Chapter 1
Introduction

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This manual was developed to provide an overview of the production strategies for farming marine shrimp in recirculating freshwater, greenhouse-enclosed, raceway production systems. A detailed review of the design and operation of these shrimp farming production systems and an economic analysis will be presented. The manual is intended for field use by shrimp farmers, students and extension agents. The focus is on the postlarval through growout phases of the production cycle and will not address broodstock or larval rearing issues. This publication and the demonstration study was funded by a contract from the Florida Department of Agriculture and Consumer Services (FDACS Contract No. 4520).

Research conducted at Harbor Branch Oceanographic Institution demonstrating the technical feasibility of growing marine shrimp in freshwater has resulted in a surge of interest in shrimp farming from the aquaculture, agriculture and business community. Florida farmers have begun to seriously consider shrimp culture as a second crop and a few Florida farms have recently begun producing shrimp.

Although Florida has lagged behind South Carolina and Texas in shrimp farming, there are signs that the Florida shrimp farming industry is on the verge of development. New technologies have been developed that make shrimp farming a viable option in Florida. The feasibility of growing *L. vannamei* in Florida's hard freshwater has been demonstrated and has greatly expanded the potential sites for shrimp farming. The technology for growing shrimp in intensive, enclosed culture systems is being refined and the economic analyses indicate that shrimp farming can be profitable.

An Overview of the Development of Shrimp Farming

Litopenaeus vannamei (also known as *Penaeus vannamei*) is the most extensively farmed species of marine shrimp in the Western Hemisphere. *L. vannamei* is rapid growing, tolerates high stocking densities, has a relatively low dietary protein requirement and tolerates a wide range of salinities. It is a hardy animal that is highly adaptable to culture conditions. The natural distribution of *L. vannamei* extends from the Pacific coast of Mexico to northern Peru (Dore and Frimodt 1987).

The technology for culturing marine shrimp is relatively new. The initial hatchery culture technology was developed in Japan in the 1930s and 1940s with *Penaeus japonicus* by Motosaku Fujinaga (Shigueno 1975). Breakthroughs in shrimp hatchery technology in the 1960s and 1970s paved the way for rapid growth of shrimp farming in the 1980s and 1990s. Annual world production of farm-raised marine shrimp has grown from 92 metric tons in

1982 to 737,200 metric tons in 1998 (Rosenberry 1998). In many areas around the world, shrimp seedstock are still collected from the wild and stocked in large coastal ponds.

In the western hemisphere, Ecuador is the leading producer of farm-raised shrimp (Rosenberry 1998). The majority of the shrimp farms in Ecuador continue to rely on extensive growout techniques. In a typical extensive growout system, stocking is accomplished by flooding the ponds and bringing naturally occurring shrimp postlarvae into the pond, along with fish, crabs and other organisms. Little or no feeding is done and shrimp growth depends on the natural productivity of the pond. Extensive systems produce around 50-500 kg/ha/yr.

As the shrimp industry matured, producers adopted more intensive production methods. Stocking rates are closely monitored through the use of hatchery-reared postlarvae and the shrimp are fed specially formulated feeds. Most farms in the western hemisphere use a semi-intensive pond production strategy. Semi-intensive growout systems produce around 500-5,000 kg/ha/yr and the natural food in the pond is supplemented with formulated feeds. Intensive production systems produce around 5,000-10,000 kg/ha/yr (Brock and Main 1994). Shrimp are fed large quantities of formulated feeds, pond water is frequently exchanged and supplemental aeration is provided. A two-phase production system may be used, where juvenile shrimp are grown at high densities in small nursery ponds. Juvenile shrimp are later transferred to large growout ponds, where they are reared to harvest.

One of the obstacles to the development of commercial shrimp farming in the U.S. has been the lack of a reliable supply of high quality seedstock. It is critical for U.S. hatcheries to be able to rear their own broodstock to produce high-health or specific pathogen free (SPF) seedstock for U.S. farms. Reliance on broodstock and seedstock from other countries increases the risk of introduction of new shrimp diseases. Broodstock that are guaranteed to be free from specific disease-causing organisms are called "Specific Pathogen Free" (SPF) broodstock. Some states, such as South Carolina, now require that all shrimp seedstock sold in the state come from SPF broodstock. Development of new hatcheries should help to overcome the obstacle of a short supply of *L. vannamei* seedstock in Florida.

Over the past twenty years there has been a significant increase in U.S. consumer demand for marine shrimp, while the U.S. commercial catch has remained relatively constant. Increasingly the demand for marine shrimp has been met by farm-raised shrimp. Nearly 30% of the world shrimp supply is now being provided by pond aquaculture (Browdy 1998). Until recently, commercial shrimp farming in the United States has been limited to a few farms located in south Texas, South Carolina and Hawaii.

There are several reasons why commercial shrimp culture has been slow to develop in the United States. A combination of regulatory constraints, temperate climate conditions and high labor costs have limited the development of U.S. coastal shrimp ponds. Unlike the tropics, where air and water temperatures allow for year-round shrimp production, low temperatures during the late fall and early spring limit the production of this species to one crop per year (Main and Fulks, 1990). Higher U.S. land and labor costs and are also limiting factors.

New Approaches and Considerations for Shrimp Farming

The limited growing season and higher land values have forced U.S. shrimp farmers to adopt a more intensive approach to production. Researchers and farmers in Florida have recently been investigating intensive tank or raceway recirculating aquaculture systems. These systems are often enclosed in greenhouses to allow for greater control of temperature. A full description of the steps involved in greenhouse construction is presented in Chapter 3.

The system design principles for recirculating, intensive raceway or tank production systems are discussed in Chapter 4. Stocking densities in intensive raceway culture systems range from 100-250/m^2. Water in the culture system is typically circulated through a water treatment system that removes solids and nitrogenous wastes. Ultraviolet light or ozone is often used to reduce bacteria levels in the water. Blowers or liquid oxygen are used to maintain adequate levels of dissolved oxygen in the water.

Recirculating aquaculture systems require a higher level of technical expertise and are more expensive to build and operate than a pond culture system. However, there are several advantages associated with these types of systems. They allow shrimp to be grown commercially in locations where land is limited or land values make pond construction prohibitively expensive. The controlled environmental conditions allow for year-round production in areas otherwise restricted to a limited growing season. Water reuse technology can reduce the water requirements and discharge from the culture system, minimizing the environmental impact and permitting requirements for the operation. Harbor Branch is currently evaluating a relatively low-cost, recirculating production system. The design objectives and system features are described in Chapter 5 of this volume.

Providing the animals with the optimum quantities of a nutritionally complete feed is one of the most critical aspects of shrimp husbandry. Feeds remain the single highest expense for farmers that are operating intensive production systems. Feeds still need to be formulated to meet the nutritional requirements of shrimp farmed in intensive raceway production systems. Chapter 7 discusses the nutritional requirements and the feeding strategies that are appropriate for intensive shrimp production.

One of the biggest challenges facing the shrimp industry is the control of disease in farmed shrimp populations. Effective strategies to control the occurrence and spread of disease are primarily related to management of the production system. The common health problems, diseases and strategies that farmers can use to control disease in *L. vannamei* are discussed in Chapter 9.

The success of a new aquaculture business is closely correlated with careful planning. Chapter 2 addresses three issues that need to be addressed as you are getting started in shrimp farming. The first issue is business planning. Training, marketing and the preparation of a business plan are all discussed. The second issue that must be addressed is obtaining the required permits to construct and operate a business. At the time this manual was prepared, Florida's permitting requirements were undergoing revision. The state was working with the key stakeholder groups to develop Best Management Practices (BMPs) for each of the commodity groups, including shrimp. A general overview of the changes that have occurred in Florida's permitting process is also discussed in this chapter. The third issue that needs to be examined is the suitability of your water source for shrimp farming. The parameters that need to be examined are listed and the water testing process is presented.

The last chapter of the manual is an analysis of the economic feasibility of culturing marine shrimp in a hypothetical freshwater production system. The analysis in Chapter 10 uses the data gathered by Harbor Branch during the experiments conducted during the demonstration study and certain key assumptions to run the economic model. The assumptions, investment requirements, production inputs and operating costs are presented.

Freshwater Culture of Marine Shrimp

The Pacific white shrimp's tolerance to low salinities has greatly expanded the potential locations for shrimp aquaculture in Florida. That information, coupled with the desire of the agriculture community to diversify their production options, has significantly increased the interest in shrimp farming in Florida. Studies have shown that *L. vannamei* can be successfully farmed in freshwater raceways and ponds, provided the water is hard enough and has the correct mineral balance (Scarpa and Vaughan 1998; Scarpa et. al. 1999). Other penaeid species have also been shown to be adaptable to low salinities. Shivappa and Hambrey (1997) found that *Penaeus monodon* can be grown at salinities ranging from 2-3 ppt.

Maturation and postlarval production of *L. vannamei* still requires saltwater. Once the postlarvae reach the PL12 to PL14 stage, they can be acclimated to freshwater. At this stage, the gills are developing and they can withstand the osmotic stress (Scarpa 1998). Chapter 6 describes the procedures for handling and acclimating postlarvae from saltwater to freshwater production systems.

The ionic composition of the well water in a number of locations around Florida appears to be suitable to support *L. vannamei* and the results of a water testing program are presented in HBOI's 1999 final project report to the Department of Agriculture and Consumer Services. A full discussion of the water quality parameters and requirements for culture of *L. vannamei* is presented in Chapter 8. Taste tests have shown that shrimp grown in freshwater are well accepted and are difficult to distinguish from those grown in saltwater.

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