Chapter 13 – Economics of Super-intensive Biofloc-Dominated Systems for the Production of the Pacific White Shrimp, *Litopenaeus vannamei*

Terry Hanson, Tzachi Samocha, David Prangnell, Granvil Treece,
Timothy Morris, Leandro Castro, & Nick Staresinic

Aquaculture 2016 – February 22-26, 2016
Las Vegas, Nevada

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TEXAS A&M AGRILIFE RESEARCH

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The Manual – Chapter 13

- Covers several important issues relating to the economic viability of the super-intensive BFD including:
  1. Enterprise budgeting to evaluate the economic viability of super-intensive BFD systems
  2. A bio-economic model for developing a business plan and conducting scenario analyses
  3. Capital investment examples
  4. Factors affecting cost-of-production and their impact on financial viability
  5. Economic analyses of the Texas A&M AgriLife Research 2013 & 2014 trials
  6. Marketing principles & sensitivity analyses

1) Enterprise Budgeting

- Enterprise budgeting to evaluate the economic viability of super-intensive BFD systems
  - Contains Explanation & Examples of:
    - Enterprise budgets
    - Cash flows
    - Calculated financial indicators of profitability

1) Enterprise Budgeting

- Budget developed from research trial data
  - Biology and input quantity/costs

- Provides Examples of Scaled Up Commercial Investments for:
  - Capital items
  - Machinery & equipment

2) Bio-Economic Model

- Provides detail on a Bio-Economic Model
  - Can be used for developing a business plan and/or conducting sensitivity analyses
- Provides an overview of spreadsheets
  - Required data entry
  - Outputs from model

2) Bio-Economic Model

- Provides Spreadsheet Examples of Inputs:
  - Biological
  - Physical
  - Cost-price
  - Capital investment
  - Replacement schedule

2) Bio-Economic Model

- Provides Spreadsheet Examples of Outputs:
  - Loan details
  - Cash flows
  - Enterprise budgets
  - Financial & economic indicators of profitability
    - NPV, IRR, Payback Period

Investment Schedule Examples

Investment item information required for the Bio-Economic Model.

Item	Total cost Per GH ($)	Econ life (yr)	Average investment ($)	Annual depreciation ($)	Annual interest ($)	Annual Repairs & Maintenance (%)	Annual Repairs & Maintenance ($)
A. Capital costs							
Land for greenhouses	$0		$0		$0		
Land for waste treatment, plant and office	$0						
Greenhouse components							
- Structure	$55,429	15	$27,715	$3,695	$2,217	1.67%	$924
- Covering	$18,307	5	$9,153	$3,661	$732	5.00%	$915
- Interior automated aluminized shade system							
- Heat system	$3,743	7	$1,871	$535	$150	3.57%	$134
- Cooling systems	$20,300	7	$10,150	$2,900	$812	3.57%	$725
- Controls	$2,436	7	$1,218	$348	$97	3.57%	$87
- Concrete for installation	$14,747	20	$7,374	$737	$590	1.25%	$184
- Pre-paid freight	$9,153	20	$4,577	$458	$366	1.25%	$114
- Installation cost	$93,548	20	$46,774	$4,677	$3,742	1.25%	$1,169
Greenhouse Electrical System							
- Materials	$5,476	5	$2,738	$1,095	$219	5.00%	$274
- Labor	$14,309	20	$7,154		$572	1.25%	$179
Raceway Construction							
- Materials	$139,790	5	$69,895	$27,958	$5,592	5.00%	$6,989
- Labor	$40,545	20	$20,273	$2,027	$1,622	1.25%	$507
- Equipment	$4,165	5	$2,083	$833	$167	5.00%	$208
Catwalk system	$0	5	$0			5.00%	$0
Mechanical & Lab Building							
- Materials	$72,715	5	$36,357	$14,543	$2,909	5.00%	$3,636
- Labor	$32,045	20	$16,023	$1,602	$1,282	1.25%	$401
- Equipment	$6,981	5	$3,491	$1,396	$279	5.00%	$349
Raceway Heating System							

Etc.

Replacement Cost Examples

Calculation of initial investment and annual replacement costs.

Item / Year	0	1	2	3	4	5	6	7	8	9	10	SV
A. Capital costs												
Land for greenhouses	0											0
Land for waste treatment, plant and office	0											0
Greenhouse components												
- Structure	55,429	0	0	0	0	0	0	0	0	0	0	5,543
- Covering	18,307	0	0	0	0	0	18,307	0	0	0	0	1,831
- Interior automated aluminized shade system	50,297	0	0	0	0	0	0	0	0	0	50,297	5,030
- Thermal blanket	0	0	0	0	0	0	0	0	0	0	0	0
- Heat system	3,743	0	0	0	0	0	0	0	3,743	0	0	374
- Ventilation	0	0	0	0	0	0	0	0	0	0	0	0
- Cooling systems	20,300	0	0	0	0	0	0	0	20,300	0	0	2,030
- Controls	2,436	0	0	0	0	0	0	0	2,436	0	0	244
- Concrete for installation	14,747	0	0	0	0	0	0	0	0	0	0	1,475
- Pre-paid freight	9,153	0	0	0	0	0	0	0	0	0	0	915
- Installation cost	93,548	0	0	0	0	0	0	0	0	0	0	9,355
Greenhouse Electrical System												
- Materials	5,476	0	0	0	0	0	5,476	0	0	0	0	548
- Labor	14,309	0	0	0	0	0	0	0	0	0	0	1,431
Raceway Construction												
- Materials	139,790	0	0	0	0	0	139,790	0	0	0	0	13,979
- Labor	40,545	0	0	0	0	0	0	0	0	0	0	4,055
- Equipment	4,165	0	0	0	0	0	4,165	0	0	0	0	417
Catwalk system	0	0	0	0	0	0	0	0	0	0	0	0
Mechanical & Lab Building												
- Materials	72,715	0	0	0	0	0	72,715	0	0	0	0	7,271
- Labor	32,045	0	0	0	0	0	0	0	0	0	0	3,205
- Equipment	6,981	0	0	0	0	0	6,981	0	0	0	0	698
Raceway Heating System												
- Labor	12,205	0	0	0	0	0	0	0	0	0	0	1,220

Etc.

Enterprise Budgets Examples

Enterprise budget (receipts, variable costs, fixed costs, net returns to land) and breakeven prices for a super-intensive shrimp production system consisting of 10 greenhouses (with 8 growout RW/GH and 2 nursery RW/GH) based on average of 10-yr Cash Flow.

	Unit	Quantity	Price or Cost / unit	Value or Cost	Percent of Costs	Value/Cost per lb
1. Gross Receipts						
Farm-gate Shrimp value, whole, heads-on	lb	338,044	3.27	$1,104,215		$3.27
(kg/m3)		8.213				
2. Variable Costs						
Feed						
Grow-out	ton	222	$1,748	$388,717	46.6%	$1.15
Nursery	ton	23	$1,098	$25,465	3.1%	$0.08
Labor, nursery and growout						
Farm management	annual	1	$140,875	$140,875	16.9%	$0.42
Hired labor, hourly	hour	1	$62,818	$62,818	7.5%	$0.19
Hatchery supplies	crop	9	$962	$8,179	1.0%	$0.02
Post larvae, PL12	$/1,000	3,444	$8.00	$27,650	3.3%	$0.08
Utilities						
Fuel, gasoline	$/gallon	1,096	$3.30	$3,617	0.4%	$0.01
Fuel, diesel	$/gallon	1,460	$3.95	$5,767	0.7%	$0.02
Electricity	$/kwh	1,359	$0.08	$39,677	4.8%	$0.12

Etc.

10-year Detailed Cash Flow Example

Table 13.2.2.3. Example of a one year cash flow generated as na output from Cash Flow, Year 1, for a recirculating bio-secure shrimp production facility.

	Price, $/unit	Unit	Quantity	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Total
Shrimp sales price, head-on	$ 3.27	lb (18g / 21-25 / lb)		3.29	3.33	3.38	3.43	3.43	3.32	3.23	3.21	3.19	3.13	3.12	3.13	
Shrimp produced, head-on		lb	338,488			72,019			72,019		72,019			72,019		$ 288,075
BEGINNING CASH BALANCE				0	500	500	181,052	118,017	54,812	231,020	-230,029	500	500	500	161,889	
Farm-gate shrimp value, heads-on	$ 3.27	$/lb	338,488	0	0	243,758	0	0	239,243	0	231,303	0	0	224,424	0	$ 938,728
TOTAL CASH INFLOW				**0**	**500**	**244,258**	**181,052**	**118,017**	**294,055**	**231,020**	**1,276**	**500**	**500**	**224,924**	**161,889**	
OPERATING EXPENSES																
Feed																
Grow-out	$ 1,748	ton	223	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 32,436	$ 389,228
Nursery	$ 1,098	ton	23	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 2,122	$ 25,465
Labor, Nursery and growout																$ -
Farm management	$ 140,875	annual	1	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 11,740	$ 140,875
Hired labor, hourly	$ 62,818	hour	1	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 5,235	$ 62,818
Hatchery supplies	$ 962	crop	8.5	682	682	682	682	682	682	682	682	682	682	682	682	$ 8,179
Port larvae, PL12	$ 8	$/1,000	3,444	3,242	2,296	2,296	2,296	2,296	2,296	2,296	2,296	2,296	2,296	2,296	2,296	$ 28,501
Utilities																
Fuel, gasoline	$ 3.30	$/gallon	1,096	$ 301	$ 301	$ 301	$ 301	$ 301	$ 301	$ 301	$ 301	$ 301	$ 301	$ 301	$ 301	$ 3,617
Fuel, diesel	$ 3.95	$/gallon	1,460	$ 481	$ 481	$ 481	$ 481	$ 481	$ 481	$ 481	$ 481	$ 481	$ 481	$ 481	$ 481	$ 5,767
Eletricity	$ 0.08	$/kwh	1,359	$ 3,370	$ 3,044	$ 3,370	$ 3,261	$ 3,370	$ 3,261	$ 3,370	$ 3,370	$ 3,261	$ 3,370	$ 3,261	$ 3,370	$ 39,677
Fresh Water																
- Initial 80 RW fill	$ 0.14	$/1,000 gal	1,489	208												$ 208
- Evaporation replacement	$ 0.14	$/1,000 gal	8,412	100	90	100	97	100	97	100	100	97	100	97	100	$ 1,178
Chemicals																
Salt, Red Sea Salt	$ 650	bag (2200 lb/bag)	90	$ 58,500												
Sodium bicarbonate	$ 0.165	$/lb	54,000	$ 743	$ 743	$ 743	$ 743	$ 743	$ 743	$ 743	$ 743	$ 743	$ 743	$ 743	$ 743	$ 8,910
Mineral additive to water	$ 10,000	$/yera/GH	1							$ 10,000						$ 10,000
Liquid oxygen																
- liquid oxygen tank rental	$ 1,500	11K-gal tank/mo	1	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 18,000
- liquid oxygen supply	$ 0.40	100 ft3 vol/RW/d	148	$ 1,833	$ 1,656	$ 1,833	$ 1,774	$ 1,833	$ 1,774	$ 1,833	$ 1,833	$ 1,774	$ 1,833	$ 1,774	$ 1,833	$ 21,585
Sludge removal	$ 15	$/gallon	45	$ 168	$ 168	$ 168	$ 168	$ 168	$ 168	$ 168	$ 168	$ 168	$ 168	$ 168	$ 168	$ 2,019
Telephone expense	$ 200	$/month	12	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 200	$ 2,400
Insurance	0.2083%	%/investment $	991,997	$ 2,067												$ 2,067
Property tax	$ 9.48	$/acre	7	$ 63												$ 63
Scheduled debt payments																
Long-term																
Principal			921,603							$ 103,286						$ 103,286
Interest	8.00%	percent	317,498							$ 73,728						$ 73,728
Intermediate-term																
Principal / 1			70,395	$ 7,889												$ 7,889
Interest	8.00%	percent	24,251	$ 5,632												$ 5,632
TOTAL CASH OUTFLOW				**$ 138,510**	**$ 62,693**	**$ 63,206**	**$ 63,035**	**$ 63,206**	**$ 63,035**	**$ 250,220**	**$ 63,206**	**$ 63,035**	**$ 63,206**	**$ 63,035**	**$ 63,206**	**$ 1,019,591**
CASH AVAILABLE				$ (138,510)	$ (62,193)	$ 181,052	$ 118,017	$ 54,812	$ 231,020	$ (19,200)	$ (61,930)	$ (62,535)	$ (62,706)	$ 161,889	$ 98,684	
New Borrowing				$ 139,010	$ 62,693	0	0	0	0	$ 19,700	$ 62,430	$ 63,035	$ 63,206			**$ 410,074**
Payment on principal										$ 221,403						**$ 221,403**
Payment on interest	8.00%	percent								$ 9,126						**$ 9,126**
ENDING CASH BALANCE				**$ 500**	**$ 500**	**$ 181,052**	**$ 118,017**	**$ 54,812**	**$ 231,020**	**$ (230,029)**	**$ 500**	**$ 500**	**$ 500**	**$ 161,889**	**$ 98,684**	**$ 98,684**

Etc.

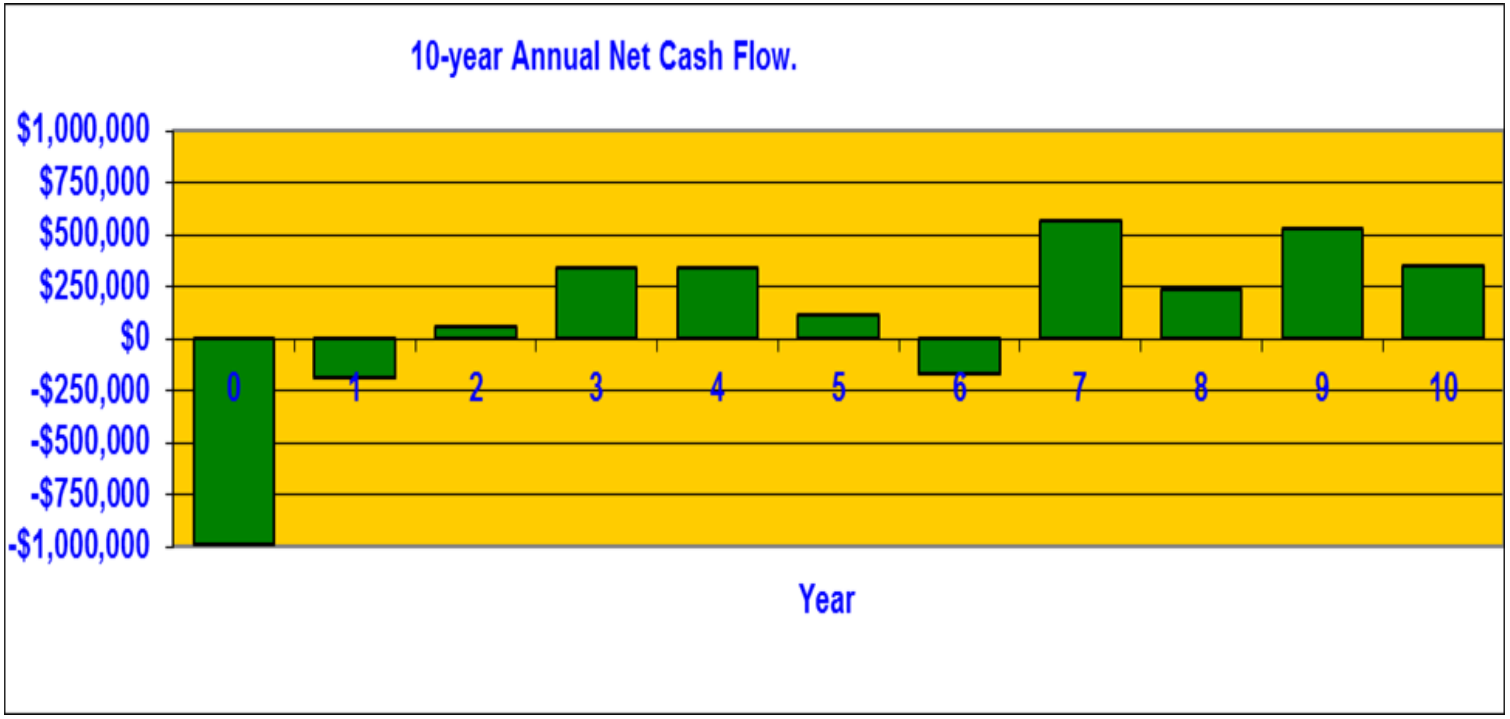
10-year Summary for NPV, IRR & Payback Calculation Example

Bio-Economic Model Output - Ten year cash flow for calculating payback period, net present value and internal rate of return for a super-intensive recirculating shrimp production system (using Hyper Intensive 35% crude protein feed, stocking at 324 PL/m^3, PLs weighing 4.7 g and grown to 27.22 g, having a 1.59 FCR, grown for 77 days).

Item / Year	0	1	2	3	4	5	6	7	8	9	10
Gross receipts	0	937,496	1,176,127	1,172,674	1,172,603	945,138	1,176,127	1,404,291	938,837	1,171,356	1,040,700
Total costs	0	1,249,941	1,242,665	959,423	959,423	959,423	959,423	959,423	768,888	768,888	768,888
Investor dividend	0	0	0	0	0	0	0	0	0	0	0
Taxable income	0	-312,445	-66,537	213,251	213,180	-14,285	216,704	444,868	169,949	402,469	271,812
Income taxes	0	0	0	0	0	0	0	0	0	0	0
Net income	0	-312,445	-66,537	213,251	213,180	-14,285	216,704	444,868	169,949	402,469	271,812
Depreciation	0	126,610	126,610	126,610	126,610	126,610	126,610	126,610	126,610	126,610	126,610
Net income + depreciation	0	-185,835	60,072	339,860	339,789	112,325	343,314	571,478	296,559	529,078	398,422
Initial Investment and Replacement costs	-991,997	0	0	0	0	0	510,717	0	61,479	0	50,297
Net cash flow	-991,997	-185,835	60,072	339,860	339,789	112,325	-167,403	571,478	235,080	529,078	348,125

Etc.

10 Year Annual Net Cash Flow Example



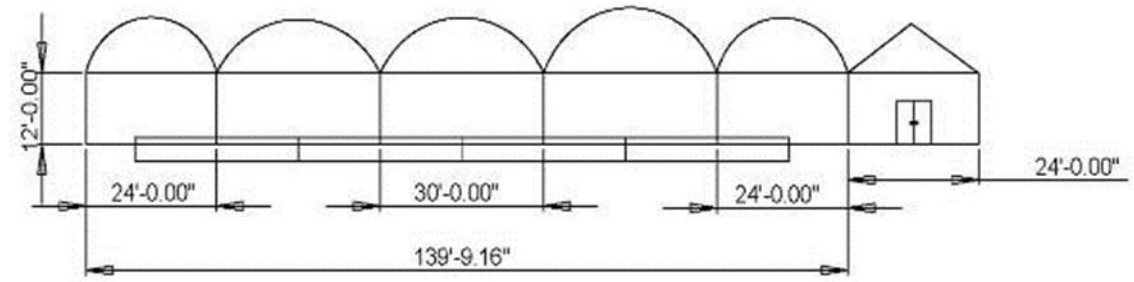
Pay-back period	yr	4.55
Discount rate	%	10.00%
Net present value	$	102,641
Internal rate of return	%	11.72%

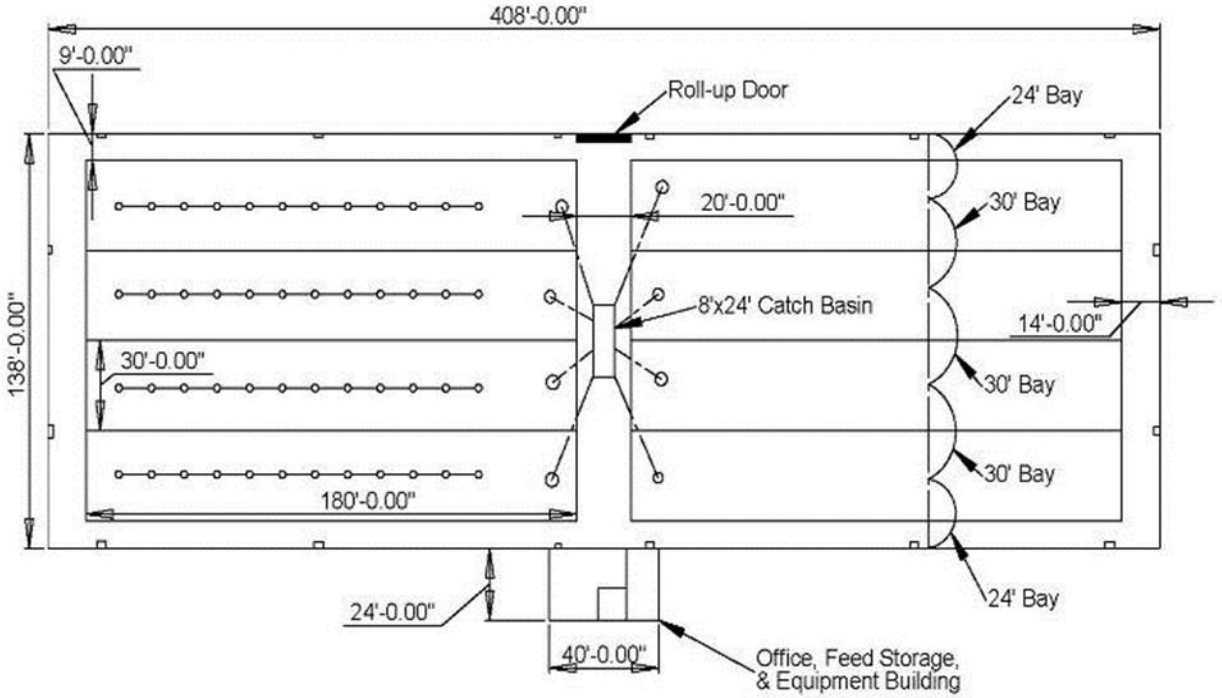
3) Capital Investment Examples

- Covering GH/RW design, materials, construction, and economies of scale
  - Building and material options to enclose RWs
  - RW wall and bottom material selection & costs
  - Raceway economies of scale with post and liner construction

3) Capital Investment Examples

GH structure to cover eight 500 m^2 RW units with central harvesting area





4) Factors Affecting Profitability

- Provides Analysis of Factors affecting cost-of-production and their impact on financial viability (NPV and IRR):

1. **GO survival**
2. **Shrimp price**
3. **GO stocking density**
4. **Initial investment**
5. **GO growth rate**
6. **Nursery & GO feed**
7. **Source of financing**
8. **Nursery survival**
9. **PL cost**

Change in NPV and IRR with 20% Improvement in Critical Production Factors

Grow-out Components	Change	Change from Base	
		NPV $mil.	IRR %
1. GO survival	+20%	10.48	13.7
2. Shrimp price	+20%	9.57	12.5
3. GO stocking density	+20%	6.16	8.1
4. Initial investment	-20%	2.24	6.8
5. GO growth rate	+20%	2.23	6.4
6. Nursery & GO feed	-20%	2.37	3.1
7. Source of financing	20/80-0/100	1.79	2.4
8. Nursery survival	+20%	1.12	1.5
9. PL cost	-20%	1.01	1.2

Compared to Base Scenario: $10.8 million and 25.3% IRR

5) Economic Analyses of Production Trials

- Economic analyses of 2013 & 2014 research trials at the Texas A&M AgriLife Research Lab
  - Large- and small-scale RW/GH systems

2013 – Economic Analysis of Two Feeds At Two Shrimp Selling Prices

Summary of economic analysis for the 2013 trial results extrapolated to a GH with eight 500-m^3 grow-out RWs and two 500-m^3 nursery RWs using two shrimp selling prices.

	HI-35%	HI-35%	EXP (HI-40%)	EXP (HI-40%)
Gross Receipts	3.27	4.00	3.27	4.00
Variable Costs	2.47	2.47	2.67	2.67
Income Above Variable Cost	0.80	1.53	0.60	1.33
Fixed Cost	0.58	0.58	0.61	0.61
Total of All Specified Expenses	3.05	3.05	3.28	3.28
Net Return Above All Costs	0.22	0.95	(0.02)	0.72
Payback period, years	4.5	2.0	11	2.5
Net present value ($ mil.)	0.1	1.7	-0.7	1.1
Internal Rate of Return (%)	12	38	-1	29

2014 – Economic Analysis of Two Feeds In Two GH/RW Configurations

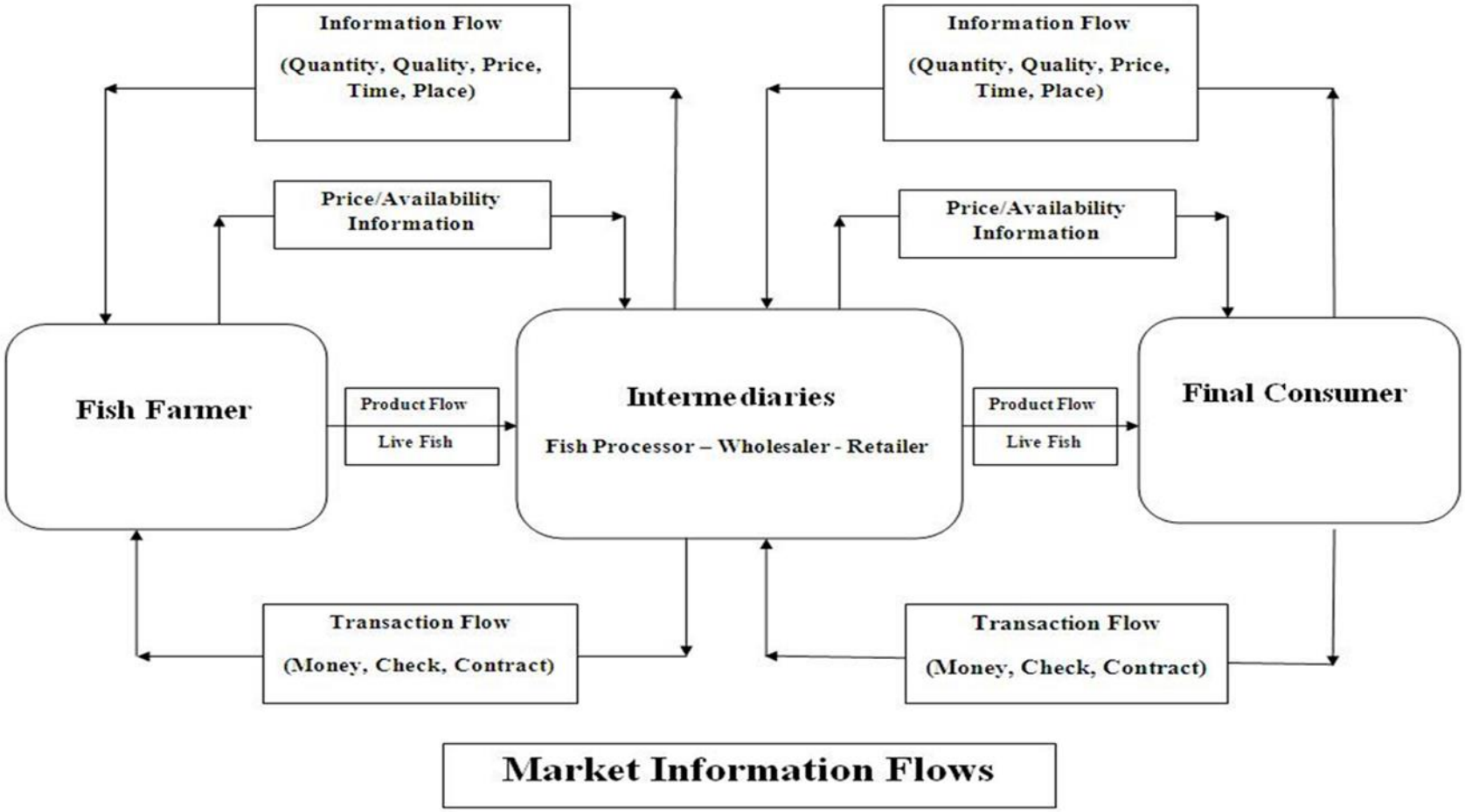
Summary of 2014 grow-out study cost of shrimp production grown in two different GH/RW configurations and fed two diets in the GH having six RWs.

Total $	Six 40-m^3 RWs		Two 100-m^3 RWs
	HI-35	Exp14	Exp14
Variable Costs	8,976	8,911	10,077
Fixed Cost	1,761	1,761	1,549
Total Expenses	10,737	10,672	11,627
Breakeven Price, $/kg, to Cover:			
Variable Costs	10.33	10.09	7.79
Total Expenses	12.36	12.08	8.99

6) Marketing Principles and Sensitivity Analyses

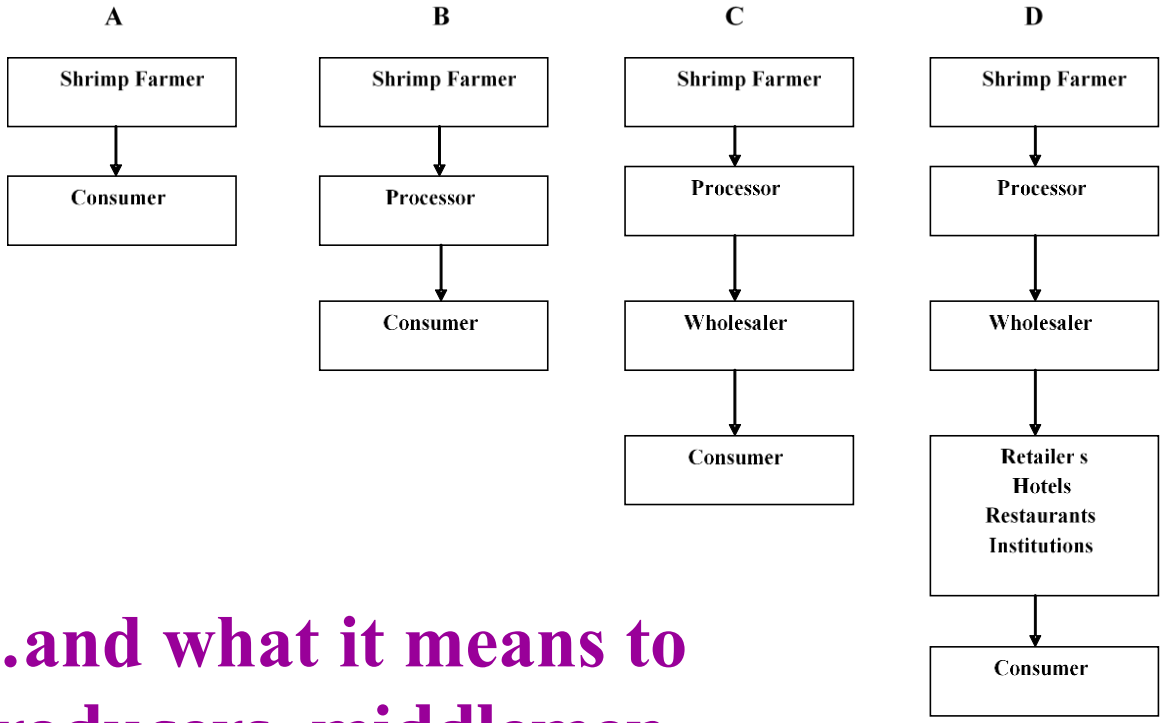
- Contains Basics on Marketing
- Questions to consider early on:
  - Who are the customers?
  - What size shrimp should be produced?
  - How much shrimp should be produced?
  - How will the shrimp be distributed?
  - What is the shrimp selling price to be?

Explains Market Channels



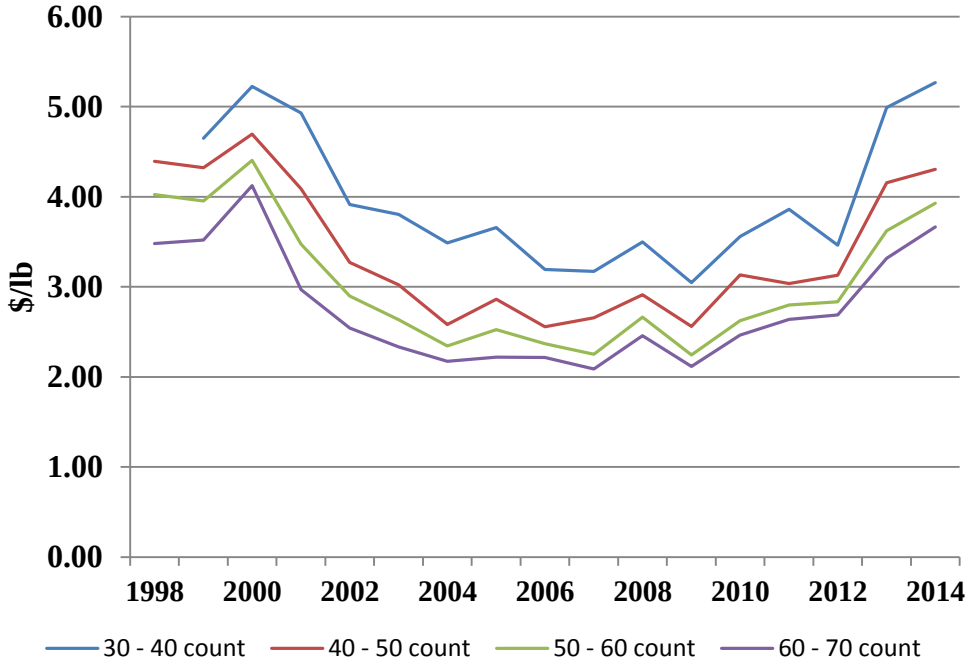
Information, Price/Availability, Product, $ Flow Chart

Provides Examples of Distribution Channels for Shrimp Products



…and what it means to producers, middlemen, retailers and consumers

Charts of Historical Shrimp Prices That can be used for Planning & Sensitivity Analyses



Farm-raised white shrimp prices, Central and South American, head-on, at first point of same, 1998 - 2014

Use of Historical Data for Determining Shrimp Size to Produce and What Quantity

Historical Ex-vessel price, $/lb, for Penaeid shrimp species, heads-on, for Northern Gulf of Mexico.

Shrimp size, count (number per pound)	Shrimp weight, g	10 year average price $/lb
Under 15	> 30 g	5.02
15 - 20	22 – 30	4.28
21 - 25	18 - 22	3.27
26 – 30	15 - 18	3.13
31 – 35	13 - 15	2.77

Better to Sell Larger or Smaller Shrimp?

Conclusions

- Biofloc system designs becoming less expensive and more practical
- Technically and economically feasible
  - Many outcomes possible: shrimp size, # of crops annually, PL supply
- Market and Selling Price is Critical to Success
- Business Planning Essential
  - Integration of biological, technical, physical, financial and marketing for viable business
- Chapter 13 Economics - Helps Work Through the Financial Portion of the Business Planning Process

Acknowledgements