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Economic Analysis of an Intensive, Zero-Water Exchange, Saltwater Shrimp Culture Demonstration Project in Nicaragua[1]

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Introduction

Shrimp farming has recently received considerable attention in the United States due to emerging technologies in farm management, water purification, hatchery design/production, maturation, nutrition, and disease management. Worldwide shrimp aquaculture production is approaching one million metric tons (MT) annually. Meanwhile, the U.S. shrimp aquaculture industry was estimated to produce 4,500 MT in 2001 (Rosenberry, 2002).

In the United States, there were approximately 45 shrimp farms and 3,500 acres of ponds in 2001 (Rosenberry, 2002). Texas is currently the largest producer of farm-raised shrimp in the United States and accounts for approximately 80 percent of the domestic production of farm-raised shrimp, with South Carolina being second (Florida International Shrimp Harvesters, 2002). Neither of these states is characterized by the same environmental situation as exists in Florida (Florida International Shrimp Harvesters, 2002). Florida is uniquely situated to capitalize upon the current technologies being used in other countries and states to develop a shrimp aquaculture industry that has the potential to be profitable. In particular, the use of lined, earthen ponds with zero-water exchange provides a means to achieve a higher degree of bio-security. This is extremely important in that bacterial and viral contamination in shrimp ponds has resulted in recent dramatic disruptions in production in virtually all major shrimp culture regions around the world. This technology may be well-suited for inland culture systems in Florida.

According to the Florida Agricultural Statistics Service, in 2001 there were 13 producers of shrimp in Florida, eight of which reported farmgate sales totaling $7.4 million. Most of this sales figure was post-larvae shrimp being sold as seed to other producers, and the remainder was shrimp being sold for the food market. It was also reported the industry had a total water surface area of 36 acres in 2001, with a potential to exceed 150 acres in 2002. Currently, several shrimp culture operations are poised to expand rapidly. And although numerous attempts at commercial shrimp culture have failed in

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Florida, shrimp farming may develop into a profitable venture for a limited number of farmers (Florida International Shrimp Harvesters, 2002).

Objective

Several shrimp culture production technologies exist: enclosed raceways, earthen ponds, and lined ponds. This paper will discuss the economic characteristics of a lined pond system. The information will be useful for prospective shrimp farmers in Florida to make informed decisions regarding the most appropriate culture technology. The reader should note that the system described is for saltwater application and can be a built upland rather than actually *in* an estuary, where traditional farms are sometimes located. Using this intensive system on inland property provides an environmental advantage. The document provides existing and prospective shrimp farmers with the findings of an economic analysis on an intensive, zero-water exchange shrimp culture demonstration project built in Nicaragua. Capital investment in such an intensive system can be relatively high, but the profit per hectare can be higher than for other technologies. This technology in intensive shrimp culture has been shown to be a potentially profitable alternative to the traditional semi-intensive method used in other shrimp-producing countries.

Intensive, Zero Water-Exchange Shrimp Culture Project

The intensive, zero-water exchange shrimp culture demonstration project was funded by the U.S. Agency for International Development (USAID) and the National Oceanic and Atmospheric Administration (NOAA). It was conducted in cooperation with University of Florida/Florida Sea Grant, Michigan Sea Grant, Aquatic Designs Inc., and Camarones de Nicaragua, S.A. (Camanica). The project was built at the demonstration farm of the University of Central America (UCA) in Puerto Morazán, Nicaragua. Information concerning this shrimp culture project is based upon the report completed by the University of Florida team and is available by contacting the authors.

Intensive, Zero-Water Exchange Technology

Bacteria are the foundation of the heterotrophic, intensive, zero-water exchange shrimp culture process. A key element of this system is efficient recycling of nutrients through the pond with the use of heavy aeration. This technology does not release effluent (such as feces and bacteria) into natural water resources, and no new water is introduced to avoid water-borne viruses that kill shrimp. Thus with this technology biosecurity is high. Water circulation is induced by the operation of paddlewheel aerators, which also allows locating production inland away from sensitive coastal environments.

Site Description

The demonstration facility consisted of four one-half-hectare production ponds and two one-hectare settling ponds. Each of the four production ponds was lined with high-density polyethylene (HDPE) plastic liners. Each pond had ten two-horsepower paddlewheel aerators. The four ponds were built during the first half of 2001 and operated for one production cycle from August to December 2001. The system was built within an existing shrimp culture farm that has been used for traditional semi-intensive shrimp farming. The ponds were stocked in late Summer 2001, with the final pond harvested in December 2001. For the trial cycle, *Litopenaeus vannamei*, a species not natural to Florida, was used.

Initial Investment Requirements

Total initial investment for the demonstration project was $254,543 (all dollar amounts are U.S. dollars). Of the total, $4,100 was for feeding equipment; $65,416 for permanent equipment; and $185,027 for earthwork, ponds, liners, electrical, water control structures and miscellaneous equipment. Total cost per hectare for the prototype facility was $127,272 (Table 1).

Production Economics of the Zero-Water Exchange Shrimp Farming Demonstration Project

Actual production for the four one-half hectare demonstration ponds was 20,008 pounds of shrimp after one production cycle. Average production per hectare, per cycle for the four one-half hectare pond system was 10,004 pounds of shrimp. With two production cycles possible during a given year, total annual production at this rate could be 40,016 pounds of shrimp. Actual average survival rate was 29.69 percent, while actual weighted average size of the harvested shrimp was 13.29 grams (heads-on) [Table 2]. Actual production levels, survival rates, and harvest size per animal were lower than predicted. However, it is anticipated that predicted levels can be achieved as the operators gain more expertise with the system and improvements are made based on what was observed during the initial production cycle.

Cost and Returns Budgets for the Zero-Water Exchange UCA Demonstration Project

The analysis represents one production cycle. These data were then projected to two cycles to estimate what may be achieved on an annual basis. The detailed budgets include revenue, operating costs, and gross profit in total U.S. dollars per harvested pound (heads-on) and per seeded hectare. Table 3 presents unit cost and prices used to determine annual operating expenses for the UCA zero-water exchange system, while Table 4 presents both the predicted values and the adjusted production costs and revenues after completing the first production cycle. Based on the actual demonstration project results, total projected operating expense would be $30,147 on a per hectare basis, while total projected revenues would be $20,508, given a market price of $2.05 per pound (heads-on). The latter results in a negative net revenue of $9,639. However, it is important to note that the December 2001 market prices in Nicaragua for shrimp were at the lowest in a number of years. At a market price of approximately $3.00 per pound, a break-even situation would have resulted. Note that total cost per pound of harvested shrimp was $3.01.

Sensitivity Analysis

A sensitivity analysis was also conducted to show variations in the intensive, zero-water exchange culture system. The sensitivity analysis provides potential investors with some insight into the production and financial risks associated with the zero-water exchange system.

Tables 5 and 6 show the variation in costs and net returns of (1) *predicted* values and (2) *projected* values, based on actual data obtained from one real production cycle, for an annual operation, as average shrimp price per pound (heads-on) varies. Four different shrimp prices per pound were considered: $2.50, $3.00, $3.50, and $4.00. On a per harvested pound and per seeded hectare basis, the break-even price for the UCA prototype farm is any price above $3.00 per pound of shrimp harvested if an annual production of 40,016 pounds of shrimp is achieved and production costs remain constant as those incurred in the one real production cycle.

Conclusion

Various projects have shown that the relatively more biosecure, intensive, zero-water exchange system has the capacity to manage the White Spot Virus and other viruses better than semi-intensive farm methods in Nicaragua. The zero-water exchange technology also has the potential to be profitable, given that technical recommendations (such as zero water exchange during the grow-out period, high stocking densities, ponds adequately lined and aerated) are applied. The yield per hectare generated by the intensive, zero-water exchange technology can be higher than most of the other methods of shrimp farming. However, additional work with the zero-exchange system is needed to reveal its true capabilities. Readers should note that the system described above was used in a saltwater application. In Florida, the use of saltwater is not advised due to environmental concerns and the high cost of coastal property. Using this intensive system with freshwater on inland property may have potential in Florida, but additional costs, including wells, acclimation of post-larvae, etc., must be considered. Even with the latest technological advances and with a good crop of shrimp, the profitability of shrimp farms also depends upon market prices. Therefore, prospective Florida shrimp farmers need to evaluate and investigate potential markets, potential production systems, business risks, financial requirements, zoning, and other regulations (Elovaara, 2001).

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Table 1. Cost to construct the zero-water exchange demonstration project at UCA.

	Total Cost (US dollars)
Feeding Equipment	
Feed Storage	2,500
Feeders	1,600
Sub-total feed equipment	4,100
Permanent Equipment	
Aeration Equipment	20,969
Pumps	15,850
Electrical Generators	25,953
Scientific Equipment	2,644
Sub-total permanent equipment	65,416
Other Costs	
Pond Construction	
Earthwork	46,438
Setting ponds (1 ha)	
Grow-out ponds (1/2 ha)	
Canals/Reservoirs	
Roads/Drains	
HDP pond liners	39,093
Electrification	32,715
Wire/Panels	
Water control structures	43,677
Piping/Sluice gates/Valves	
House/Office	13,921
Office Equipment	9,183
Sub-total other costs	185,027
TOTAL DIRECT COSTS (US dollars)	254,543
Cost Per Hectare (US dollars)	127,272

Table 2. Production assumptions based on first cycle of demonstration farm.

Production Variables	Predicted		Actual	Projected
	1 Cycle	2 Cycles	1 Cycle	2 Cycles
Total Seeded PL/pond	2,300,000	4,600,000	2,300,000	4,600,000
Stocking Density (PL/m2)	115	115	115	115
Survival Rate (%)	55.00	55.00	29.69	29.69
Harvest Size (g) Fixed	13.50	13.50	13.29	13.29
Number of Cycles Per Year	1	2	1	2
Feed Conversion Ratio	1.73	1.73	2.44	2.44
Total Seeded Hectare	2	4	2	4
Total Seeded Hectare in m^2	20,000	40,000	20,000	40,000
Total Pounds Harvested (2-ha farm)	37,370	74,740	20,008	40,016
Pounds Harvested/Ha (head-on)	18,685	18,685	10,004	10,004

Table 3. Unit costs based upon first cycle of demonstration farm (U.S. dollars).

Units	Predicted		Actual	Projected
	1 Cycle	2 Cycles	1 Cycle	2 Cycles
Average Shrimp Price ($/pound)	3.00	3.00	2.05	2.05
Postlarvae ($/1,000)	5.22	5.22	5.22	5.22
Feed ($/pound) [excluding shipping cost]	0.21	0.21	0.21	0.21
Shipping Cost ($/pound)	0.11	0.08	0.14	0.10
Fertilizer/Chemical ($/Hectare)	625.74	625.74	625.74	625.74
Fuel ($/Hectare)	2,933.16	2,933.16	3,433.16	3,433.16
Direct Labor ($/Pound Harvested)	0.15	0.15	0.28	0.28
Indirect Cost ($/Hectare)	21,547.49	11,054.02	18,900.35	9,552.72

Table 4. Cost and returns budget for UCA zero-water exchange demonstration project (U.S. dollars).

	Predicted		Annual		Actual	Projected	Annual	
	Total 1 Cycle	Total 2 Cycles	Per Harvest Pound	Per Seeded Hectare	Total 1 Cycle	Total 2 Cycles	Per Harvest Pound	Per Seeded Hectare
Pounds Harvested	37,370	74,740			20,008	40,016		
Price ($/pound)	3.00	3.00			2.05	2.05		
Total Revenue ($)	112,110	224,220	3.00	56,055	41,016	82,033	2.05	20,508
Operating Expenses								
Postlarvae ($)	11,995	23,991	0.32	5,998	11,995	23,991	0.60	5,998
Feed ($, includes shipping cost)	20,518	37,636	0.50	9,409	17,176	30,952	0.77	7,738
Fertilizer/ Chemicals ($)	1,251	2,503	0.03	626	1,251	2,503	0.06	626
Fuel ($)	5,866	11,733	0.16	2,933	6,866	13,733	0.34	3,433
Direct Labor ($)	5,600	11,200	0.15	2,800	5,600	11,200	0.28	2,800
Indirect Costs ($)	43,095	44,216	0.59	11,054	37,801	38,211	0.95	9,553
Total Operating Expense ($)	88,326	131,279	1.76	32,820	80,690	120,590	3.01	30,147
Gross Profit ($)	23,784	92,941	1.24	23,235	(39,674)	(38,557)	(0.96)	(9,639)

Table 5. Cost and net returns per harvested pound for UCA zero water-exchange system at different price levels (U.S. dollars).

UCA Prototype Farm	Predicted	Projected
Total Area in Production (hectare)	2	2
Production (pounds/hectare/cycle)	18,685	10,004
Expected Annual Production Level	74,740	40,016
	Per Pound Harvested	
Price ($/pound)	2.50	2.50
Total Revenue ($)	2.50	2.50
Total Operating Expense ($)	1.75	3.02
Gross Profit ($)	0.75	(0.52)
Price ($/pound)	3.00	3.00
Total Revenue ($)	3.00	3.00
Total Operating Expenses ($)	1.76	3.02
Gross Profit ($)	1.24	(0.02)
Price ($/pound)	3.50	3.50
Total Revenue ($)	3.50	3.50
Total Operating Expenses ($)	1.76	3.03
Gross Profit ($)	1.74	0.47
Price ($/pound)	4.00	4.00
Total Revenue ($)	4.00	4.00
Total Operating Expenses ($)	1.77	3.03
Gross Profit ($)	2.23	0.97

Table 6. Cost and net returns per seeded hectare for UCA zero water-exchange system at different price levels.

UCA Prototype Farm	Predicted	Projected
Total Area in Production (hectare)	2	2
Production (pounds/hectare/cycle)	18,685	10,004
Expected Annual Production Level	74,740	40,016
	Per Seeded Hectare	
Price ($/pound)	2.50	2.50
Total Revenue ($)	46,713	25,010
Total Operating Expense ($)	32,726	30,192
Gross Profit ($)	13,986	(5,182)
Price ($/pound)	3.00	3.00
Total Revenue ($)	56,055	30,012
Total Operating Expenses ($)	32,820	30,242
Gross Profit ($)	23,235	(230)
Price ($/pound)	3.50	3.50
Total Revenue ($)	65,398	35,014
Total Operating Expenses ($)	32,913	30,292
Gross Profit ($)	32,484	4,722
Price ($/pound)	4.00	4.00
Total Revenue ($)	74,740	40,016
Total Operating Expenses ($)	33,007	30,343
Gross Profit ($)	41,733	9,673