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Cost and Returns Budgets for an Intensive Zero Water-Exchange Shrimp Culture Demonstration Project in Nicaragua, 2001

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Facility Description

An intensive zero water-exchange shrimp culture demonstration project was constructed at the Universidad Centro Americana (UCA) in Puerto Morazan, Nicaragua by Aquatic Design Systems. The culture facility consists of four one-half-hectare ponds and two one-hectare settling ponds. Each of the four production ponds is lined with plastic HDP pond liners and aerated. The intensive zero water-exchange system was designed to improve biosecurity and production levels. The four ponds were built during the first half of 2001 and operated for one production cycle from August to December, 2001. The goal was to determine the feasibility of producing shrimp using the zero exchange shrimp culture system where Taura Syndrome Virus (TSV) and White Spot Virus (WSSV) are common.

The system was built within an existing shrimp culture farm that has been used for traditional semi-intensive farming. Initial investment costs for the facility construction included land preparation, pond construction, building and road construction, effluent/ affluent water system development, electric hookups, HDP pond liners, and other costs associated with actual construction. Other capital costs included lab equipment, harvesting equipment, feeding apparatus, aerators, feed storage, rolling stock, generators, and pumps.

Initial Investment Requirements

Total costs for feeding equipment, permanent equipment, and other costs (including pond construction, plastic liners, electrification, water control structures, roads, drains, etc.) were US$4,100, US$65,416, and US$185,027, respectively. Construction costs totaled US$254,543 for the entire facility. Total cost per hectare for the prototype facility was US$127,272 (Table 1).

Converting Semi-Intensive Systems to Zero Water-Exchange

A traditional semi-intensive shrimp farm in Nicaragua, using the latest technology, is capable of yielding on average 1,033,661 pounds of shrimp in a year or 3,133 pounds per hectare per year[1]. A total of 2.04 production cycles per year can be achieved while the average area in production is 324 total hectares. In contrast, actual production for the four one-half hectare UCA demonstration farm during the 2001 trial production run 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 annually, total annual production at this rate will be 40,016 pounds of shrimp (Table 2). This production level is estimated

[1] Lopez, Mayra, Charles Adams, James Cato, and Donald Sweat. 2001. Draft manuscript. Cost and returns budgets for a Semi-intensive shrimp farm in Nicaragua, 1994-2000. Florida Sea Grant. University of Florida. Gainesville.

based on one production cycle, from August to December, 2001, at the demonstration facility, as summarized in Table 2. This was the only production cycle after completion of the demonstration facility. Predicted production levels (pounds/hectare/cycle), survival rate, and average harvest size of shrimp were not achieved. However, it is anticipated they can be achieved as the local operators gain more knowledge about the system and improvements are made based on what was observed during the first production cycle.

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

Feeding Equipment	**Total Cost**
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 Perm Equipment	**65,416**
Other Costs	
Pond Construction	
Earthwork	46,438
Settling Ponds (1ha)	
Grow-out Ponds (1/2ha)	
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 variables achieved during the initial production cycle at UCA demonstration project.

Production (lbs/ha/cycle)	10,004
Expected Production Level (lbs/2ha/yr)	40,016
Cycles	2
Total Production (lbs/ha/yr) (1 Cycle)	20,008
Total Area (ha)	2
Number of 1/2 ha ponds	4
Average Practical Survival Rate (%)	30
Stocking Density (PL/m2)	115
Average Harvest Size (g)	13.29

Investment costs were determined for various sized zero water-exchange hypothetical systems by varying production levels needed to achieve the same production level per year (1,033,661 pounds) as the traditional system. Production levels (pounds/hectare/cycle) varied from 10,000 to 40,000 pounds/hectare/cycle (Table 3). As a result, the total hectares required changed as well the total investment (Table 3). The capital investment assumptions used were:

- Feed storage cost remains constant at US$2,500 regardless of the size of the system given the change in production level on a per hectare basis.
- The cost of feeders is estimated at US$400 per one-half-hectare pond.
- There is a linear relationship between generators and aerators as the number of ponds increase. 40 horsepower of aeration per hectare were used at the demonstration project.
- Current set of pumps on the UCA site can handle up to 6 hectares of production ponds. (Twelve one-half hectare ponds).
- Linearity also exists in costs such as earthwork, HDP liners, electrification, and water control structures.
- Some costs including scientific and office equipment, and office construction do not vary as farm size changes along with the various per hectare yields.

Table 3. Initial investment requirements at different production levels for a zero water-exchange system to achieve the same production level as a traditional system.

Production Levels using Zero Exchange System		Initial Investment Cost for Zero Exchange System (US$)	Total Area in production	Number of 1/2- ha
lbs/ha/cycle	lbs/ha/year	to produce 1,033,661 lbs/yr	(ha)	ponds
10,000	20,000	5,602,996	52	103
15,000	30,000	3,744,747	34	69
20,000	40,000	2,815,622	26	52
25,000	50,000	2,258,147	21	41
30,000	60,000	1,886,498	17	34
35,000	70,000	1,621,033	15	30
40,000	80,000	1,421,935	13	26

The predicted production level for the UCA demonstration project was 18,865 pounds/hectare/cycle. Actual production from the project was 10,004 pounds/ hectare/ cycle (Table 2). Project managers maintain that the higher harvest levels can be achieved based on a full year's production and using knowledge gained during the first production cycle.

The traditional semi-intensive farm referenced earlier is to produce 1,033,661 pounds. Assuming 25,000 pounds of shrimp per hectare from two production cycles, a total of 41 one-half-hectare ponds (21 hectares) and associated holding ponds using the zero water-exchange technology are needed to achieve the same production level (Table 4). Since the total construction cost mentioned above is for the two-hectare demonstration farm and associated holding ponds at UCA, total cost for a 21-ha farm using the zero water-exchange, intensive system has been generated by taking into account all the capital investment assumptions listed previously. Total cost of some specific categories including aeration equipment, electric generators, earthwork, HDP liners, electrification, and water control structures were estimated by multiplying total cost of these categories for the prototype farm by the corresponding multiplier. The multiplier is obtained by dividing the total area in hectares (Table 4) needed to produce 1,033,661 pounds of shrimp by 2 to take into consideration the investment costs on the two-hectare demonstration project. At a production level of 25,000 pounds of shrimp per hectare, the multiplier used to estimate total cost of the categories is 10.34. Since the current set of pumps at UCA can handle a farm of six hectares of production ponds, the cost for pumps for the various sized systems was estimated by dividing the total area (expressed in hectares using the new system to produce the same production level as the traditional system) by 6, and then by multiplying that figure by the price of the current pump at the demonstration project. Total cost of feed storage, scientific and office equipment, and building construction remain constant regardless of the variation in farm size. Finally, the cost for feeders was calculated by multiplying US$400 by the number of one-half-hectare ponds needed to generate the same annual yield as the traditional system.

As projected production levels per hectare per cycle increase from 10,000 pounds to 15,000 pounds, 20,000 pounds, and 25,000 pounds, total construction cost decreases from US$5,602,996 to US$3,744,747, US$2,815,622, and US$2,258,147, respectively (Table 4). Total construction costs at production levels of 10,000, 15,000, and 20,000 pounds are determined by multiplying the specific cost categories by previously defined multipliers of 25.84, 17.23, and, 12.92 respectively. The higher the production levels, the smaller the area needed using the zero water-exchange, intensive system, making total initial investment requirements lower. In contrast, construction costs per hectare decrease as total area in production increases (Table 4). When production level per hectare increases from 25,000 pounds to 30,000 pounds, 35,000 pounds, and 40,000 pounds, total construction cost decreases to US$1,886,498, US$1,621,033, and US$1,421,935, respectively (Table 4). The multipliers to calculate total cost of the categories that vary linearly are 8.61, 7.38, and 6.46 when production level per hectare is 30,000, 35,000, and 40,000 pounds, respectively.

Depreciation

Annual fixed costs include concession fee[2] and depreciation. Using the straight-line method, the annual depreciation cost was estimated based on the useful life of the different assets with no salvage value. Aeration equipment was assumed to have a useful life of two years. Feeders, electric generators, and scientific equipment were assumed to

[2] Concession fee refers to the annual leasing cost of land per hectare paid to the Nicaraguan government. For this analysis, an average of US$25 per hectare was used.

have a five-year life. A 10-year life was assumed for feed storage, pumps, HDP liners, electrification, and office equipment. Earthwork and water control structures were assumed to have a 15-year life. Finally, the office building on the site was assumed to have a 25-year life. To compute the amount of annual depreciation expense using the straight-line method requires two numbers: the initial cost of the asset and its estimated useful life. The initial cost of the assets (Table 4) predicted and adjusted annual depreciation for the UCA demonstration site, and estimated depreciation costs for the various sized hypothetical systems are also given (Table 5).

Table 4. Initial investment requirements for different sized production farms using the zero water-exchange system to achieve 1,033,661 pounds of shrimp per year.

	UCA Prototype Farm		Different Production Scenarios - Hypothetical Farms						
	Predicted	Actual							
Production (lbs/ha/cycle)	18,685	10,004	10,000	15,000	20,000	25,000	30,000	35,000	40,000
Expected Production Level (lbs/2ha/yr)	74,740	40,016							
Total Average Production of Traditional System (lbs/324ha/yr)			1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Cycles	2	2	2	2	2	2	2	2	2
Total Production (lbs/ha/yr)	37,370	20,008	20,000	30,000	40,000	50,000	60,000	70,000	80,000
Total Area (ha)	2	2	52	34	26	21	17	15	13
Number of 1/2 ha ponds	4	4	103	69	52	41	34	30	26
Survival Rate (%)	55	30	55	55	55	55	55	55	55
Stocking Density (PL/m2)	115	115	61	92	122	153	183	214	244
Average Harvest Size (g)	13.50	13.29	13.50	13.50	13.50	13.50	13.50	13.50	13.50
Multiplier	1	1	25.84	17.23	12.92	10.34	8.61	7.38	6.46
	Investment Cost for Zero Exchange System		Investment Cost to Achieve Production Level of 1,033,661 lbs. per year as Traditional Semi-Intensive Systems						
	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost
A. Feeding Equipment									
Feed Storage	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Feeders	1,600	1,600	41,346	27,564	20,673	16,539	13,782	11,813	10,337
Sub-Total Feed Equipment	**4,100**	**4,100**	**43,846**	**30,064**	**23,173**	**19,039**	**16,282**	**14,313**	**12,837**
B. Permanent Equipment									
Aeration Equipment	20,969	20,969	541,871	361,247	270,935	216,748	180,624	154,820	135,468
Pumps	15,850	15,850	136,529	91,020	68,265	54,612	45,510	39,008	34,132
Electrical Generators	25,953	25,953	670,665	447,110	335,333	268,266	223,555	191,619	167,666
Scientific Equipment	2,644	2,644	2,644	2,644	2,644	2,644	2,644	2,644	2,644
Sub-Total Perm Equipment	**65,416**	**65,416**	**1,351,710**	**902,021**	**677,177**	**542,270**	**452,333**	**388,092**	**339,911**
C. Other Costs									
Pond Construction									
Earthwork -	66,438	46,438	1,200,019	800,013	600,009	480,008	400,006	342,863	300,005
Settling Ponds (1ha)									
Grow-out Ponds (1/2ha)									
Canals/Reservoirs									
Roads									
Drains									
HDP pond liners	54,093	39,093	1,010,231	673,488	505,116	404,093	336,744	288,638	252,558
Electrification	32,715	32,715	845,402	563,602	422,701	338,161	281,801	241,544	211,351
Wire									
Panels									
Water Control Structures	58,677	43,677	1,128,683	752,455	564,341	451,473	376,228	322,481	282,171
Piping									
Sluice Gates									
Valves									
House/Office	13,921	13,921	13,921	13,921	13,921	13,921	13,921	13,921	13,921
Office Equipment	9,183	9,183	9,183	9,183	9,183	9,183	9,183	9,183	9,183
Sub-Total Other Costs	**235,027**	**185,027**	**4,207,440**	**2,812,661**	**2,115,272**	**1,696,838**	**1,417,883**	**1,218,629**	**1,069,188**
TOTAL DIRECT COSTS (US Dollars)	304,543	254,543	5,602,996	3,744,747	2,815,622	2,258,147	1,886,498	1,621,033	1,421,935
Cost per hectare (US Dollars)	152,272	127,272	108,411	108,684	108,957	109,231	109,504	109,777	110,050

Table 5. Annual depreciation costs for zero water-exchange demonstration project and different farm scenarios.

	UCA Prototype Farm		Different Production Scenarios - Hypothetical Farms						
	Predicted	Actual							
Production (lbs/ha/cycle)	18,685	10,004	10,000	15,000	20,000	25,000	30,000	35,000	40,000
Expected Production Level (lbs/2ha/yr)	74,740	40,016							
Total Average Production of Traditional System (lbs/324ha/yr)			1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Cycles	2	2	2	2	2	2	2	2	2
Total Production (lbs/ha/yr)	37,370	20,008	20,000	30,000	40,000	50,000	60,000	70,000	80,000
Total Area (ha)	2	2	52	34	26	21	17	15	13
Number of 1/2 ha ponds	4	4	103	69	52	41	34	30	26
Survival Rate (%)	55	30	55	55	55	55	55	55	55
Stocking Density (PL/m2)	115	115	61	92	122	153	183	214	244
Average Harvest Size (g)	13.50	13.29	13.50	13.50	13.50	13.50	13.50	13.50	13.50
Multiplier	1	1	26	17	13	10	9	7	6
	Depreciation Cost for Zero Exchange System		Depreciation Cost to Achieve Production Level of 1,033,661 lbs. per year as Traditional Semi-Intensive Systems						
	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost	Total Cost
A. Feeding Equipment (US Dollars)									
Feed Storage	250	250	250	250	250	250	250	250	250
Feeders	320	320	8,269	5,513	4,135	3,308	2,756	2,363	2,067
Sub-Total Feed Equipment	570	570	8,519	5,763	4,385	3,558	3,006	2,613	2,317
B. Permanent Equipment (US Dollars)									
Aeration Equipment	10,484	10,484	270,931	180,621	135,465	108,372	90,310	77,409	67,733
Pumps	1,585	1,585	13,653	9,102	6,826	5,461	4,551	3,901	3,413
Electrical Generators	5,191	5,191	134,133	89,422	67,067	53,653	44,711	38,324	33,533
Scientific Equipment	529	529	529	529	529	529	529	529	529
Sub-Total Perm Equipment	17,789	17,789	419,246	279,673	209,887	168,016	140,101	120,162	105,208
C. Other Costs (US Dollars)									
Pond Construction									
Earthwork	4,429	3,096	80,001	53,334	40,001	32,001	26,667	22,858	20,000
Settling Ponds (1ha)									
Grow-out Ponds (1/2ha)									
Canals/Reservoirs									
Roads									
Drains									
HDP pond liners	5,409	3,909	101,023	67,349	50,512	40,409	33,674	28,864	25,256
Electrification	3,271	3,271	84,540	56,360	42,270	33,816	28,180	24,154	21,135
Wire									
Panels									
Water Control Structures	3,912	2,912	75,246	50,164	37,623	30,098	25,082	21,499	18,811
Piping									
Sluice Gates									
Valves									
House/Office	557	557	557	557	557	557	557	557	557
Office Equipment	918	918	918	918	918	918	918	918	918
Sub-Total Other Costs	18,497	14,664	342,285	228,682	171,880	137,799	115,079	98,849	86,678
TOTAL DEPRECIATION COSTS (US Dollars)	36,856	33,022	770,050	514,118	386,152	309,373	258,186	221,624	194,203
Depreciation Cost per hectare (US Dollars)	18,428	16,511	14,899	14,921	14,943	14,965	14,987	15,009	15,030

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

For the zero water-exchange UCA demonstration project in Puerto Morazan, Nicaragua, the costs and returns budget represents (1) predicted values for one cycle and for an annual operation before first harvest, (2) actual values for the first production cycle, and (3) projected values for annual operation costs and revenues based on the actual data obtained from one real production cycle[3]. The analysis focuses initially on both per cycle and annual operating expenses for the prototype farm. These estimates are then utilized to construct an annual operating budget to generate 1,033,661 pounds of harvested shrimp from different hypothetical farms by varying production levels on a per hectare basis. Finally, a sensitivity analysis is included to determine how financial performance measures change as key management parameters including farm production levels and shrimp price are varied. The sensitivity analysis provides the potential investor with some insight into the production and financial risks associated with the zero water-exchange system.

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

Single Cycle and Annual Estimates

The demonstration farm consisted of four one-half-hectare production ponds. Predicted practical survival rates varied from 40 to 60 percent and predicted harvest size ranged from 13 to 15 grams (heads-on). For this analysis, the average predicted survival rate and harvest size of shrimp were calculated at 55 percent and 13.50 grams (heads-on), respectively. After the completion of the August-December 2001 production cycle, actual average survival rate was 29.69 percent while actual weighted average size was 13.29 grams (heads-on). The weighted average size was determined based on the production yields as reported in the liquidation report by the processing plant (Table 6). Survival rate was calculated by using the following formula:

$$\text{Computed Survival Rate} = \frac{\text{Total Pounds Harvested}}{(\text{Stocking Density} * \text{Total Seeded Area } (m^2) * \text{Harvest Weight} * \text{Cycles})/453.59237}$$

Table 6. Actual production yields from zero water-exchange demonstration project.

	Stocking Density PL/m²	Net Weight (lbs) Received at Plant	Total Number of Shrimp	Average size (g) (heads-on)
Pond 1	100	3,275	129,953	11.44
Pond 2	120	5,750	200,308	13.03
Pond 3	120	5,713	175,763	14.76
Pond 4	120	5,270	177,041	13.51
TOTAL		**20,008**	**683,065**	

Source: Camarones de Nicaragua. S.A.

[3] The word "predicted" is used to indicate what was originally thought would happen. The word "actual" refers to the actual harvest data including selling price, harvest size, etc. Finally, the word "projected" indicates what can happen by using specific assumptions, better knowledge, at various prices, etc.

Total production was 20,008 pounds from the August-December 2001 demonstration project. Using the same production variables (Table 7) for two cycles per year, projected annual production would be 40,016 pounds.

Table 7. 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
Days Shrimp in Pond/cycles				
Weeks Shrimp in Pond/Cycles				
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 Ha	2	4	2	4
Total Seeded Ha in m2	20,000	40,000	20,000	40,000
Total Pounds Harvested (2ha farm)	37,370	74,740	20,008	40,016
Lbs Harvested/ha (head-on)	18,685	18,685	10,004	10,004

Unit costs and prices used to determine annual operating expenses for the UCA Zero Water-Exchange system are shown in Table 8.

Table 8. Unit costs based on first cycle of demonstration farm.

Unit Cost	Predicted		Actual	Projected
	1 Cycle	2 Cycles	1 Cycle	2 Cycles
Average Shrimp Price (US$/lb)	3.00	3.00	2.05	2.05
Postlarvae (US$/1000)	5.22	5.22	5.22	5.22
Feed (US$/lb) (excluding shipping cost)	0.21	0.21	0.21	0.21
Shipping Cost (US$/lb)	0.11	0.08	0.14	0.10
Fertilizer/Chemical (US$/ha)	625.74	625.74	625.74	625.74
Fuel (US$/ha)	2,933.16	2,933.16	3,433.16	3,433.16
Direct Labor (US$/lb harvested)	0.15	0.15	0.28	0.28
Indirect Cost (US$/ha)	21,547.49	11,054.02	18,900.35	9,552.72

Production costs include both direct and indirect costs. Direct costs include variable costs for post-larvae, feed, chemicals and fertilizers, fuel, and labor. Indirect costs include equipment and facility maintenance costs, depreciation, concession fees, and taxes. In order to determine the annual operating expenses for both the UCA demonstration project and the hypothetical farms, the formulas below were used.

Post-Larvae Cost. The average stocking density for the UCA system was 115 PL/m² and the cost per thousand PL was US$5.22. Annual PL cost was calculated by using the following formula:

$$\frac{[(\text{Total seeded area}(m^2) * \#\text{ of cycles}) * (\text{Stocking Density }(PL/m^2))]}{1{,}000\ PL} * \text{PL Cost per thousand}$$

Feed Cost. Based on actual project results, the food conversion ratio (FCR) was estimated at 2.44. During the first production cycle, 48,840 pounds of feed were consumed and only 20,008 pounds of shrimp were harvested.

Feed price per pound was determined at US$0.21 by (1) excluding a shipping cost of US$3,400 for every 44,000 pounds of feed and (2) by dividing the total reported feed cost after excluding the shipping cost, by the total pounds of feed. Shipping cost on per pound basis decreases as the number of pounds of feed approaches the 44,000 pounds (capacity of a load).

The formula used to calculate annual feed cost is as follows:
= (FCR * Expected Annual Production (lbs. of shrimp) * Feed Price/lb. excluding shipping costs) + (US$3,400 for every 44,000 pounds of feed)

Chemicals, Fertilizers, and Fuel Cost. Actual cost for chemicals and fertilizers on a per hectare basis was US$626 while actual per-hectare cost for fuel was US$3,433.16. The annual cost is computed by simply multiplying the corresponding cost per hectare by the total area in hectares using the new system, and then by two, which is the number of cycles per year.

Direct Labor Cost. Direct labor is estimated at US$1,400 per month for a two-hectare farm. This cost includes food, transportation, and security. The duration of every production cycle is approximately four months. Annual labor cost for a two-hectare farm is then calculated by multiplying US$1,400 by eight, which is the number of months to complete two production cycles and by the total area in hectares employing the zero water-exchange system. The total cost is then obtained by multiplying the number by the total number of four half-hectare ponds used in the system.

Indirect Costs. Annual indirect costs per hectare, based on the results obtained were estimated at US$9,553. All the variables included in this cost category have been determined utilizing the following assumptions:

- Equipment and facility maintenance costs equal 1.5 percent of the total initial investment cost.
- Depreciation costs are estimated by considering zero salvage value and by using a straight-line method. Given the economic life of the corresponding asset, depreciation reported is annual.

- Annual land concession fees are estimated on average as US$25 per hectare.[4]
- Taxes are determined as US$500 plus one percent of total revenues.[5]

Cost and Returns Budget

Detailed budgets including revenue, operating costs, and gross profit in total U.S. dollars, per seeded hectare and per harvested pound (heads-on) basis are presented below (Table 9). Predicted annual expenses and revenues for the prototype UCA farm were based on two production cycles per year and an annual predicted production of 74,740 pounds of shrimp (heads-on) per four half-hectare pond system. At a selling price per pound of US$3.00(heads-on), total revenue would have equaled US$224,220. Total annual operating expenses would have been US$131,280, generating an annual gross profit of US$92,940.

Total harvest for the two-hectare demonstration farm was 20,008 pounds for the one cycle. Average selling price was US$2.05 (heads-on)[6], given the average size of shrimp harvested from the four ponds (Table 10). Based on the production yields from the first cycle, annual production is assumed to be 40,016 pounds of shrimp. Table 9 also presents the adjusted production costs and revenues after completing the first production cycle.

Table 9. Cost and returns budget for zero water-exchange UCA demonstration project.

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

[4] Rivera, César. 2000. Guía Informativa. Nicaragua y el Sector Pesquero. Administración Nacional de La Pesca. Centro de Investigaciones Pesqueras y Acuícolas (CIPA). p. 21
[5] Rivera, César. 2000. Guía Informativa. Nicaragua y el Sector Pesquero. Administración Nacional de La Pesca. Centro de Investigaciones Pesqueras y Acuícolas (CIPA). p. 21
[6] The average heads-on price for 70/80 count per kilogram shrimp is currently lower than it has been for several years. The price for 70/80 count per kilogram heads-on shrimp during the same time in 2001 was in excess of US$3.00

Table 10. Prices for shrimp sold from demonstration project.

Size Ct/Kg	Heads-on Prices US$ per lb
50/60	2.41
60/70	2.16
70/80	2.05
80/100	1.95

Source: Camarones de Nicaragua, S.A.

Based on predicted values before first harvest, indirect costs constituted the largest operating expense. Indirect costs accounted for 33.68 percent of the estimated production costs from two production cycles. Depreciation accounted for 28.07 percent of indirect costs. Feed was the largest direct expenditure at 28.67 percent of the annual estimated operating expense. Post-larvae cost was 18.27 percent of total annual costs. Fuel and direct labor accounted for 8.94 and 8,53 percent of total expenses. Chemicals and fertilizers accounted for 1.91 percent of total production costs (Table 11).

Based on the actual demonstration project results, total actual operating expense was US$80,690. The actual percentage contribution of every operating expense to total operating expenses increased over what was predicted, except feed and indirect costs. Feed cost decreased because only 48,840 pounds out of the 64,570 pounds (purchased) of feed were consumed. Although feed consumption decreased by 24.36 percent from the quantity originally predicted, total feed cost decreased by only 16 percent due to the fixed shipping cost associated for every 44,000 pounds of feed. The percentage contribution from total indirect costs decreased as total investment cost of the UCA facility decreased, thus lowering depreciation and facility and equipment maintenance costs. Taxes decreased due to (1) a lower average price per pound of shrimp and (2) the lower actual production achieved, thus generating lower revenues.

Table 11. Percentage contribution to total operating expenses for zero water-exchange demonstration project.

	Predicted		**Actual**	**Projected**
	1 Cycle	**2 Cycles**	**1Cycle**	**2 Cycles**
Operating Expenses	Percentage (%)		Percentage (%)	
Postlarvae	13.58	18.27	14.87	19.89
Feed (include shipping cost)	23.23	28.67	21.29	25.67
Chemicals/Fertilizer	1.42	1.91	1.55	2.08
Fuel	6.64	8.94	8.51	11.39
Direct Labor	6.34	8.53	6.94	9.29
Indirect Costs	48.79	33.68	46.85	31.69
Total Operating Expenses	100.00	100.00	100.00	100.00

Annual Cost and Returns Budgets for Different Sized Farms

Annual expenses include both cash expenses and non-cash expenses such as depreciation. The operating budget assumes that production levels, survival rate, average harvest size, number of operating cycles, and unit prices remain constant for each cycle and across the different sized farms. For instance, the selling price per pound of 13.50 grams heads-on shrimp (the average harvest size) is US$3.00. Since target annual production yield is at least 1,033,661 pounds of shrimp (head-on), total revenue across the different sized systems is constant at US$3,100,983. Some costs including post-larvae, feed, and taxes remain constant (since production is constant) across the different sized farms. Total annual cost for chemicals and fertilizers, fuel, and concession fees vary accordingly with increases or decreases in total area expressed in hectares using the zero water-exchange system. Equipment and facility maintenance cost is set at 1.5 percent of the corresponding total investment cost given the production level per hectare. Depreciation also varies accordingly with the economic life of assets and ultimately with total investment cost associated with the size of the farm. Total operating expenses decrease as production level per hectare increases and as the total production area expressed in hectares decreases. The lower operational costs result in higher gross profit.

Sensitivity Analysis

Tables 12a - 15b show the variation in costs, net returns, and break-even prices as production levels (pounds/hectare/cycle) and average shrimp price per pound (heads-on) vary. Production levels range from 15,000 to 40,000 pounds per hectare per cycle while four different shrimp prices per pound were considered: US$2.50, US$3.00, US$3.50, and US$4.00. For all the price levels and for every hypothetical farm, annual gross profits, expressed in (1) total US dollars, (2) per pound harvested, and (3) per hectare seeded, are positive. As annual yields increase per hectare and less area using the zero water-exchange technology is needed to produce 1,033,661 pounds of shrimp annually, the hypothetical farms become more efficient. Influenced by economies of size, certain total costs including chemicals/fertilizers, fuel, direct labor, and indirect costs decrease.

Table 12a. Cost and returns budgets for the UCA zero water-exchange system and hypothetical farms at US$2.50 per pound.

	UCA Prototype Farm Predicted	UCA Prototype Farm Actual	Different Production Scenarios - Projected Hypothetical Farms					
Production (lbs/ha/cycle)	18,685	10,004	15,000	20,000	25,000	30,000	35,000	40,000
Expected Production Level (lbs/2ha/yr)	74,740	40,016						
Total Ave. Production _Traditional System (lbs/324ha/yr)			1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Cycles	2	2	2	2	2	2	2	2
Total Production (lbs/ha/yr)	37,370	20,008	30,000	40,000	50,000	60,000	70,000	80,000
Total Area (ha)	2	2	34	26	21	17	15	13
Number of 1/2 ha ponds	4	4	69	52	41	34	30	26
Survival Rate (%)	55	30	55	55	55	55	55	55
Stocking Density (PL/m2)	115	115	92	122	153	183	214	244
Average Harvest Size (g)	13.50	13.29	13.50	13.50	13.50	13.50	13.50	13.50

OPERATING COST AND RETURN BUDGET	UCA Prototype Farm Predicted		UCA Prototype Farm Actual	UCA Prototype Farm Projected	Total	Total	Total	Total	Total	Total
	1 Cycle	2 Cycles	1 Cycle	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles
Pounds Harvested	37,370	74,740	20,008	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Price (US$/lb)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Total Revenue US$	**93,425**	**186,850**	**50,020**	**100,040**	**2,584,153**	**2,584,153**	**2,584,153**	**2,584,153**	**2,584,153**	**2,584,153**
Operating Expenses										
Postlarvae US$	11,995	23,991	11,995	23,991	329,335	329,335	329,335	329,335	329,335	329,335
Feed US$	20,518	37,636	17,176	30,952	675,456	675,456	675,456	675,456	675,456	675,456
Chemicals/Fertilizer US$	1,251	2,503	1,251	2,503	43,120	32,340	25,872	21,560	18,480	16,170
Fuel US$	5,866	11,733	6,866	13,733	236,582	177,436	141,949	118,291	101,392	88,718
Direct Labor US$	5,600	11,200	5,600	11,200	385,900	289,425	231,540	192,950	165,386	144,713
Indirect Costs US$	42,908	43,842	37,891	38,391	597,492	455,374	370,103	313,256	272,651	242,197
Equipment & Facility Maintenance US$	4,568	4,568	3,818	3,818	56,171	42,234	33,872	28,297	24,316	21,329
Depreciation US$	36,856	36,856	33,022	33,022	514,118	386,152	309,373	258,186	221,624	194,203
Concession Fees US$	50	50	50	50	861	646	517	431	369	323
Taxes US$	1,434	2,369	1,000	1,500	26,342	26,342	26,342	26,342	26,342	26,342
Total Operating Expenses US$	**88,139**	**130,905**	**80,780**	**120,770**	**2,267,885**	**1,959,366**	**1,774,255**	**1,650,848**	**1,562,699**	**1,496,588**
Gross Profit US$	**5,286**	**55,945**	**(30,760)**	**(20,730)**	**316,268**	**624,786**	**809,898**	**933,305**	**1,021,453**	**1,087,565**

Table 12b. Costs and net returns per harvested pound and per seeded hectare for the UCA system and hypothetical farms (US$2.50).

	UCA Prototype Farm		Different Production Scenarios - Projected Hypothetical Farms					
	Predicted	Projected						
Total Area (ha)	2	2	34	26	21	17	15	13
Production (lbs/ha/cycle)	18,685	10,004	15,000	20,000	25,000	30,000	35,000	40,000
Expected Annual Production Level	74,740	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
OPERATING COST AND RETURN BUDGET	Annual Per Harvested Pound		Annual Per Harvested Pound					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	**2.50**	**2.50**	**2.50**	**2.50**	**2.50**	**2.50**	**2.50**	**2.50**
Operating Expenses								
Postlarvae US$	0.32	0.60	0.32	0.32	0.32	0.32	0.32	0.32
Feed US$	0.50	0.77	0.65	0.65	0.65	0.65	0.65	0.65
Chemicals/Fertilizer US$	0.03	0.06	0.04	0.03	0.03	0.02	0.02	0.02
Fuel US$	0.16	0.34	0.23	0.17	0.14	0.11	0.10	0.09
Direct Labor US$	0.15	0.28	0.37	0.28	0.22	0.19	0.16	0.14
Indirect Costs US$	0.59	0.96	0.58	0.44	0.36	0.30	0.26	0.23
Total Operating Expenses US$	**1.75**	**3.02**	**2.19**	**1.90**	**1.72**	**1.60**	**1.51**	**1.45**
Gross Profit US$	**0.75**	**(0.52)**	**0.31**	**0.60**	**0.78**	**0.90**	**0.99**	**1.05**
OPERATING COST AND RETURN BUDGET	Annual Per Seeded Ha		Annual Per Seeded Ha					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	**46,713**	**25,010**	**37,500**	**50,000**	**62,500**	**75,000**	**87,500**	**100,000**
Operating Expenses								
Postlarvae US$	5,998	5,998	4,779	6,372	7,965	9,558	11,151	12,744
Feed US$	9,409	7,738	9,802	13,069	16,336	19,604	22,871	26,138
Chemicals/Fertilizer US$	626	626	626	626	626	626	626	626
Fuel US$	2,933	3,433	3,433	3,433	3,433	3,433	3,433	3,433
Direct Labor US$	2,800	2,800	5,600	5,600	5,600	5,600	5,600	5,600
Indirect Costs US$	10,961	9,598	8,671	8,811	8,951	9,092	9,232	9,372
Total Operating Expenses US$	**32,726**	**30,192**	**32,910**	**37,911**	**42,912**	**47,913**	**52,913**	**57,914**
Gross Profit US$	**13,986**	**(5,182)**	**4,590**	**12,089**	**19,588**	**27,087**	**34,587**	**42,086**

Table 13a. Cost and returns budgets for the UCA zero water-exchange system and hypothetical farms at US$3.00 per pound.

	UCA Prototype Farm		Different Production Scenarios - Projected Hypothetical Farms					
	Predicted	Actual						
Production (lbs/ha/cycle)	18,685	10,004	15,000	20,000	25,000	30,000	35,000	40,000
Expected Production Level (lbs/2ha/yr)	74,740	40,016						
Total Ave. Production _Traditional System (lbs/324ha/yr)			1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Cycles	2	2	2	2	2	2	2	2
Total Production (lbs/ha/yr)	37,370	20,008	30,000	40,000	50,000	60,000	70,000	80,000
Total Area (ha)	2	2	34	26	21	17	15	13
Number of 1/2 ha ponds	4	4	69	52	41	34	30	26
Survival Rate (%)	55	30	55	55	55	55	55	55
Stocking Density (PL/m2)	115	115	92	122	153	183	214	244
Average Harvest Size (g)	13.50	13.29	13.50	13.50	13.50	13.50	13.50	13.50

OPERATING COST AND RETURN BUDGET	UCA Prototype Farm									
	Predicted		Actual	Projected	Total	Total	Total	Total	Total	Total
	1 Cycle	2 Cycles	1 Cycle	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles
Pounds Harvested	37,370	74,740	20,008	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Price (US$/lb)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Total Revenue US$	**112,110**	**224,220**	**60,024**	**120,048**	**3,100,983**	**3,100,983**	**3,100,983**	**3,100,983**	**3,100,983**	**3,100,983**
Operating Expenses										
Postlarvae US$	11,995	23,991	11,995	23,991	329,335	329,335	329,335	329,335	329,335	329,335
Feed US$	20,518	37,636	17,176	30,952	675,456	675,456	675,456	675,456	675,456	675,456
Chemicals/Fertilizer US$	1,251	2,503	1,251	2,503	43,120	32,340	25,872	21,560	18,480	16,170
Fuel US$	5,866	11,733	6,866	13,733	236,582	177,436	141,949	118,291	101,392	88,718
Direct Labor US$	5,600	11,200	5,600	11,200	385,900	289,425	231,540	192,950	165,386	144,713
Indirect Costs US$	43,095	44,216	37,991	38,591	602,661	460,542	375,271	318,424	277,819	247,365
Equipment & Facility Maintenance US$	4,568	4,568	3,818	3,818	56,171	42,234	33,872	28,297	24,316	21,329
Depreciation US$	36,856	36,856	33,022	33,022	514,118	386,152	309,373	258,186	221,624	194,203
Concession Fees US$	50	50	50	50	861	646	517	431	369	323
Taxes US$	1,621	2,742	1,100	1,700	31,510	31,510	31,510	31,510	31,510	31,510
Total Operating Expenses US$	**88,326**	**131,279**	**80,880**	**120,970**	**2,273,053**	**1,964,535**	**1,779,423**	**1,656,016**	**1,567,868**	**1,501,756**
Gross Profit US$	**23,784**	**92,941**	**(20,856)**	**(922)**	**827,930**	**1,136,449**	**1,321,560**	**1,444,967**	**1,533,116**	**1,599,227**

Table 13b. Costs and net returns per harvested pound and per seeded hectare for the UCA system and hypothetical farms (US$3.00).

	UCA Prototype Farm		Different Production Scenarios - Projected Hypothetical Farms					
	Predicted	Projected						
Total Area (ha)	2	2	34	26	21	17	15	13
Production (lbs/ha/cycle)	18,685	10,004	15,000	20,000	25,000	30,000	35,000	40,000
Expected Annual Production Level	74,740	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
OPERATING COST AND RETURN BUDGET	**Annual Per Harvested Pound**		**Annual Per Harvested Pound**					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**
Operating Expenses								
Postlarvae US$	0.32	0.60	0.32	0.32	0.32	0.32	0.32	0.32
Feed US$	0.50	0.77	0.65	0.65	0.65	0.65	0.65	0.65
Chemicals/Fertilizer US$	0.03	0.06	0.04	0.03	0.03	0.02	0.02	0.02
Fuel US$	0.16	0.34	0.23	0.17	0.14	0.11	0.10	0.09
Direct Labor US$	0.15	0.28	0.37	0.28	0.22	0.19	0.16	0.14
Indirect Costs US$	0.59	0.96	0.58	0.45	0.36	0.31	0.27	0.24
Total Operating Expenses US$	**1.76**	**3.02**	**2.20**	**1.90**	**1.72**	**1.60**	**1.52**	**1.45**
Gross Profit US$	**1.24**	**(0.02)**	**0.80**	**1.10**	**1.28**	**1.40**	**1.48**	**1.55**
OPERATING COST AND RETURN BUDGET	**Annual Per Seeded Ha**		**Annual Per Seeded Ha**					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	**56,055**	**30,012**	**45,000**	**60,000**	**75,000**	**90,000**	**105,000**	**120,000**
Operating Expenses								
Postlarvae US$	5,998	5,998	4,779	6,372	7,965	9,558	11,151	12,744
Feed US$	9,409	7,738	9,802	13,069	16,336	19,604	22,871	26,138
Chemicals/Fertilizer US$	626	626	626	626	626	626	626	626
Fuel US$	2,933	3,433	3,433	3,433	3,433	3,433	3,433	3,433
Direct Labor US$	2,800	2,800	5,600	5,600	5,600	5,600	5,600	5,600
Indirect Costs US$	11,054	9,648	8,746	8,911	9,076	9,242	9,407	9,572
Total Operating Expenses US$	**32,820**	**30,242**	**32,985**	**38,011**	**43,037**	**48,063**	**53,088**	**58,114**
Gross Profit US$	**23,235**	**(230)**	**12,015**	**21,989**	**31,963**	**41,937**	**51,912**	**61,886**

Table 14a. Cost and returns budgets for the UCA zero water-exchange system and hypothetical farms at US$3.50 per pound.

	UCA Prototype Farm Predicted	UCA Prototype Farm Actual	Different Production Scenarios - Projected Hypothetical Farms					
Production (lbs/ha/cycle)	18,685	10,004	15,000	20,000	25,000	30,000	35,000	40,000
Expected Production Level (lbs/2ha/yr)	74,740	40,016						
Total Ave. Production _Traditional System (lbs/324ha/yr)			1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Cycles	2	2	2	2	2	2	2	2
Total Production (lbs/ha/yr)	37,370	20,008	30,000	40,000	50,000	60,000	70,000	80,000
Total Area (ha)	2	2	34	26	21	17	15	13
Number of 1/2 ha ponds	4	4	69	52	41	34	30	26
Survival Rate (%)	55	30	55	55	55	55	55	55
Stocking Density (PL/m2)	115	115	92	122	153	183	214	244
Average Harvest Size (g)	13.50	13.29	13.50	13.50	13.50	13.50	13.50	13.50

OPERATING COST AND RETURN BUDGET	UCA Prototype Farm Predicted		UCA Prototype Farm Actual	UCA Prototype Farm Projected	Total	Total	Total	Total	Total	Total
	1 Cycle	2 Cycles	1 Cycle	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles
Pounds Harvested	37,370	74,740	20,008	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Price (US$/lb)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Total Revenue US$	130,795	261,590	70,028	140,056	3,617,814	3,617,814	3,617,814	3,617,814	3,617,814	3,617,814
Operating Expenses										
Postlarvae US$	11,995	23,991	11,995	23,991	329,335	329,335	329,335	329,335	329,335	329,335
Feed US$	20,518	37,636	17,176	30,952	675,456	675,456	675,456	675,456	675,456	675,456
Chemicals/Fertilizer US$	1,251	2,503	1,251	2,503	43,120	32,340	25,872	21,560	18,480	16,170
Fuel US$	5,866	11,733	6,866	13,733	236,582	177,436	141,949	118,291	101,392	88,718
Direct Labor US$	5,600	11,200	5,600	11,200	385,900	289,425	231,540	192,950	165,386	144,713
Indirect Costs US$	43,282	44,590	38,091	38,791	607,829	465,711	380,440	323,592	282,987	252,533
Equipment & Facility Maintenance US$	4,568	4,568	3,818	3,818	56,171	42,234	33,872	28,297	24,316	21,329
Depreciation US$	36,856	36,856	33,022	33,022	514,118	386,152	309,373	258,186	221,624	194,203
Concession Fees US$	50	50	50	50	861	646	517	431	369	323
Taxes US$	1,808	3,116	1,200	1,901	36,678	36,678	36,678	36,678	36,678	36,678
Total Operating Expenses US$	88,513	131,652	80,980	121,170	2,278,222	1,969,703	1,784,592	1,661,184	1,573,036	1,506,925
Gross Profit US$	42,282	129,938	(10,952)	18,886	1,339,592	1,648,111	1,833,222	1,956,630	2,044,778	2,110,889

Table 14b. Costs and net returns per harvested pound and per seeded hectare for the UCA system and hypothetical farms (US$3.50).

	UCA Prototype Farm		Different Production Scenarios - Projected Hypothetical Farms					
	Predicted	Projected						
Total Area (ha)	2	2	34	26	21	17	15	13
Production (lbs/ha/cycle)	18,685	10,004*	15,000	20,000	25,000	30,000	35,000	40,000
Expected Annual Production Level	74,740	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
OPERATING COST AND RETURN BUDGET	Annual Per Harvested Pound		Annual Per Harvested Pound					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	**3.50**	**3.50**	**3.50**	**3.50**	**3.50**	**3.50**	**3.50**	**3.50**
Operating Expenses								
Postlarvae US$	0.32	0.60	0.32	0.32	0.32	0.32	0.32	0.32
Feed US$	0.50	0.77	0.65	0.65	0.65	0.65	0.65	0.65
Chemicals/Fertilizer US$	0.03	0.06	0.04	0.03	0.03	0.02	0.02	0.02
Fuel US$	0.16	0.34	0.23	0.17	0.14	0.11	0.10	0.09
Direct Labor US$	0.15	0.28	0.37	0.28	0.22	0.19	0.16	0.14
Indirect Costs US$	0.60	0.97	0.59	0.45	0.37	0.31	0.27	0.24
Total Operating Expenses US$	**1.76**	**3.03**	**2.20**	**1.91**	**1.73**	**1.61**	**1.52**	**1.46**
Gross Profit US$	**1.74**	**0.47**	**1.30**	**1.59**	**1.77**	**1.89**	**1.98**	**2.04**
OPERATING COST AND RETURN BUDGET	Annual Per Seeded Ha		Annual Per Seeded Ha					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	**65,398**	**35,014**	**52,500**	**70,000**	**87,500**	**105,000**	**122,500**	**140,000**
Operating Expenses								
Postlarvae US$	5,998	5,998	4,779	6,372	7,965	9,558	11,151	12,744
Feed US$	9,409	7,738	9,802	13,069	16,336	19,604	22,871	26,138
Chemicals/Fertilizer US$	626	626	626	626	626	626	626	626
Fuel US$	2,933	3,433	3,433	3,433	3,433	3,433	3,433	3,433
Direct Labor US$	2,800	2,800	5,600	5,600	5,600	5,600	5,600	5,600
Indirect Costs US$	11,147	9,698	8,821	9,011	9,201	9,392	9,582	9,772
Total Operating Expenses US$	**32,913**	**30,292**	**33,060**	**38,111**	**43,162**	**48,213**	**53,263**	**58,314**
Gross Profit US$	**32,484**	**4,722**	**19,440**	**31,889**	**44,338**	**56,787**	**69,237**	**81,686**

Table 15a. Cost and returns budgets for the UCA zero water-exchange system and hypothetical farms at US$4.00 per pound.

	UCA Prototype Farm Predicted	UCA Prototype Farm Actual	Different Production Scenarios - Projected Hypothetical Farms					
Production (lbs/ha/cycle)	18,685	10,004	15,000	20,000	25,000	30,000	35,000	40,000
Expected Production Level (lbs/2ha/yr)	74,740	40,016						
Total Ave. Production _Traditional System (lbs/324ha/yr)			1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Cycles	2	2	2	2	2	2	2	2
Total Production (lbs/ha/yr)	37,370	20,008	30,000	40,000	50,000	60,000	70,000	80,000
Total Area (ha)	2	2	34	26	21	17	15	13
Number of 1/2 ha ponds	4	4	69	52	41	34	30	26
Survival Rate (%)	55	30	55	55	55	55	55	55
Stocking Density (PL/m2)	115	115	92	122	153	183	214	244
Average Harvest Size (g)	13.50	13.29	13.50	13.50	13.50	13.50	13.50	13.50

OPERATING COST AND RETURN BUDGET	UCA Prototype Farm Predicted		UCA Prototype Farm Actual	UCA Prototype Farm Projected	Total	Total	Total	Total	Total	Total
	1 Cycle	2 Cycles	1 Cycle	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles	2 Cycles
Pounds Harvested	37,370	74,740	20,008	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
Price (US$/lb)	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Total Revenue US$	**149,480**	**298,960**	**80,032**	**160,064**	**4,134,644**	**4,134,644**	**4,134,644**	**4,134,644**	**4,134,644**	**4,134,644**
Operating Expenses										
Postlarvae US$	11,995	23,991	11,995	23,991	329,335	329,335	329,335	329,335	329,335	329,335
Feed US$	20,518	37,636	17,176	30,952	675,456	675,456	675,456	675,456	675,456	675,456
Chemicals/Fertilizer US$	1,251	2,503	1,251	2,503	43,120	32,340	25,872	21,560	18,480	16,170
Fuel US$	5,866	11,733	6,866	13,733	236,582	177,436	141,949	118,291	101,392	88,718
Direct Labor US$	5,600	11,200	5,600	11,200	385,900	289,425	231,540	192,950	165,386	144,713
Indirect Costs US$	43,469	44,963	38,191	38,991	612,997	470,879	385,608	328,761	288,155	257,702
Equipment & Facility Maintenance US$	4,568	4,568	3,818	3,818	56,171	42,234	33,872	28,297	24,316	21,329
Depreciation US$	36,856	36,856	33,022	33,022	514,118	386,152	309,373	258,186	221,624	194,203
Concession Fees US$	50	50	50	50	861	646	517	431	369	323
Taxes US$	1,995	3,490	1,300	2,101	41,846	41,846	41,846	41,846	41,846	41,846
Total Operating Expenses US$	**88,700**	**132,026**	**81,080**	**121,370**	**2,283,390**	**1,974,871**	**1,789,760**	**1,666,352**	**1,578,204**	**1,512,093**
Gross Profit US$	**60,780**	**166,934**	**(1,048)**	**38,694**	**1,851,254**	**2,159,773**	**2,344,884**	**2,468,292**	**2,556,440**	**2,622,551**

Table 15b. Costs and net returns per harvested pound and per seeded hectare for the UCA system and hypothetical farms (US$4.00).

	UCA Prototype Farm		Different Production Scenarios - Projected Hypothetical Farms					
	Predicted	Projected						
Total Area (ha)	2	2	34	26	21	17	15	13
Production (lbs/ha/cycle)	18,685	10,004	15,000	20,000	25,000	30,000	35,000	40,000
Expected Annual Production Level	74,740	40,016	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661	1,033,661
OPERATING COST AND RETURN BUDGET	Annual Per Harvested Pound		Annual Per Harvested Pound					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Operating Expenses								
Postlarvae US$	0.32	0.60	0.32	0.32	0.32	0.32	0.32	0.32
Feed US$	0.50	0.77	0.65	0.65	0.65	0.65	0.65	0.65
Chemicals/Fertilizer US$	0.03	0.06	0.04	0.03	0.03	0.02	0.02	0.02
Fuel US$	0.16	0.34	0.23	0.17	0.14	0.11	0.10	0.09
Direct Labor US$	0.15	0.28	0.37	0.28	0.22	0.19	0.16	0.14
Indirect Costs US$	0.60	0.97	0.59	0.46	0.37	0.32	0.28	0.25
Total Operating Expenses US$	1.77	3.03	2.21	1.91	1.73	1.61	1.53	1.46
Gross Profit US$	2.23	0.97	1.79	2.09	2.27	2.39	2.47	2.54
OPERATING COST AND RETURN BUDGET	Annual Per Seeded Ha		Annual Per Seeded Ha					
Pounds Harvested								
Price (US$/lb)								
Total Revenue US$	74,740	40,016	60,000	80,000	100,000	120,000	140,000	160,000
Operating Expenses								
Postlarvae US$	5,998	5,998	4,779	6,372	7,965	9,558	11,151	12,744
Feed US$	9,409	7,738	9,802	13,069	16,336	19,604	22,871	26,138
Chemicals/Fertilizer US$	626	626	626	626	626	626	626	626
Fuel US$	2,933	3,433	3,433	3,433	3,433	3,433	3,433	3,433
Direct Labor US$	2,800	2,800	5,600	5,600	5,600	5,600	5,600	5,600
Indirect Costs US$	11,241	9,748	8,896	9,111	9,326	9,542	9,757	9,972
Total Operating Expenses US$	33,007	30,343	33,135	38,211	43,287	48,363	53,438	58,514
Gross Profit US$	41,733	9,673	26,865	41,789	56,713	71,637	86,562	101,486

Comparing Zero Water-Exchange and Semi-intensive Systems

This section contains information on the projected investment cost of a hypothetical 26-hectare farm with a projected production level of 20,000 pounds/hectare/cycle[7] employing a zero water-exchange technology. Total production cost and revenues as well as annual operating costs per harvested pound and per seeded hectare for both the hypothetical zero water-exchange farm and a typical semi-intensive farm are also presented.

Even though each shrimp producer has a unique set of resources and thus experiences investment requirements and operating costs unique to a specific situation, the information provided in this document may be used as a guide for evaluating individual investments, operating costs and production practices.

Table 16. Investment requirements for a zero water-exchange system to produce annually 1,033,661 pounds of shrimp (heads-on) at a production level of 20,000 pounds/hectare/cycle on a 26-hectare farm.

	Total Cost
Feeding Equipment	
Feed Storage	2,500
Feeders	20,673
Sub-Total Feed Equipment	**23,173**
Permanent Equipment	
Aeration Equipment	270,935
Pumps	68,265
Electrical Generators	335,333
Scientific Equipment	2,644
Sub-Total Perm Equipment	**677,177**
Other Costs	
Pond Construction	
Earthwork	600,009
Settling Ponds (1ha)	
Grow-out Ponds (1/2ha)	
Canals/Reservoirs	
Roads	
Drains	
HDP pond liners	505,116
Electrification	422,701
Wire	
Panels	
Water Control Structures	564,341
Piping	
Sluice Gates	
Valves	
House/Office	13,921
Office Equipment	9,183
Sub-Total Other Costs	**2,115,272**
TOTAL DIRECT COSTS (US Dollars)	**2,815,622**
Cost per hectare (US Dollars)	**108,957**
Annual Depreciation	386,152
Depreciation per ha	14,943

[7] Actual production achieved at the UCA demonstration project was 10,004 pounds/hectare/cycle.

One of the objectives of this analysis was to compare traditional and zero water-exchange systems. Thus, a zero water-exchange system using actual production rates from the demonstration project was designed to achieve a production level of 1,033,661 pounds. A 26-hectare-zero water-exchange system would be required[8]. Total investment requirements for feeding equipment, permanent equipment, and other costs associated with the construction of a 26-hectare zero water-exchange farm (52 one-half-hectare ponds) amounts to US$2,815,622 or US$108,957 on a per hectare basis. Total annual depreciation for this system is US$386,152 and per hectare depreciation cost equals US$14,943. As indicated above, total initial investment requirements may vary from producer to producer. For instance, earthwork cost could increase or decrease depending on the existing land characteristics. Utilizing the levees of an existing farm system would decrease the cost of pond construction. In contrast, the per hectare cost of building a pond system utilizing the semi-intensive technology has been estimated to be between US$4,000 and US$10,000.

The assumptions used for estimating production costs and revenues for the hypothetical zero water-exchange farms and the typical semi-intensive farm are shown in Table 17. It was estimated that the 20,000-pounds/hectare/cycle-production level might be achieved if optimum production management practices of the zero water-exchange intensive technology are employed. The total area utilized by each of the two systems was determined dependent on the production objective (1,033,661 pounds annually) and the production variables after implementing the corresponding production strategies. With the zero water-exchange technology, a 26-hectare farm with 52 one-half-hectare ponds is needed to produce the desired annual production with a survival rate of 55 percent and average harvest size of 13.50 grams (heads-on). In contrast, a 324-hectare farm using the semi-intensive technology will be required to produce the 1,033,661 pounds annually. For the semi-intensive farm, survival rate is 31.68 percent and average harvest size is approximately 13 grams (heads-on). Stocking density varies as well between the two systems: 122 PL/m² for the zero exchange system and 18 PL/m² for the semi-intensive system. The selling price used in this comparison is US$3.00 per pound of shrimp.

Table 17. Production assumptions for the 26-hectare zero water-exchange farm and the 324-hectare semi-intensive farm.

	Zero Exchange System	Semi-Intensive System
Production (lbs/ha/cycle)	20,000	1,536
Cycles	2.00	2.04
Total Production (lbs/ha/yr)	40,000	3,133
Total Area (ha)	26	324
Number of 1/2 ha ponds	52	-
Survival Rate (%)	55.00	31.68
Stocking Density (PL/m2)	122	18
Average Harvest Size (g)	13.50	12.98
Shrimp Price US$/lb (heads-on)	3.00	3.00

[8] This is actual pond production area and des not include the land needed for settling ponds. Costs for settling ponds are included in estimates.

Comparing the Cost and Earnings of the Zero Water-Exchange System and the Semi-intensive System

The costs vary between the two systems mainly due to the total area needed to produce the desired production. The costs for each system are compared on a total, per harvested pound of shrimp, and per seeded hectare basis (Tables18-21). The cost of post-larvae per pound harvested for the zero water-exchange system is lower than for the semi-intensive technology. However, PL cost per hectare is greater for the zero water-exchange system since stocking density (PL/m^2) is much higher. Feed cost, on the other hand, is greater in both per pound harvested and per seeded hectare for the zero water-exchange system. The estimated value was calculated using the feed conversion ratio of 2.44; however, this ratio should decrease significantly if more efficient production strategies, such as a better assessment of the actual survival rate, are used. The cost of chemicals and fertilizers per pound harvested is lower, while on a per seeded hectare basis this cost is much greater for the zero water-exchange system. When considering this cost in total U.S. dollars, the zero water-exchange system costs less money to operate than the semi-intensive system. Direct labor for the hypothetical farm using the zero water-exchange technology is always greater (on per seeded hectare, per harvested pound, and in total U.S. dollars) than for the semi-intensive system. With respect to indirect costs, it was not accurate to make a comparison between the two systems since the variables included in this cost category vary for each system. (i.e. the semi-intensive system indirect cost data available for this analysis do not allow a comparison with the UCA demonstration project indirect costs). Nevertheless, total operating costs clearly indicate that the zero water-exchange system can be more cost efficient than the semi-intensive system.

Table 18. Annual financial comparison for the 26-hectare zero water-exchange farm and the 324-hectare semi-intensive farm.

Financial Item	Zero Exchange System Total	Semi-Intensive System Total
Annual Production per ha.	40,000	3,133
Total Area (ha)	26	324
Pounds Harvested	1,033,661	1,033,661
Shell-On Price (US$/lb)	3.00	3.00
Total Revenue US$	3,100,983	3,100,983
Total Operating Expenses US$	1,964,535	2,069,834
Gross Profit US$	1,136,449	1,031,150

Table 19. Detailed annual operating expenses for the zero water-exchange and semi-intensive systems (on a per harvested pound basis).

Operating Expenses	Per harvested Lb.	
	Zero Exchange System	Semi-Intensive System
Postlarvae US$	0.32	0.47
Feed US$	0.65	0.46
Chemicals/Fertilizer US$	0.03	0.06
Direct Labor US$	0.28	0.06
Indirect Costs US$ including Fuel	0.62	0.95
Total	1.90	2.00

Table 20. Detailed annual operating expenses for the zero water-exchange and semi-intensive systems (on a per seeded hectare basis).

Operating Expenses	Per Seeded Ha.	
	Zero Exchange System	Semi-Intensive System
Postlarvae US$	6,372	720
Feed US$	13,069	713
Chemicals/Fertilizer US$	626	91
Direct Labor US$	5,600	96
Indirect Costs US$ including Fuel	12,344	1,456
Total	38,011	3,076

Total revenue, total operating costs and gross profit summarized on per harvested pound and per seeded hectare for the two systems are also shown (Table 21). Even though the zero water-exchange system provides a small profit (10 cents) difference on per harvested pound when compared to the semi-intensive system, gross profit generated by the zero water-exchange technology on per hectare basis is significantly higher. Annual profit per seeded hectare for the zero water-exchange system was US$21,989, whereas the same value for the traditional system was US$1,552.

Table 21. Annual financial comparison for the 26-hectare zero water-exchange farm and the 324-hectare semi-intensive farm (per harvested pound and per seeded hectare).

Cost and Revenues	Zero Exchange System		Semi-Intensive System	
	Per Harvested Lb.	Per Seeded Ha.	Per Harvested Lb.	Per Seeded Ha.
Annual Production per ha.	40,000		3,133	
Total Area (ha)	26		324	
Pounds Harvested	1,033,661		1,033,661	
Shell-On Price (US$/lb)	3.00		3.00	
Total Revenue US$	3.00	60,000	3.00	4,608
Total Operating Expenses US$	1.90	38,011	2.00	3,076
Gross Profit US$	1.10	21,989	1.00	1,532

Advantages and Disadvantages of the Zero Water-Exchange System

Disadvantages

The zero water-exchange system requires a very large initial investment, which may discourage many potential investors from considering the system as a profitable alternative to traditional semi-intensive shrimp farming. This may be particularly true for those semi-intensive farmers who might wish to retrofit a portion of their existing farms.

Given the relatively large initial investment, the financial risk associated with a crop failure is much higher with the zero water-exchange system.

Advantages

The zero water-exchange technology can result in sustained higher yields. The yields are higher due to (1) the high survival rates because of the biosecurity practices implemented and (2) the high stocking density.

The zero water-exchange system also reduces the amount of nutrients released into the environment since no water is exchanged.

The above technical advantages can lead to lower operating costs in total U.S. dollars and per pound harvested. The feed conversion ratio should be better for the zero water-exchange system due to high levels of aeration, which creates a current that suspends solids for shrimp grazing. Thus, feed costs should be reduced.

Another advantage of the new system is the use of less land to produce the same desired production objective. This should result in lower annual concession fees.

Due to lower operating costs, the zero water-exchange system generates slightly higher profits per pound harvested, but much higher profits on per hectare basis when compared to the semi-intensive technology.

Finally, the zero water-exchange system reduces the amount of time required to prepare pond water for stocking. By using both the recycled water and the ponds lined with plastic, restocking can take place as soon as five days after a pond is harvested. A more efficient use of the available growing season is allowed.