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Profitability of Indoor Production of Pacific White Shrimp (*Litopenaeus vannamei*): A Case Study of the Indiana Industry

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Structural changes in Midwest agriculture over the past two decades have resulted in a number of empty and unused farm buildings. Farmers therefore have been exploring alternative uses of livestock farm buildings for the production of other cash crops, including aquaculture products. In Indiana, Pacific White shrimp (*Litopenaeus vannamei*) production has attracted interest, and a number of small producers are investing in shrimp production in their farm buildings and other farm facilities. The producers are motivated by the fact that they could produce and market fresh (never frozen) high-quality shrimp products in these systems to compete with imported frozen shrimp.

The industry-wide standard for selling fresh or frozen shrimp in the shell without the head on is by quantitative unit, i.e., count per pound. There are several standardized sizes, which range from "U/10" (under 10 count), representing shrimp that are large enough that fewer than 10 weigh about a pound, to "61/70" shrimp (61-70 count), which are relatively very small in size. Data and information gathered from the Indiana shrimp industry suggests that producers are producing and selling shrimp counts in the range of "21/25," "26/30," "31/35," and "36/40." Some producers have indicated that, on certain occasions, the increased demand does not allow them to grow the shrimp to bigger sizes and that they are forced to sell at smaller sizes. This publication compares the profitability of producing different shrimp sizes, i.e., "21/25," "26/30," and "31/35" in an indoor farm facility.

Indoor Shrimp Production

Production Process

The shrimp-production process generally involves a hatchery, nursery, and grow-out phases. There are no hatcheries in Indiana at the moment, and post larvae (PL) are imported from out of state, particularly from Florida and Texas. A few Indiana producers have a nursery phase to grow shrimp from about 0.35g to greater than 1.0g before stocking in grow-out tanks/pools. The nursery phase helps to evaluate shrimp quality through grading to ensure that quality PL are stocked for grow-out. Some producers have experienced significant PL mortality or low survival when PL are stocked in small sizes, particularly directly from the hatchery without the nursery phase. Indiana farmers are operating mostly at the grow-out phase with PL that are at least 1.3g.

The grow-out phase is intensive and produces marketable shrimp of various size counts. Tanks or pools are stocked at high densities and fed commercially formulated feed that supplies all the nutrition needed by the shrimp. The intensive operations require good water quality in the production process to maintain optimum

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growth conditions for the shrimp. The shrimp grow-out systems in Indiana are mainly biofloc systems that remove metabolic wastes during the production process. The biofloc are cultured colonies of bacteria in the grow-out tanks that convert ammonia into nitrate. The bacteria can also become supplemental feed for the shrimp.

Economics of Production

In spite of the increased interest in Pacific White shrimp production in Indiana, there are no studies of the economics of shrimp production in indoor systems. This study therefore examines the industry in Indiana by developing estimates of production costs using actual field data. The study should help to inform investment decisions on Pacific White shrimp aquaculture in the Midwest region. It also provides information on investment requirements, inputs, and costs necessary to undertake shrimp production in pools, which are common equipment used in Indiana. The estimated profit margins provided allows a prospective producer/investor to compare the profit margins with alternative enterprises.

A detailed spreadsheet for Pacific White shrimp enterprise budgeting process as well as for other fish species is available at Purdue University's Department of Agricultural Economics Web page https://ag.purdue.edu/agecon/Pages/Aquaculture-Budget.aspx. The spreadsheet can be used for various sensitivity analysis to assess budget variables that have significant impact on profitability. It can also be used to assess the changes needed for specific budget variables to enhance profitability. However, it should be noted that some variables such as prices may be beyond the control of a prospective farmer/investor, while other variables such as survival or mortality and feed conversion are dependent on management skills. Thus, the spreadsheet can be used as a tool to determine management issues as well as determine production targets, capital requirements, cost structure, and profit potential.

The production and marketing assumptions made for this study are as follows.

1. A prospective producer will renovate an existing farm building with a concrete floor or may decide to construct a new pole barn with concrete floor. The building should be large enough to accommodate the number of tanks/pools and targeted production levels. Making room for potential expansion is recommended.
2. The system comprises an 8-pool system, each with a capacity of 4,200 gallons. These systems are sold as a complete package with pumps, aeration system, biofloc settling system, etc.
3. A significant amount of support equipment and materials are needed, which includes water heater, water storage, emergency generator, purge tank, agitators, blowers, monitoring equipment, water quality test kits, and miscellaneous equipment (nets, scale, buckets, etc).

Production parameters used in the study reported here are presented in Table 1. A 4,200 gallon capacity pool is equivalent to 15.9m3, and the literature suggests stocking rates from 300-500/m3. The focus of the study is the grow-out phase; therefore a stocking size of 1.3g is stocked at 450/m3, i.e., 7,200 PL per tank/pool. The production period varies by marketable size as "21/25" count requires a relatively longer period to market size compared to the other counts (Table 1). It is therefore assumed that "21/25" and "26/30" count shrimp will have a slightly higher feed conversion than the production process for "31/35" count shrimp.

The production schedule assumes that shrimp will be harvested every other week, resulting in an average of 28 pools harvested every year for "21/25" count, 32 pools for "26/30" count, and 34 pools for "31/35" count. The "21/25" count shrimp are harvested at 20g after 14 weeks of grow-out, "26/30" count shrimp is harvest at 16g after 12 weeks, and "31/35" shrimp is harvested at 14g after 11 weeks.

Some economic models on indoor recirculating biofloc shrimp production system have suggested stocking PL of at least 3g. The last column in Table 1 provides the parameters used to examine a budget for a "21/25" count shrimp that is stocked at 3g and reared for 12 weeks to obtain a harvest weight of 22g. The price of a 3g PL is taken to be twice that of 1.3g PL.

Profitability Analysis

The study develops enterprise budgets for the various shrimp counts; however, only an enterprise budget for a "21/25" count shrimp stocked at 1.3g (Table 1, column 2) is reported in Table 2. The enterprise budget provides a summary and detailed estimates of all costs and resources associated with raising Pacific White shrimp in an 8-pool system over a year. The rest of the study focuses on profit margins and compares profitability using a range of survival and market prices for all the profiles presented in Table 1.

Table 1: Growth Parameters for Shrimp Grown in Indoor Biofloc Systems

Parameters	"21/25" count	"26/30" count	"31/35" count	"21/25" count
Rearing period (weeks)	14	12	11	12
Frequency of harvest (pools/yr)	28	32	34	32
Stocking rate (PL//m^3	450	450	450	450
Stocking size (g)	1.3	1.3	1.3	3.0
Feed conversion	1.4	1.4	1.3	1.4
Final weight (g)	20	16	14	22

Table 2: Revenue, Operating and Total Costs for "21/25" Count Shrimp in an 8-Pool System

	Unit	Cost / Unit ($)	Quantity	Cost ($)	% of Total cost
Sales Receipts	lb	16.00	6,222	99,557.31	
VARIABLE INPUTS:					
PL	Number	0.10	201,600	20,160.00	24%
Feed Price	lb.	1.20	7,904	9,484.87	11%
Electricity	kw-hr.	0.06	9,333	560.01	1%
Hired Labor	Hour	10.00	1095	10,950.00	13%
Heating	year	8.00	560.64	4,485.12	5%
Chemicals	$	100.00	8	800.00	1%
Insurance	%	148.51	12	1,782.10	2%
Loan + Interest	%			7,794.97	9%
Total Variable Costs (TVC)	$			**56,017.07**	**65.42%**
Cost/lb				**9.00**	
FIXED INPUTS:					
Building	$	4,500.00	0.03	150.00	0%
Complete Tank System	$	46,800.00	0.10	4,680.00	5%
Water Heater	$	4,230.00	0.10	423.00	0%
Water Storage	$	2,340.00	0.10	234.00	0%
Emergency Generator	$	4,050.00	0.07	270.00	0%
Purge Tank	$	405.00	0.10	40.50	0%
Agitators	$	4,320.00	0.20	864.00	1%
Blower	$	3,060.00	0.20	612.00	1%
Monitoring Equipment	$	675.00	0.20	135.00	0%
Water Quality Equipment	$	4,636.80	0.20	927.36	1%
Fish Handling Equipment	$	900.00	0.50	450.00	1%
Feed Storage	$	450.00	0.20	90.00	0%
System Set-up labor	$	5,120.00	1.00	5,120.00	6%
Miscellaneous equipment	$	4,500.00	0.20	900.00	1%
Maintenance	$	297.02	12.00	3,564.21	4%
Management	$	928.80	12	11,145.60	13%
Total Fixed Costs				**29,605.67**	**34.58%**
Total Costs (TC)	$			**85,622.74**	**100.00%**
Break-even price (BEP)	$/lb			**13.76**	
Profit Above TVC	$/lb			**4.76**	**35%**
Profit Above TC	$/lb			**2.24**	**16%**

Sales Revenue

Most of Indiana's shrimp farmers market shrimp direct to consumers from the farm; therefore, marketing cost is minimal. In Table 2, the yearly average of harvesting 28 pools of shrimp requires stocking 28 pools at 7,200 PL/pool with 1.3g PLs. Assuming a 70% survival (or 30% mortality) and harvest weight of 20g yields 141,120 shrimp or 6,222lb of shrimp at harvest. At a selling price of $16.00/lb, the revenue generated from sales is $99,557 for a "21/25" shrimp count.

Variable Costs

These are operational costs incurred within the production period, and they vary with the level of production. The major variable costs include the cost of PL, feed cost, hired labor, and loan payments with interest (Table 2). The cost of the PLs includes transportation, and, at $0.10 each, it accounts for 24% of total cost. (Note that the budget for the profile presented in the last column of Table 1 assumed that a 3g PL cost $0.20). The amount of feed used is based on the difference between ending biomass and beginning biomass multiplied by the feed conversion ratio. About 7,904lb of feed is required, and, at $1.20/lb, it accounts for 11% of total cost. With labor, about 3 hours a day are required for various activities on the farm, including water quality testing, feeding, etc. At a rate of $10.00/hr and 365 days in a year, $10,950 labor cost will be incurred, which accounts for 13% of total cost. The analysis assumes that a commercial loan is secured for the capital costs with a 20% down payment and interest rate of 8%. The loan with interest amounts to about $7,795, which is 9% of total cost.

Electricity is required to operate pumps and agitators, and it is estimated that 9,333kwh will be required. The price from Duke Energy, Indiana is about $0.06/kwh for a total cost of $560 per year. This cost is different from the heating cost, which is estimated by million BTU/tank. The price from Duke Energy, Indiana for million BTU from electricity is $8.00. The costs for BTU from natural gas and propane gas are higher. It is estimated that each pool/tank uses about 8,000 BTU per hour, and, for the year, the total cost is about $4,485. Insurance is estimated to be 1% of annual capital cost.

Fixed Costs

These costs are mainly the capital investment costs. This budget does not include the purchase of land. It is assumed that the farmer already has land for either the construction of a new pole barn with concrete floor or that there is an existing farm building with concrete floor that will be renovated. The building and all the equipment listed in Table 2 are assumed to have a salvage value of 10% of initial cost. A straight line depreciation is used to determine the annual cost. For the study, an existing building is renovated at a cost of $5,000 and will have a useful life of 30 years, which amounts to an annual cost of $150. (Note that construction of an entirely new building will cost more.) The 8-pool system cost $6,500 per tank for a total of $52,000 for the complete set. The tank system is assumed to have a 10 year useful life and an estimated annual cost of $4,680. These systems are sold as a complete package with pumps, aeration system, biofloc setting system, etc. It is estimated that 32 hours are required to set up a pool with all the plumbing work, which suggests 256 hours are required to set-up an 8-pool system. This amounts to $5,120. This is a one-time initial cost.

There is other equipment needed, including water heater, water storage, emergency generator, purge tank, agitators, blowers, monitoring equipment, water quality test kits, and miscellaneous equipment (nets, scale, buckets, etc). The cost of a water heater is about $4,700, and, with an operational life of 10 years, the annual cost is $423. The water storage tank costs $2,600, with a useful life of 10 years as well. The annual cost is $234. The emergency generator is estimated to have an operational life of 15 years and to cost $4,500, meaning an annual cost of $270. The water quality equipment cost $6,624 and has an annual cost of $927. The water quality equipment set comprises of all required meters, reagents, mini-lab instruments, etc. This cost can be significantly lower if a farmer knows exactly what is needed and can purchase items individually. Other expenses are estimated for storage and other miscellaneous equipment. A 2% charge on the annual capital investment is allocated to maintenance, and a 2% charge on total operating costs is allocated for management services.

Profitability

Table 2 indicates a breakeven price of about $13.76/lb. The break-even price is the price point where the sale price covers total cost (both fixed and variable). In Table 2, it is calculated as the total cost $85,623 divided by the pounds of shrimp obtained, 6,222lb. It implies that the minimum a farmer can sell shrimp to recover all costs is $13.76 with no profit. Profit is obtained when the selling price is higher than $13.76. At a selling price of $16.00/lb, the profit margin after covering all cost is $2.24 or 16% (Table 2). Aquaculture in general is considered a high-risk industry, so obtaining at least a 15% profit margin is considered a good margin.

To assess the variables that significantly affect profitability, the enterprise budgets were subjected to a sensitivity analysis for various shrimp size counts. The results suggest that survival rate (or mortality) and selling price were the most significant variables. Therefore, the profit margin was analyzed using a range of selling prices and survival rates. Figures 1 and 2 show the estimated percentage profit with survival rates of 50% – 80% and selling price from $14.00 – $18.00 for "21/25" count and "26/30" count shrimp, respectively. Figure 3 shows the estimated percentage profit with survival rates of 60 – 80% and selling price from $12.00 – $15.00 for "31/35" count. Figure 4 presents estimated percentage profit for a "21/25" count where 3g PL were stocked at the beginning of production. The selected ranges reflect what pertains in the Indiana shrimp industry.

In Figure 1, farmers producing a "21/25" count shrimp will obtain at least 14% profit margin in the $14 - $18/lb price range with a high survival of 80% (or 20% mortality). The percentage profit increases with the sales price and can be as much as 46% profit at $18.00/lb. If the survival realized is 70% (or 30% mortality), farmers can only obtain a profit margin of 16% if they sell the shrimp at a minimum of $16.00/lb. With 60% survival (or 40% mortality), shrimp has to be sold at $18.00/lb to obtain a 15% profit margin. A farmer will incur losses with a 50% survival (or 50% mortality) irrespective of the selling price within the selected range.

In Figure 2, farmers producing a "26/30" count shrimp will obtain at least 16% profit with 80% survival (or 20% mortality) when the shrimp is sold at a minimum of $16.00/lb. With 70% survival (or 30% mortality), and a selling price of $18.00/lb, a 17% profit margin will be obtained, but a 10% profit margin will be obtained if the selling price is $17.00/lb. In this scenario also, a farmer will incur losses with a 50% survival (or 50% mortality) irrespective of the selling price within the selected range.

Figure 3 generally does not show any profitability except for a marginal 8% profit with 80% survival (or 20% mortality) and a selling price of $16.00/lb and a 2% profit at $15.00/lb.

The profitability outcomes observed in Figure 4 are similar to what is observed in Figure 2. The results suggest that with a minimum target of 15% profit margin, a farmer can achieve that target with a survival of 80% (or 20% mortality) and at least $16 selling price, and with a 70% survival (30% mortality) and a selling price of $18.00/lb.

Figure 1: Percentage Profit with Different Survival and Selling prices for "21/25" Count

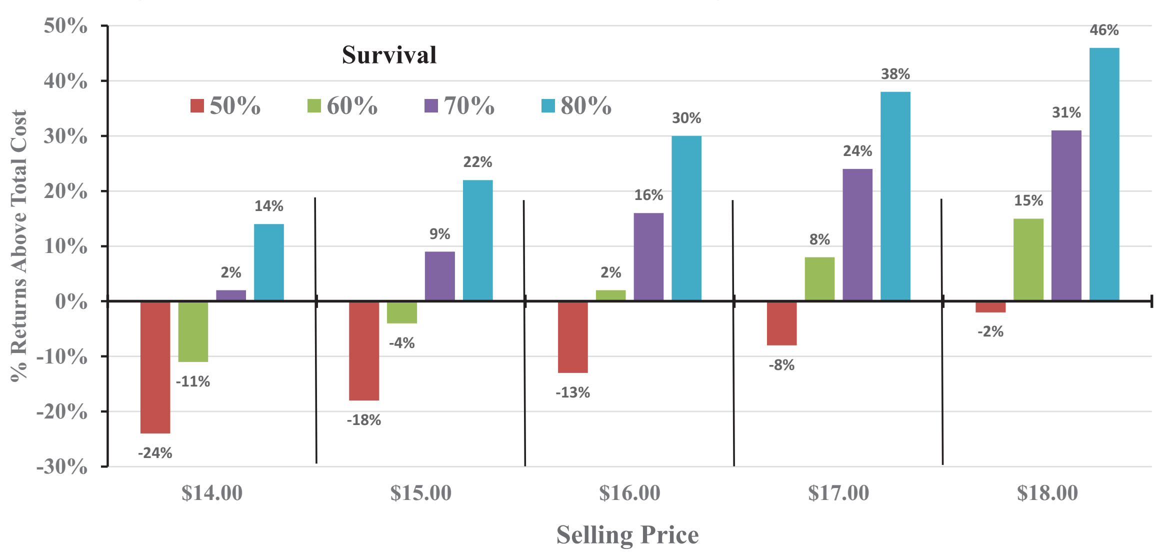


Figure 2: Percentage Profit with Different Survival and Selling prices for "26/30" Count

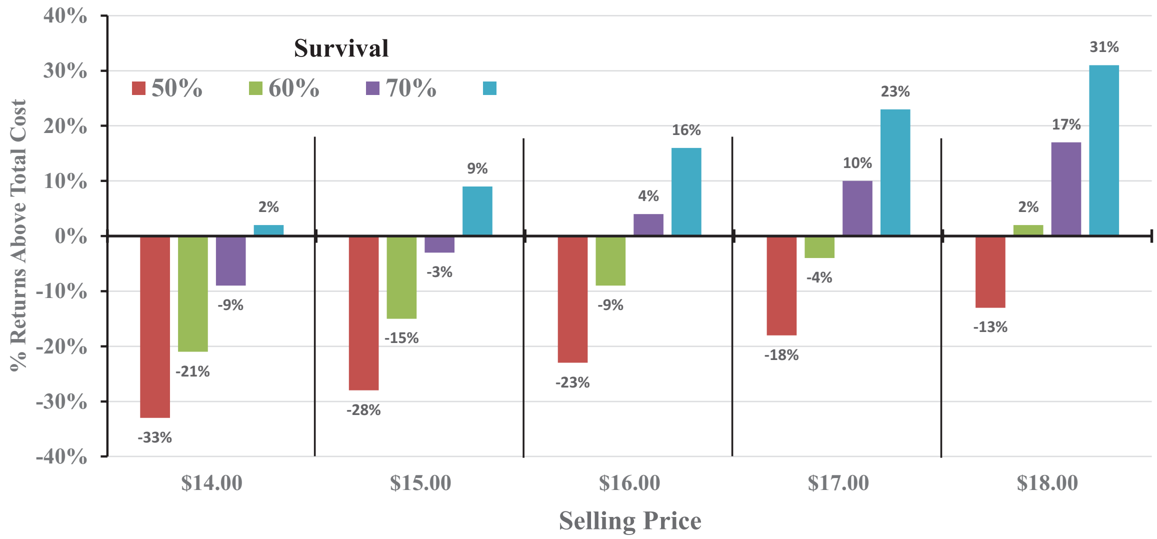


Figure 3: Percentage Profit with Different Survival and Selling Prices for "31/35" Count

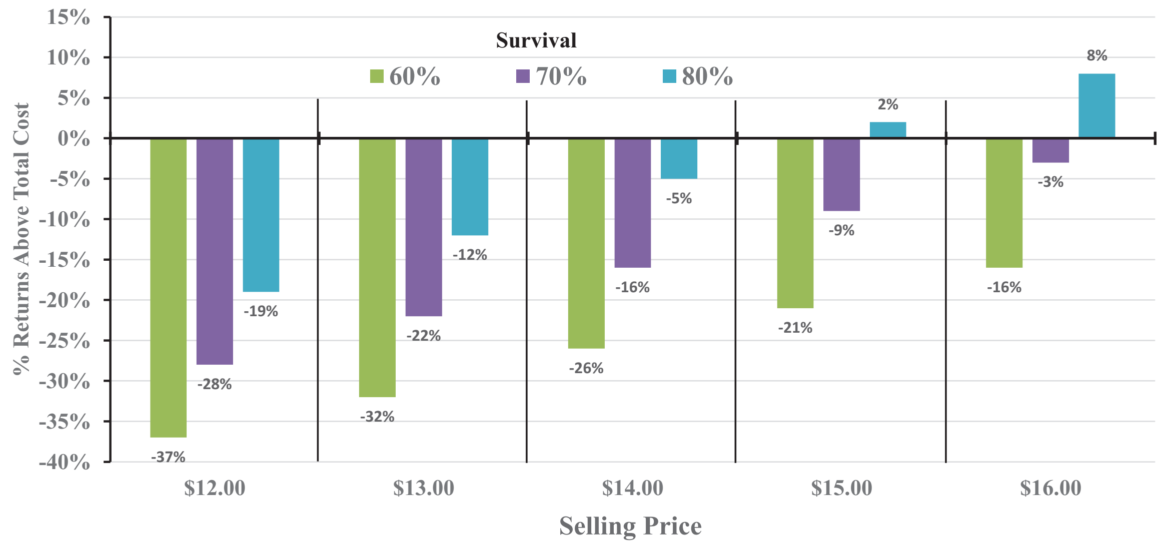
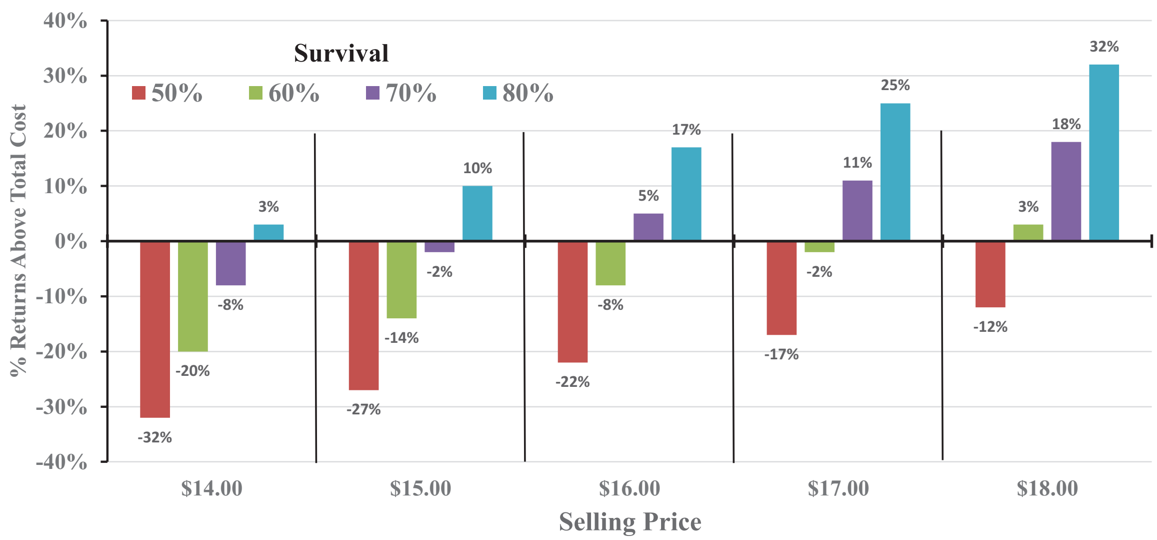


Figure 4: Percentage Profit with Different Survival and Selling Price for "21/25" Count (3g PL Stocked)



Conclusions

Indoor production of Pacific White shrimp is profitable if they are grown to bigger sizes of at least "26/30" count. In spite of pressures on farmers to sell smaller size count due to demand, farmers will be better off allowing the shrimp to grow into bigger sizes before selling. This is because given the range of current industry selling prices, the additional value of weight gain for large shrimp is more than the additional cost incurred in producing it. The returns on growing shrimp to larger sizes far outweigh the cost of producing them.

If farmers want to sell shrimp due to high demand, they can consider stocking larger PL of about 3g – 4g to obtain larger shrimp within a shorter rearing period. A 3g – 4g PL will cost about twice that of 1.3g but the returns will be more than the additional cost.

Though small size shrimp takes relatively less time to reach market size and thus have a high turnover, the relative value of a unit weight at harvest is generally less than the cost of production. Note that the major operational costs as shown in Table 2 are the cost of PL, feed, hired labor and loan repayment. The high turnover involves more production and requires more resources, and therefore higher cost.

High survival (low mortality) during the shrimp production process is very crucial to the profitability of the shrimp business. Good and efficient farm management practices are needed to minimize mortality.

Due to the relatively high cost of indoor production of Pacific White shrimp, marketing strategies are essential to obtain premiums to assure profitability.

Suggested Additional Materials

Aquaculture Economics and Marketing Resources, Purdue University. https://ag.purdue.edu/agecon/Pages/Aquaculture-Budget.aspx

Hanson, T. (2014). Economic Overview of Biofloc-Dominated, Super-Intensive *Litopenaeus vannamei* Grow-out Raceway. Paper present at Aquaculture America 2014, Seattle, WA. February 10, 2014.

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