds, and a tidal lagoon. The earthen ponds are in the tidal zone and are filled by seepage and drained by pumping.

3. Florida Atlantic University, Boca Raton, Florida 33432.

Technical advice is supplied to industry.

4. Florida State University, Department of Oceanography, Tallahassee, Florida 32306.

Research on shrimp foods is conducted in the laboratory.

5. Gulf Coast Research Laboratory, P.O. Box 218, Ocean Springs, Mississippi 39564.

Research on the pond culture of shrimp will begin in the near future. Plans call for 3.2 ha of ponds with pumping facilities.

6. Louisiana State University, Baton Rouge, Louisiana 70803.

A 1-year study is designed to provide information on the feasibility of using salt-water marshes for intensive mariculture.

They have constructed five 0.04-ha ponds in the marsh for maturation studies. Four of the earthen ponds are 1.2 m deep and one is 3.0 m.

7. Louisiana Wild Life and Fisheries Commission Biological Laboratory, Grande Terre Island, P.O. Grand Isle, Louisiana 70358.

Research to date has concentrated on feeding and growth experiments in ponds. Future plans call for the establishment of a hatchery and studies on larval physiology.

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Research facilities include twenty 0.1-ha ponds, and one well-equipped laboratory. The ponds are above high tide level and are filled by pumping and drained by gravity. They are earthen bottoms and their sides are constructed of corrugated asbestos roofing material.

8. Francis T. Nicholls State College, Thibodaux, Louisiana 70301.

A 2-year project to study shrimp production in Louisiana salt-marsh impoundments under existing and managed conditions is in progress. Within a marsh, two study areas - one of 15.4 ha and the other of 6.9 ha - have been enclosed with earthen levees. Water flow is controlled by weirs.

9. Texas A & M University, College Station, Texas 77840.

Plans are being made for diversified mariculture projects that will involve shrimp, fishes, and other marine organisms.

10. Texas Parks and Wildlife Department, John H. Reagan Building, Austin, Texas 78701.

A salt-water pond experiment station and marine laboratory is under construction on a 16.2-ha site on Matagorda Bay near Palacios, Texas. This installation will have 21 ponds ranging from 0.1 to 1.6 ha. The ponds are above high tide and they will be filled by pumping salt water from the bay and fresh water from deep wells. They will be drained by gravity. Only a portion of the earthen ponds will be used to study shrimp culture.

11. University of Georgia, Sapelo Island Research Laboratory, Sapelo Island, Georgia 31327.

Research is conducted on pond culture and spawning. Facilities include two ponds - 0.1 ha and 0.2 ha - plus a well-equipped laboratory.

12. University of Miami, 10 Rickenbacker Causeway, Miami, Florida 33149.

Research includes growth studies in ponds in which water temperatures are controlled, larval culture, and food preference studies.

Seven ponds that range from 0.1 ha to 0.4 ha and a hatchery building were constructed recently at Turkey Point south of Miami. The p nds are above high tide, and are filled by pumping and drained by gravity. The ponds have marl bottoms and the sides are lined with rubber.

B. Industry

1. Akima International Development Corp., P.O. Box 2414, Panama City, Florida 32401.

Akima International has employed Japanese biologists and is adapting the Japanese methods of shrimp culture to the United States. They have cultured larvae of pink shrimp to postlarvae on a large scale, and they are now working to determine the best and most economical growing conditions.

2. Florida Seafood Growers, 29 E. Fairfield Drive, Pensacola, Florida 32501.

3. Marinus Laboratories, Inc., Melbourne, Florida 32901.

4. Sea Farms Inc., 3732 Flagler Ave., Key West, Florida 33040.

C. Industry Supporting Research on Mariculture

1. Armour and Company - University of Miami and Florida State University.

2. Florida Power and Light Company - University of Miami.

3. Louisiana Land and Exploration Company - Francis T. Nicholls State College.

4. United Fruit Company - University of Miami.