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"How close are we, with today's technology to commercial farming of shrimp?" An NMFS scientist takes a close look at...

Progress Toward Farming Shrimp in the United States

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Although no commercially viable penaeid shrimp farms exist at present in the United States, the strong demand and resulting high prices for shrimp are incentives for development of economical farming practices. Several large firms and a number of smaller groups are operating shrimp hatcheries and farms on a developmental basis in efforts to reduce costs and thereby make shrimp-rearing a profitable business. Shrimp culture has been a profitable enterprise for years in some parts of the world, such as Southeast Asia and Japan, where economic circumstances are different from those in the United States.

A number of State, University, and Federal research groups in the United States are contributing to the rapidly accumulating pool of information concerning shrimp farming. Major contributions to our technical knowhow in this field have been made by Texas A&M University, Texas Parks and Wildlife Department, NMFS Galveston Laboratory, Louisiana Wild Life and Fisheries Commission, Nicholls State College, Louisiana State University, the University of Miami, and the University of Georgia. Much of this research has been directed toward methods of rearing shrimp from postlarvae to market size in ponds; however, research is also underway on many aspects of shrimp biology, physiology, and nutrition.

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How close are we, with today's technology, to commercial farming of shrimp? Unfortunately, the research groups working with shrimp farming have produced very little information on production costs. The emphasis so far has been on finding ways to rear shrimp at high densities. Because the research has required experimentation with many factors, accurate costs are difficult to obtain. Cost data developed by industry in its pilot-scale operations are considered proprietary and are generally not available to the public.

We do know approximately what quantities and sizes of shrimp can be produced and the amount of time required to rear shrimp using several different approaches. Shrimp can be reared fairly easily to a size of about 4 inches (the size they normally leave the estuaries) in ponds. Production (single crop) of these small shrimp in static ponds in the United States with no supplemental feed or fertilizer has averaged about 100-150 lb (heads-off) per acre. Fertilization of the ponds with inorganic or organic fertilizer will generally add roughly 100 lb (heads-off) per acre to the crop. Feeding may add an average of fifty to several hundred additional pounds (heads-off) per acre depending upon the feed used and the amount fed. Continuous exchange of water will increase production beyond these levels in some instances; however, restrictions on effluents from aquaculture many prohibit the use of this method.

Since the market value of 4-inch shrimp is low (average price, heads-off in 1972 was $0.47 per lb), considerable effort has gone into developing methods of rearing shrimp to a larger, more valuable size. Usually growth rates of captive shrimp decrease when shrimp reach sizes of 3-5 inches, depending in part upon the density of shrimp in the ponds. Typical growth rates in captivity for the Gulf species of shrimp at temperatures of 26°-30°C are presented in the following table.

Size	Days after hatching
0.25 inch (postlarvae)	10-14
1 inch	25-35
4 inch	75-130
5 inch	100-150

These rates are only approximate since growth varies drastically depending upon environmental conditions and availability of food. Growth of shrimp larger than 5 inches is slow and inconsistent on feeds presently being used.

The decision of when to harvest is an economic one based on growth and mortalities of the shrimp, the value of the shrimp, labor and feed costs, and the time the farmer's facilities are tied up. An interesting way of viewing the economics of shrimp farming is to look at the value of an individual shrimp (Figure 1). Prices used in this graph are retail bait shrimp prices and dockside prices for food shrimp. Postlarvae for stocking will cost a farmer between one-half and one cent each in the United States. Even if mortality rates are low, the farmer will have to raise food shrimp well beyond the 4-inch size to recoup his expenditures for postlarvae. He must also consider the cost for facility, food, and operation. Clearly, the only logical approaches from an economic viewpoint are (1) rear shrimp for the bait market to take advantage of the good early growth in ponds and the possibility of harvesting several crops a

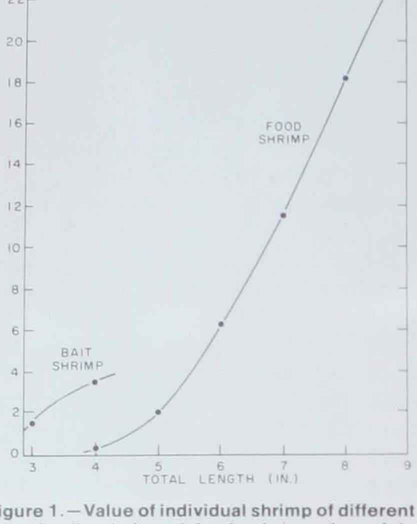


Figure 1.—Value of individual shrimp of different sizes for live bait and for food, based on July 1972 prices.

year or (2) raise the shrimp to a relatively large size to take advantage of the higher price per pound.

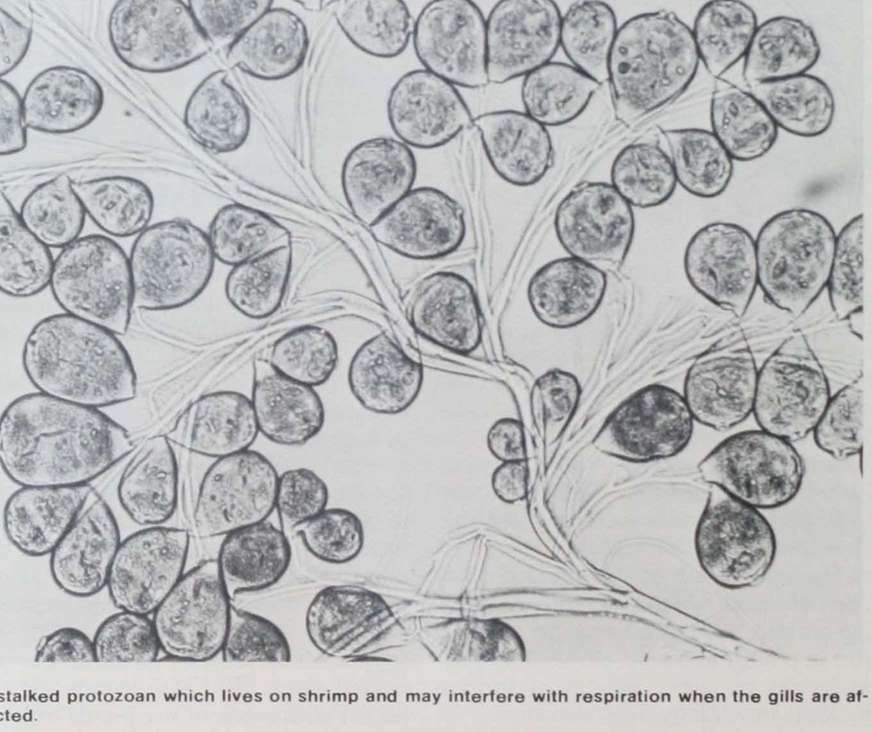
Since mortality rates are so important, we need to examine them more closely. Typical survival in pond-rearing experiments from postlarvae to the 4-inch size has been about 50 percent with a range of 0 to nearly 100 percent. Characteristically, survival is extremely variable and reasons for mortalities are very poorly understood. With present prices for postlarvae these mortalities are intolerable from the shrimp farmer's point of view.

Research related to shrimp culture presently underway at the Galveston Laboratory is directed toward the solution of several key problems which will help make shrimp farming a reality. Early work in Galveston was oriented primarily toward the development of economical hatchery techniques. Dependable methods for mass culture of larvae in small tanks were perfected in Galveston and several commercial groups are presently using these methods. The availability of a constant supply of uniform postlarvae opened the door for research in several other key areas. At present, work at the Galveston Laboratory is directed toward the solution of problems in the following four areas: (1) finding a dependable method for maturing female shrimp in captivity, (2) developing economical feeds which will provide the nutritional needs of shrimp, (3) developing methods for the recognition, prevention, and treatment of shrimp diseases, and (4) developing methods for the intensive culture of shrimp in closed systems.

Since female shrimp do not mature sexually in captivity, major emphasis has been placed on determining why. Obvious factors which differ between the offshore environment where wild shrimp do mature and the ponds where they do not are foods and environmental factors such as temperature, light, salinity, water quality, and pressure. These factors are all being examined in controlled laboratory experiments to determine their importance in sexual maturation. After numerous experiments, the first indication of success was observed in tanks held at a high pH. Egg production began in these shrimp and is continuing although the animals are not yet sexually mature. We hope this initial success will be a key to establishing procedures for the routine production and spawning of mature female shrimp.

A second approach to the maturation problem, a study of shrimp hormones, is being pursued simultaneously. Because the developmental process in shrimp is regulated by hormones, ovulation could conceivably be induced through injection of hormones if proper hormones were available. We are presently isolating and identifying hormones suspected to play key roles in sexual maturation. When they have been identified, the hormones or synthetic analogs can be injected experimentally in an effort to induce sexual maturation of female shrimp on demand.

Once maturation of shrimp in captivity is possible, culture will be simplified and the probability of economical farming of shrimp will be increased. Not only would larval production costs be reduced through elimination of the necessity of capturing wild females, but a dependable supply of spawners would be available at all times of the year.



A stalked protozoan which lives on shrimp and may interfere with respiration when the gills are affected.

In addition, selective breeding programs could be initiated and new, improved breeds of shrimp could be reared which are better adapted to culture than the wild stocks.

Shrimp nutrition is poorly understood even though considerable research on the subject has been conducted in the United States and Japan. After overcoming initial obstacles of the shape, consistency, binder, and attractiveness of the feed, we began present comparative studies of various formulations which make use of economical components. The feed presently used as our standard includes rice bran, shrimp meal, fish meal, soybean meal, algin, fish soluble, and lecithin. The formula for this diet is available to anyone wishing to use it as an experimental or control diet. Since growth on our best variations of this feed is still slower than that observed in nature at comparable temperatures, we still have a long way to go in describing the nutritional needs of shrimp. We have good evidence that the nutritional needs of shrimp change with successive life history stages, and the types of feed acceptable to animals in different stages are certainly different. One of the difficulties in studying nutritional needs is that we still must use live foods for the larval stages; no acceptable compounded feeds have been developed for these tiny shrimp.

The cost of ingredients in a feed is particularly important at this point since food conversion rates are poor with the diets presently in use. For this reason we have tried to make maximum use of ingredients which are waste products or at least inexpensive in the areas where shrimp are likely to be reared.

The role of diseases in shrimp mortality is not clear. In nature, diseases probably weaken some shrimp, making them easy prey of their many enemies. The extent to which this happens in seminatural rearing ponds is unknown. Some diseases have been observed, however, and as crowding increases with intensive culture practices more disease problems are anticipated.

Basic background histological studies of normal and diseased shrimp are underway in Galveston to aid in the recognition of diseases. In addition, diseases of shrimp from wild and cultured

Juvenile shrimp searching for food on the bottom with their clawlike legs which have hairs sensitive to certain chemicals. Shrimp here are eating a standard extruded diet.

Foods of various forms and textures are given shrimp at various stages in their life cycle. The flakes at right are fed to young postlarvae while older animals eat a similar food in a wormlike extruded form.

Experimental closed raceway system enclosed in a greenhouse to provide a controlled environment.

shrimp are being described. Methods of preventing and treating diseases are also being tested. The implementation of suitable techniques for preventing and controlling diseases should provide at least a partial solution to the poor survival of shrimp in ponds.

In addition to the biological and economic problems already discussed, the potential shrimp farmer has to overcome an additional set of problems in selecting a site. Difficulties such as the high cost of coastal land, pollution of or from an aquaculture operation and weather-related problems have led us to begin experimentation with systems offering more control than the seminatural open pond.

A closed raceway system is one of these systems which has been used successfully in prelimiary efforts to rear shrimp under very crowded conditions. The system has the advantage of being enclosed so that environmental control is possible, and predators and competitors are completely eliminated. Once the system has been filled, no more water enters or leaves the system until the shrimp are harvested so no pollution problems exist and disease control is simplified. Circulation and aeration are accomplished by air-lift pumps and waste removal methods used are techniques developed for treatment of sewage. The system when perfected may have applications in the culture of many fish and shellfish.

Profitable shrimp aquaculture is probably several years off and the "get-rich-quick" schemes many have dreamed of will probably remain only dreams; however, we do see some steady progress toward farming shrimp.

Fishery biologist using the rotary evaporator to concentrate steroid containing solutions for the isolation of shrimp hormones.

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