CTSA Publication No. 146

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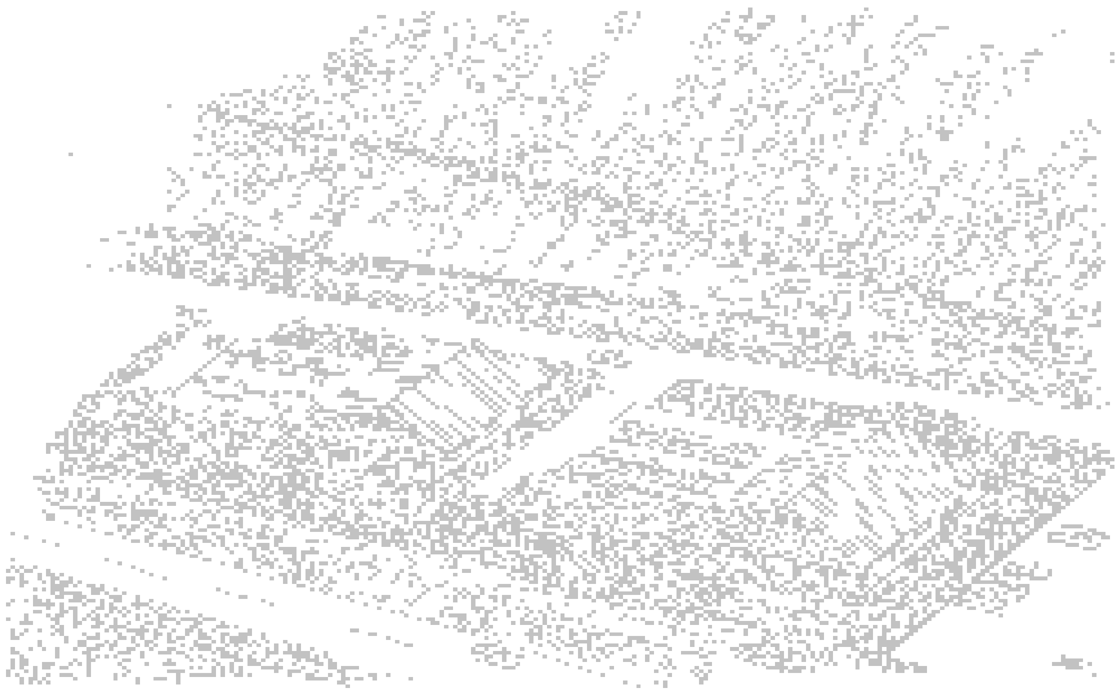

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CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

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Publication No. 146

July 2001

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Acknowledgments

This publication was prepared based on work done under CTSA project "Marine Foodfish Seedstock Production – Year 2." Funding for the project and the publication was provided by the Center for Tropical and Subtropical Aquaculture through a grant from the Cooperative State Research, Education and Extension Service of the U. S. Department of Agriculture (grant # 98-38500-5947). The views expressed herein are those of the authors and do not necessarily reflect the views of the U. S. Department of Agriculture, the Center for Tropical and Subtropical Aquaculture, The Oceanic Institute, the University of Hawaii, or any of their sub-agencies.

Special thanks to The Oceanic Institute researchers Michael Chambers and Chris Demarke for their erudition in the area of Pacific threadfin hatchery technology, which significantly contributed to the study. Appreciation is also extended to the hatchery staff, Bob Cantrell, and engineers Jim Muratsuchi and Randy Honke of The Oceanic Institute; Natural Energy Laboratory of Hawaii Authority Operations Manager Jan War; Mechanical Engineer Daniel Paquin of the University of Hawaii, College of Tropical Agriculture and Human Resources, Department of Molecular Biosciences and Biosystems Engineering; and State of Hawaii Department of Agriculture, Aquaculture Development Program Manager, John Corbin and Marketing Specialist, Dean Toda.

Update: For viewing from the World Wide Web, Ms. Alcian Choy-Clegg of the Center for Tropical and Subtropical Aquaculture processed this publication for Adobe Acrobat viewing. Page numbers in this publication has been altered from its original printed version. ***9/6/01***

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

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Abstract

A spreadsheet model has been developed to determine a viable scale for a commercial Pacific threadfin (*Polydactylus sexfilis*) hatchery in Hawaii. The production scheme is modeled after current practices performed at the Oceanic Institute. For a hatchery enterprise producing 1.2 million fry per year, the cost associated with raising a Day-40 fry (at 1 g) is estimated at 22.01¢. The largest variable costs are in labor and supplies, which comprised 49% and 9% of the total production cost, respectively. The combined annualized fixed cost for development and equipment is approximately 12% of total production cost. At a sale price of 25¢ per fry, the 20-year internal rate of return (IRR) is 30.63%. In comparison to the 22.01¢ unit cost for 1.2 million fry production, analyses of smaller enterprises producing 900,000 and 600,000 fry per year reflected significant size economies with unit costs of 27.41¢ and 38.82¢, respectively.

Since smaller scale commercial hatcheries may not be economically feasible, facilities may seek to outsource live feed production modules or pursue multi-product and multi-phase approaches to production. An analysis of the production length, for example, indicates that the cost for producing a Day-25 fingerling (at 0.05 g) is 17.25¢ before tax and reveals the financial impact of transferring the responsibility of the nursery stage to growout farmers. Moreover, sensitivity analyses indicate the potential cost savings associated with the elimination of rotifer, microalgae, and enriched artemia production. The estimated production costs associated with rotifer, microalgae, and enriched artemia feeds suggest the maximum price a commercial hatchery is willing to spend on outsourcing or investing in commercial substitutes for each type of feed. Sensitivity analyses recommend the development of alternative technologies in live feed production. Managerial decisions, however, must also consider the quality and associated production efficiencies of substitutes. An investigation of the effect of lengthening the nursery period revealed that unit costs increase at a slower rate. This is largely due to the ability to spread out fixed costs over larger production volumes. The incremental change in variable cost per fry increases as a result of escalating feed rates. Evaluation of the benefits gained from changes in nursery length, however, must also consider additional facility requirements, shipping costs, and market demand.

Introduction

Hawaii's high labor and land costs create a competitive climate for businesses. Well-informed decision-making is therefore critical to survival in the volatile economy. For practitioners of aquaculture, informed decisions are even more crucial as a result of the exogenous factors that increase risk in bioproduction. In hatcheries where the mortality rates are highest, it is paramount for farmers to pursue economic efficiencies to remain profitable. This study investigated the production and financial parameters of a theoretical hatchery enterprise based on the practices of an existing hatchery facility housed at the Oceanic Institute (OI) and expenditures relevant to Hawaii commercial aquaculture.

Pacific threadfin (***Polydactylus sexfilis***), commonly known as *moi* in Hawaii, is a potentially lucrative product for Hawaii aquaculture. The Pacific threadfin's delicate flavor is desirable for food and is cause for popularity among sport fishermen. Its popularity resulted in overfishing, which depressed the once thriving local market (Ostrowski and Molnar 1998). Consequently, efforts have been made by OI to provide fry as seedstock for land-based Pacific threadfin culture and enhancement efforts. Until recently, farmers obtained their seedstock free of charge from the OI hatchery, supported by funds from the USDA's Center for Tropical and Subtropical Aquaculture.

According to the Hawaii State Department of Agriculture - Aquaculture Development Program, Pacific threadfin is expected to add another 0.5 million pounds to the market, or $1.5 to $2.5 million in sales (Gillingham 1996). In 1999, the Hawaii Agricultural Statistics Service (Aquaculture Development Program, personal communication) reported an exchange of 119,568 lbs of Pacific threadfin and an associated farm-gate sales revenue of $459,150. The Hawaii Offshore Aquaculture Research Project that began in 1999 contributed to the sizeable production of 119,568 lbs in comparison to 1998 (41,500 lbs) and 1997 (25,000 lbs) production levels. The 1999 production volume and sales are equal to a 288% increase in production and 215% increase in sales revenue from 1998. Accordingly, the average farm-gate price has decreased from $5.16/lb to $3.84/lb. Market forces may therefore decrease sale prices in reaction to larger supply. Consequently, commercial enterprises must pursue economic efficiencies in order to remain profitable.

The objectives of this study were to determine the cost of producing the fry and the commercially viable scale for a Pacific threadfin hatchery in Hawaii. The hatchery production system used in the analysis is a theoretical model based on the OI production protocols and costs incurred by Hawaii's aquafarms. The study also examines decision variables that may be modified to effect satisfactory returns.

Method

Production System

The study was based on the three-stage production cycle currently practiced at the OI facility following procedures outlined by Ostrowski and Molnar (1998). These stages of production include a **spawning** phase, a **larval rearing** phase, and an early **nursery** phase.

The **spawning** phase is comprised of the establishment of broodstock and spawning. Under current OI operations, the captive Pacific threadfin are spawned naturally (i.e., without the use of environmental or hormonal conditioning). For the model used in this study, the spawning period was measured from the beginning of the conditioning period through spawning and egg collection.

Good eggs are stocked and hatched directly in the larval rearing tanks. The **larval rearing** phase spans from hatching to metamorphosis (Ostrowski and Molnar 1998). The larvae are initially sustained by live feed in the form of microalgae and rotifers. The microalgae also serve as a food support system for the rotifers. The larvae are slowly weaned off the microalgae and rotifers, to enriched artemia (metanauplii), and finally, artificial dry feed. Water exchange is increased substantially during the larval rearing phase.

The larval rearing phase (approximately 25 days) is supported by intensive **live feed production** of microalgae, rotifers, and artemia enrichment:

> **Microalgae** (*Nannochloropsis oculata*) production from test tube stock cultures occurs in five upscaling steps at OI. The batch culture technique uses continuous upscaling which consists of the transfer from flasks to carboys, inoculation tanks, raceway tanks, and harvest tanks. The transfer of each culture into the subsequent larger volume results in decreased algae density. Upscaling is achieved when growth in the larger volume meets the desired density. The culture is stocked for approximately four days of growth between transfers. Microalgae is used to support rotifer production and is used to sustain the rotifers that are used for feed in the larval rearing tanks.
>
> **Rotifer** production is initiated using a starter culture that is supported by microalgae and freshwater. The rotifer population doubles 24 hours after stocking and additional microalgae and fresh water are added to the tank. The Pacific threadfin are fed rotifers for approximately two weeks. When larvae are weaned from rotifers and algae to enriched artemia, rotifer production is reduced to half-capacity in order to maintain an adequate starter culture.
>
> **Artemia enrichment** (metanauplii) is performed in a two-Day-process. The process begins with hatching artemia from canned cysts, followed by a 24-hour enrichment process. Artemia are fed to the larvae for approximately 15 days.

Significant reduction in mortality rates and growth in body weight occur during the early **nursery** phase. In this model, the nursery phase is the final stage of the hatchery, approximately 25-40 days post-hatch. The juveniles are nourished by practical, dry feeds in the nursery stage. The healthy fry are then distributed as seedstock to growout farms.

Economic Model

Existing studies on finfish hatchery economics frequently address variable costs such as those linked to food, oxygen and energy consumption (Shulstad 1996). The simulation model developed by Shulstad, for example, allows manipulation of selected variables relating to energy, food, and oxygen consumption, population, and selling price. Shulstad concluded that the simulation model design was consistent with theoretical models. Such results from simulation studies may be helpful in management principles, production policies, and rules-of-thumb for specific hatcheries. Simulations of production models, therefore, provide sensitivity analyses that may aid managers in decision making.

A similar analytical approach for sturgeon by Shigekawa and Logan (1986) includes operating costs as well as annual costs for maintenance, insurance, taxes, and depreciation. Shigekawa and Logan analyzed the impact of altering the size of plant (number of broodstock), stocking density, and marketing strategy on costs and rate of return in their economic analysis on commercial hatchery production of sturgeon. Changes in plant capacity and marketing strategies were emphasized and analyzed, and sensitivity to price changes were also performed. The results of the study indicate that marketing strategy had a greater impact on profitability than plant capacity.

Other research on hatchery economics include survey research that is useful for identifying industry standards and recommending efficiencies. Escover et al. (1985), for example, published quantitative survey research on tilapia fingerling production in the Philippines. The study revealed an inverse relationship between farm size and labor input per unit area, and high mortality rates associated with handling and transporting. Moreover, land-based and lake-based systems showed no economies of scale, implying that smaller hatcheries can compete with bigger hatcheries. The study also highlighted the need to identify least-cost alternatives for fingerling production in the event that profits of hatcheries begin to decline. Stronger research efforts, however, were recommended to determine factors affecting volume and quality of fingerling production and to address limitations of the population of farms surveyed.

The model applied to this analysis is a modification of an electronic spreadsheet model for the financial analysis of shrimp production developed by Leung and Rowland (1989). Considerations were made in the hatchery design to characterize finfish production and permit ease in calculation of the costs associated with variations in production design and scale of production. The format of the model may have general application to economic analyses for other finfish hatcheries. Moreover, the flexible and familiar spreadsheet format of the model permits sensitivity analyses which are comparable to that which may be achieved by decision support systems and simulation studies.

The economic model (Figure 1) is demand-driven, contingent upon financial parameters, environment and production parameters, and site-specific characteristics. Environment and production parameters are fed into modules for spawning, larval rearing, nursery, live feed (microalgae, artemia, and rotifer) production, and the general facility. These values are summarized and translated into costs incurred by each module. Dollar amounts are reported in a profit and loss module and a cash flow module for financial analysis.

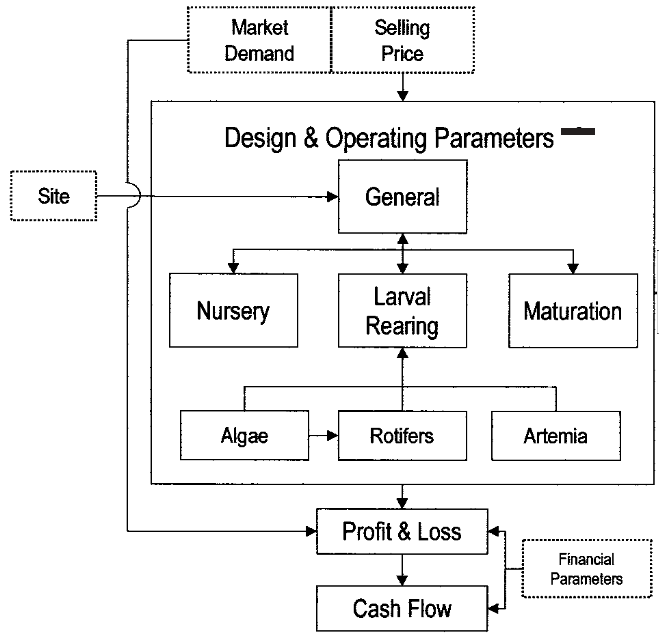

Figure 1 - Economic Model

A production summary provides an overview of requirements, annual productivity, and a conceptual schematic (allocation of indoor and outdoor area) of the physical layout. The production at each phase is determined from survival estimates and fry production requirements. The tanks required are summarized to provide the general size and scale of the facility. Synopses of the distribution of production time, labor hours, pump and blower usage, heater energy, and facility area are provided for each production phase. The energy costs associated with water pumping, aeration, and heating were allocated according to the amount of usage in each stage of the production per cycle. For aggregate development costs, such as PVC plumbing, site survey, grading, and planning and design, costs were allocated to each phase according to the percentage of facility space occupied.

The farm's net income is based on the market demand, financial parameters, and costs associated with production in each module. Net income before taxes and cost per fry are estimated based on parameters including:

Production

Â Projected Hatchery Market Demand (fry/yr)
Â Length of Hatchery Demand (months)
Â Length of Hatchery Season (days/yr)
Â Tank Tolerance
Â Efficiency in First Year (% of production)

Financial Parameters

Â Discount Rate (% risk)
Â Sale Price per Fry ($/fry)
Â Loan: annual loan rate %
% financing
life of loan
Â Tax: general excise tas rate (%)
state and federal tax table

Variable Expense Rates

Â Electricity Rates ($/kwh)
Â Rent ($/Acre)
Â Utilities Expense ($/m^2)
Â Maintenance (% of equipment and development annualized cost)
Â Fringe Benefits (% of salary)
Â Contingency (% of variable costs)
Â Design & Planning (% of constructions, drilling, survey, and other site preparation)

A 20-year **Profit and Loss Statement** reports the net income after tax from an outline of sales revenue (based on production and sale price per fry) and expenses, according to:

Variable Costs
Â Feed
Â Supplies
Â Energy (including misc. utilities)
Â Facilities Rent
Â Labor (Salaries + Fringe Benefits)
Â Maintenance
Â General Excise Tax

Fixed Costs (Annualized)
Â Depreciation on Equipment
Â Depreciation on Development

Other Expenses
Â Contingency
Â Interest Expense
Â Income Tax Expense

The 20-year **Cash Flow Summary** reflects the flow of cash according to:

Cash Flows from Operating Activities
Â Cash Collected
Â Less: Total Operating Expenses
Â Non-Cash Expenses (i.e. depreciation)

Cash Flows from Investing Activities
Â Purchase of Fixed Assets
Â Proceeds from Sale of Fixed Assets

Cash Flows from Financing Activities
Â Additions to Long-Term Debt
Â Reductions in Long-Term Debt

The internal rate of return (IRR) and cost per fry (or break-even price) are calculated to provide a measure of economic viability. The profit and loss values are based on net income after tax in the base model. The cost per fry (nominal dollars) is calculated from the total expenses after tax divided by the total number of fry sold for each year in the base model.

Assumptions: Base Model (1,200,000 Fry Per Annum)

The current operation at the OI facility can yield up to 1,200,000 fry per annum. This level of production served as a base model for the study. Broodstock are assumed to be maintained at a ratio of 1 male to 2 females, with an average fish weight of 1.07 kg and average spawner weight of 1.5 kg. The average female spawn is estimated at 70,000 eggs per kg-female at a hatching success of 70 percent (or approximately 73,500 hatchlings per brood female fish). The females spawn approximately once a month, for a period of 3-6 days.

Based on a 365-Day-hatchery season and 12-month hatchery demand, 12 harvests per year are possible. An estimate of 1 unsatisfactory egg harvest per year yields 11 fry harvests per year.[1] The length of the hatchery cycle is approximately 30 days, a consequence of the 30-Day-spawning cycle for the broodstock in captivity.

Table 1. Schedule of operations.

Cycle Summary	Days	% of Cycle	Operations	Unit	Value
Hatchery Cycle	30	100.0%	Length of Hatchery Demand	mo.	12.0
Spawning	30	100.0%	Length of Hatchery Season	days	365.0
Larval Rearing	25	82.2%	Max. Harvests Possible	cycles	12.0
Nursery	15	49.3%	Est. Harvests	cycles	11.0
Live Feed Production					
- Microalgae	30	100.0%			
- Artemia	16	52.6%			
- Rotifers	30	100.0%			

[1] The number of fry harvests per year is used to estimate annual production costs for "batch-dependent" production including Live Feed production, Larval Rearing production, and Nursery production. Broodstock Maintenance (Spawning), Labor for all phases, and Lease Rent are assumed to incur costs year-round (without regard to cycle hatching success).

The base model represents the proportion of input-output relationships researched and practiced by OI. The system described is a single-production facility for Pacific threadfin fry. The model assumes that additional broodstock requirements are met internally after the first year. Production requirements are determined according to demand and the estimates for survival rates for each phase. The number of eggs required by the hatchery is based upon annual fry requirements. The quantity of eggs required reflects the production level needed with respect to average survival rates during production. For the desired production yield, broodstock were stocked at a density of 1.5 kg-fish/m^3 in two 20,000-*l* tanks. The broodstock spawn approximately 4,200,000 eggs per cycle. This is significantly higher than the 611,633 eggs required for production, but is desirable in order to minimize risk through redundancy and to screen for egg quality. A summary of requirements for the 1,200,000 annual fry production level is included in Table 2.

Table 2. Production requirements summary.

Production Requirements	Unit	Cycle	Annual	Survival	Cum Survival
Broodstock Required	fish	**60**	**60**	-	-
Spawning – Eggs Spawned	eggs	4,200,000	50,400,000	-	-
Spawning – Eggs Required	eggs	611,633	7,339,601	**100%**	100%
Spawning – Eggs Hatched	eggs	428,143	4,709,577	**64%**	64%
Larval Rearing	larvae	128,443	1,412,873	**30%**	19%
Nursery	fry	109,091	1,200,000	**85%**	16%
Live Feed Production					
- Microalgae	cells	1.28E+15	1.41E+16		
- Artemia (Metanauplii)	pieces	8.40E+09	9.24E+10		
- Rotifers	pieces	1.61E+09	1.77E+10		

The farm schematic for 1,200,000 fry produced per year requires 2 - 20,000 *l* spawning tanks, 4 - 4000 *l* larval rearing tanks, and 8 - 2000 *l* nursery tanks. The live feed requirement needed to sustain such an operation includes 3 - 20,000 *l* VT tanks, 3 - 5,000 *l* raceway tanks, and 3 - 400 *l* inoculation tanks for microalgae cultivation; 6 - 500 *l* tanks for artemia enrichment; and 8 - 1,200 *l* tanks for rotifer production. A summary of the facility requirements to support the 1,200,000 annual fry production is listed in Table 3. A detailed summary of facility requirements and assumptions for financial parameters can be found in Appendix A.

Table 3. Facility requirements for production technology.

Facility Requirements	Spawning	Larval Rearing	Nursery	Live Feed	Shared
Area Placement	Outdoor	IndoorOutdoor	Mixed	Mixed	
Area (m^2)	126.00 (21.28%)	40.32 (6.81%)	31.50 (5.32%)	299.25 (50.54%)	95.00 (16.05%)
Stocking Density	1.5 kg-fish / m^3	25-30 eggs / *l*	8 larvae / *l*	—-	—-
Survival Rate	64%[2]	30%	85%	—-	—-
Tanks	2 – 20,000 *l*	4 – 4,000 *l*	8 – 2,000 *l*	3 – 20,000 *l* 3 – 5,000 *l* 3 – 400 *l* 6 – 500 *l* 8 – 1,200 *l*	

[2]The Hatching Success Rate is included in place of the Survival Rate for the Spawning Phase. The Hatching success per spawn is 70%. OI encounters the equivalent of one unsatisfactory (or unusable) egg harvest per year. This adjusts the average hatching rate to:

70% x [(12 total cycles per year – 1 unsatisfactory cycle) / (12 total cycles per year)] = 64%

Results

Site-specific requirements including construction, site survey, and preparation are based on the Natural Energy Laboratory of Hawaii Authority (NELHA) estimates for a hypothetical facility located in Kona, Hawaii.[3] The engineering designs for plumbing, drilling and aeration requirements are based on OI recommendations. The development assumptions for the facility are included in Appendix A.

Site-specific development assumptions are used to calculate the development costs for construction and site preparation of the 592.07 m^2 (6,373 ft^2) site. The breakdown of the total area of the hypothetical facility is exhibited in Appendix B. Planning and design is assumed to be 12% of construction, drilling, site survey, and other site preparation costs (including grading, utilities installation, and PVC plumbing). Costs associated with development based on the facility area of the base model are summarized in Table 4.

Table 4. Development costs summary ($US)

Development	SP	LR	NU	LF	General	Total	%
Construction	13,563	21,701	3,391	84,957	153,391	277,002	66.53
Drilling					26,249	26,249	6.30
Utilities Installation					22,000	22,000	5.28
PVC Plumbing*	7,023	2,247	1,756	16,679	5,295	33,000	7.93
Site Survey*	532	170	133	1,264	401	2,500	0.60
Grading*	2,335	747	584	5,546	1,761	10,973	2.64
Planning & Design**	2,814	2,984	704	13,013	25,092	44,607	10.71
Total Development Cost	26,267	27,849	6,567	121,459	234,188	416,330	100.00
	6.31%	6.69%	1.58%	29.17%	56.25%	100.00%	

SP = Spawning LR = Larval Rearing NU = Nursery LF = Live Feed

* The total (aggregate) costs for these development items are allocated according to the % of facility space occupied for each phase of production.
** Planning & Design is estimated at 12% of the total Construction, Drilling, Utilities, Installation, PVC Plumbing, and Grading Costs.

[3] Estimates in the model do not reflect State and County Enterprise Zone Incentives offered by NELHA due to the complexity of incentives and terms for qualification. Actual results of financial analyses may be more favorable to the commercial hatchery than reported here.

Development costs for PVC plumbing, site survey, and grading are distributed according to the amount of area occupied by each phase of production. Development for the general facility comprises 56% of the total development costs, followed by live feed production at 29%. In the base model, over half of all development expenditures (67%) are spent on construction.

A list of the equipment and supplies specified for each phase of production is located in Appendix C. Over half of capital expenditures are invested in long-term equipment such as tanks, air blowers, fan filters, and seawater pumps (Table 5); i.e., costs annualized over 20 years. Fixed costs are primarily due to development, 67% of annualized fixed costs (Table 6). The majority of capital expenditures are either shared by the entire facility (44%) or used for live feed production (29%).

Table 5. Equipment costs summary ($US).

Equipment	SP	LR	NU	LF	General	Total	%
20 year		100	20,000	43,310	29,200	92,610	57.91
15 year	33,000	19,200		30	3,000	55,230	34.54
10 year	1,300	1,060		1,600		3,960	2.48
5 year	2,936	548	596	2,533	1,500	8,113	5.07
Total Equipment	37,236	20,908	20,596	47,473	33,700	159,913	100.00
	23.29%	13.07%	12.88%	29.69%	21.07%	100.00%	

SP = Spawning LR = Larval Rearing NU = Nursery LF = Live Feed

Table 6. Fixed cost summary (annualized).

Fixed Costs	SP	LR	NU	LF	General	Total	%
Equipment	2,917	1,501	1,119	2,834	1,960	10,331	33.17
Development	1,313	1,392	328	6,073	11,709	20,817	66.83
Total	4,231	2,893	1,448	8,907	13,669	31,148	100.00
	13.58%	9.29%	4.65%	28.60%	43.89%	100.00%	

SP = Spawning LR = Larval Rearing NU = Nursery LF = Live Feed

Labor required to support year-round production and manage the facility is summarized in Table 7. The annual payroll expenditures directly associated with fry production are estimated at 41%. Payroll dedicated to the production of live feed is 27% of the total payroll. The breakdown of labor hours and wages are documented in Appendix D. The aquafarm is estimated to have one full-time hatchery manager, two full-time technicians, and one part-time technician. Site operation requirements affecting energy expenditures are exhibited in Appendix E.

Table 7. Hatchery personnel summary of cycle hours, annual hours, and annual salary ($US).

LABOR REQUIREMENTS	Cycle (Hrs)	Annual (Hrs)	Ann. Salary ($)	%
Fry Production				
- Spawning	91.25	1,095	19,163	14.74
- Larval Rearing	100.00	1,200	21,000	16.15
- Nursery	60.00	720	12,600	9.69
Sub-total: Fry Production		251.25	3,015	52,763
40.59				
Live Feed				
- Algae	60.83	730	12,775	9.83
- Artemia	48.00	576	10,080	7.75
- Rotifers	60.83	730	12,775	9.83
Sub-total: Live Feed	169.67	2,036	35,630	27.41
Sub-total: Labor	420.92	5,051	88,393	68.00
Administration	173.81	2,080	41,600	32.00
Total	594.73	7,131	129,993	100.00

Profit & Loss[4]

The cost per Day-40 fry after tax for the 1,200,000-production level is 31.38¢ in the first year. Production is assumed to reach full capacity (100%) by year two as a result of the short production cycle for Pacific threadfin fingerling. By the second year of production, the expenses associated with fry production approximate the 20-year average unit cost (including tax) of 22.70¢ per fry. The small and gradual decrease in cost-per-fry over time is due to decreasing interest payments. Variable operating costs comprise approximately 68% of the total before-tax expenses incurred. Interest expenses are based on a 30-year loan for 80% financing of capital investments at an annual loan rate of 10%.

[4]The Profit & Loss Summary does not reflect inflationary adjustments to sale price and production expenses.

Based on the facility requirements, a 25¢ per fry sale price, and 70% production in the first year, the net income for the first five years of production is as follows:[5]

Table 8. Income Statement for 1.2 million fry base model ($US).

Year	**1**	**2**	**3**	**4**	**5**
Gross Receipts from Production	210,000	300,000	300,000	300,000	300,000
Variable Operational Costs					
- Feed	5,442	5,442	5,442	5,442	5,442
- Supplies	24,985	24,985	24,985	24,985	24,985
- Energy	10,228	10,228	10,228	10,228	10,228
- Facilities Rent	4,200	6,000	6,000	6,000	6,000
- Labor	129,993	129,993	129,993	129,993	129,993
- Maintenance	1,557	1,557	1,557	1,557	1,557
- General Excise Tax	1,050	1,500	1,500	1,500	1,500
Total Variable Costs	177,454	179,704	179,704	179,704	179,704
Fixed Costs (Annualized)					
- Equipment Depreciation	10,331	10,331	10,331	10,331	10,331
- Development Depreciation	20,817	20,817	20,817	20,817	20,817
Total Fixed Costs	31,148	31,148	31,148	31,148	31,148
Contingency	8,873	8,985	8,985	8,985	8,985
Total Operational Expenses	217,475	219,837	219,837	219,837	219,837
Interest Expense	46,099	45,819	45,511	45,172	44,799
Total Expenses	263,574	265,656	265,348	265,009	264,636
Net Income Before Tax	(53,574)	34,344	34,652	34,991	35,364
Income Tax	______	6,756	6,819	6,888	6,964
Net Income After Tax	(53,574)	27,588	27,833	28,103	28,400
Cost per Fry Before Tax	**0.3125**	**0.2201**	**0.2198**	**0.2195**	**0.2192**
(i.e., Excluding G.E., State, and Federal Tax)					
Cost per Fry After Tax[6]	0.3138	0.2270	0.2268	0.2266	0.2263

Cash Flow

The 20-year Cash Flow statement includes periodic purchases of 5-, 10-, 15-, and 20-year inventory items, annual loan payments, and adjustments for non-cash items (e.g., depreciation). For a production yield of 1,200,000 fry per year, the after tax break-even price is calculated at 22.01¢ per fry. An internal rate of return was measured at 30.63% based on a sale price of 25¢ per fry. The internal rate of return reflects the maximum return available to investors and for retained earnings.

[5] An annual miscellaneous supply expenditure of $2,000 is included.
[6] Cost per fry in year one is estimated based on 84,000 fry production (70% production).

Table 9. Statement of cash flow for 1.2 million fry base model.

Year	0	1	2	3	4	5
Cash Flows from Operating Activities						
Cash Collected		210,000	300,000	300,000	300,000	300,000
Total Expenses (Less)		(263,574)	(272,412)	(272,167)	(271,897)	(271,600)
Non-Cash Expense (Add, i.e., Depreciation)		31,148	31,148	31,148	31,148	31,148
Net Cash *		(22,426)	58,735	58,981	59,251	59,547
Cash Flows from Investing Activites						
Purchase of Fixed Assets	576,243					
Proceeds**						
Net Cash ***	(576,243)					
Cash Flows from Financing Activities						
Additions to Long-Term Debt	460,995					
Reductions in Long-Term Debt (Less)[7]		(2,803)	(3,083)	(3,391)	(3,730)	(4,103)
Net Cash ****	460,995	(2,803)	(3,083)	(3,391)	(3,730)	(4,103)
Net Increase (Decrease) in Cash	(115,249)	(25,229)	55,652	55,590	55,520	55,444
Cash Starting Balance	115,249		(25,229)	30,424	86,013	141,534
Cash Ending Balance		(25,229)	30,424	86,013	141,534	196,978

IRR (20 years)
IRR based on equity paid **30.63%**
(i.e. available cash starting balance in year 0)

* Provided by operating activities
** From sale of fixed assets
*** Used in investing activities
**** Provided by financing activities

[7]Payments on loan principal only. Loan interest payments are already included in NET INCOME AFTER TAX from Profit & Loss Summary.

Discussion

Size Economies

In order to measure the economic viability of a commercial Pacific threadfin hatchery in Hawaii, a financial analysis was performed for lower annual yields of 600,000 and 900,000 fry. Our findings are exhibited in Table 10:

Table 10. Effect of scaled production levels on operating expense.[8]

Expense Summary (2nd Yr)	1,200,000 Fry		900,000 Fry		600,000 Fry	
	$	%	$	%	$	%
Variable Operational Costs						
- Feed	5,442	2.06	4,674	1.89	3,907	1.68
- Supplies	24,985	9.46	19,438	7.88	13,892	5.96
- Energy	10,228	3.87	8,903	3.61	7,980	3.43
- Facilities Rent	6,000	2.27	4,500	1.82	3,000	1.29
- Labor	129,993	49.22	129,993	52.69	129,993	55.81
- Maintenance	1,557	0.59	1,407	0.57	1,316	0.56
- General Excise Tax		0.00		0.00		0.00
Total Variable Costs	178,204	67.48	168,914	68.46	160,087	68.72
Fixed Costs (Annualized)						
- Equipment Depreciation	10,331	3.91	8,907	3.61	8,079	3.47
- Development Depreciation	20,817	7.88	19,224	7.79	18,232	7.83
Total Fixed Costs	31,148	11.79	28,131	11.40	26,311	11.30
Contingency	8,910	3.37	8,446	3.42	8,004	3.44
Total Operating Expenses	218,262	82.65	205,491	83.29	194,402	83.46
Interest Expense	45,819	17.35	41,226	16.71	38,537	16.54
Total Expenses	264,081	100.00	246,717	100.00	232,939	100.00
Cost per Fry Before Tax (i.e., Excluding G.E., State, and Federal Tax)	**0.2201**		**0.2741**		**0.3882**	

[8]Rent is based on gross revenue from the sale of fry at 25¢. Comparison between costs-per-fry were made before tax because revenues resulting from the 25¢-sale price were not sufficient for the 900,000 fry and 600,000 fry production facilities to remain profitable.

Economies of size were examined using the cost per fry (total expenses, excluding taxes) for 1.2 million, 0.9 million, and 0.6 million fry production levels. An exponential relationship was observed in the analysis, revealing unit costs of 22.01¢, 27.41¢, and 38.82¢, respectively (Figure 2). While the total expenses decrease in relation to the smaller production levels, a closer look at the cost allocation reveals trends across the different production scales. The effect of decreasing the scale of production results in an increase of the proportion of expenses attributed to labor. For example, the percentages of expenses toward labor increase to 53% for 900,000 fry and 56% for 600,000 fry (from 49% for 1,200,000 fry). In examination of the itemized cost per fry for each production scale, the expenses increase for smaller scales of production as expected.

Figure 2 - Size Economies

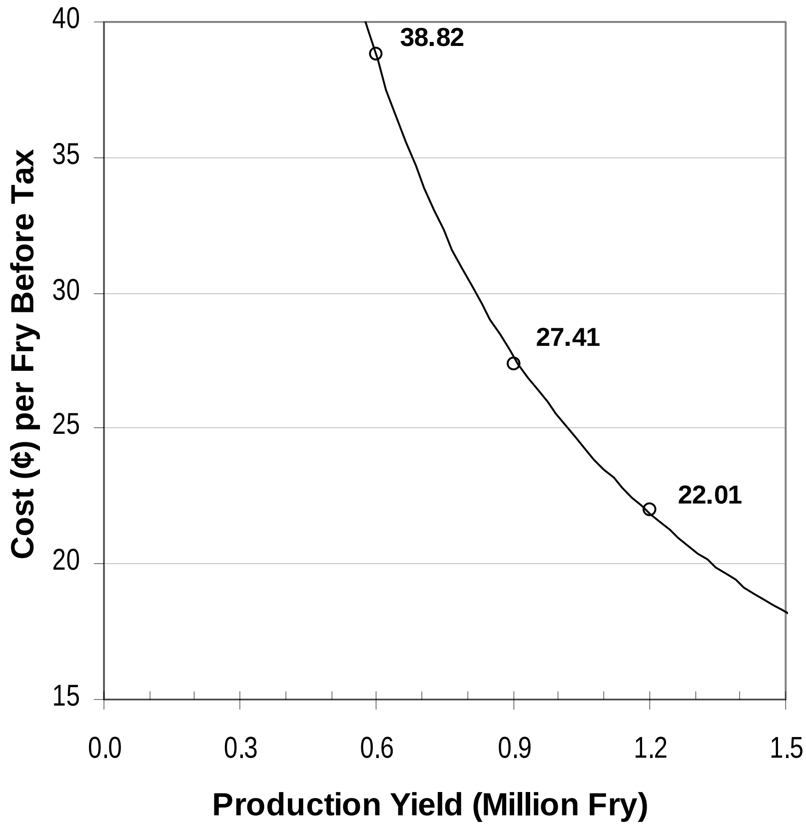

Table 11. Effect of scaled production levels on unit cost (¢US).

Expense per Fry	**Scale of Production** 1,200,000 Fry	900,000 Fry	600,000 Fry
	¢ / Fry	¢ / Fry	¢ / Fry
Variable Operational Costs			
- Feed	0.45	0.52	0.65
- Supplies	2.08	2.16	2.32
- Energy	0.85	0.99	1.33
- Facilities Rent	0.50	0.50	0.50
- Labor	10.83	14.44	21.67
- Maintenance	0.13	0.16	0.22
- General Excise Tax	——	——	——
Total Variable Costs	14.85	18.77	26.68
Fixed Costs (Annualized)			
- Equipment Depreciation	0.86	0.99	1.35
- Development Depreciation	1.73	2.14	3.04
Total Fixed Costs	2.60	3.13	4.39
Contingency	0.74	0.94	1.33
Total Operating Expenses	18.19	22.83	32.40
Interest Expense	3.82	4.58	6.42
Total Expense (per fry)	**22.01**	**27.41**	**38.82**

Requirements modified for each production level included the following (Table 12).

Table 12. Effect of scaled production levels on production requirements.

Requirement Variation	**Scale of Production** 1,200,000 Fry	900,000 Fry	600,000 Fry
Utility Installation Cost	$ 22,000	$ 18,000	$ 15,000
PVC Plumbing Cost	$ 33,000	$ 28,000	$ 23,000
Site Survey Cost	$ 2,500	$ 2,000	$ 1,800
Max Pump GPM · HP	166 · 10	136 · 7.5	105 · 5.0
Water Pump Price	$ 3,500	$ 3,350	$ 3,200
Var. Freq. Drive/Control	$ 8,500	$ 6,375	$ 4,150

Labor hours are assumed to remain the same for each scenario. The facility schematic projected for each scenario is summarized in Table 13. Tank volumes are assumed to remain constant, and are as described in the 1,200,000-fry production model.

Table 13. Tank requirements (scaled production).

Tank Schematic		Scale of Production		
Qty per Prod Level	**Volume (*l*)**	**1,200,000 Fry**	**900,000 Fry**	**600,000 Fry**
Nursery Tanks	2,000	8	6	4
Larval Rearing	4,000	4	3	2
Spawning	20,000	2	2	2
VT Tank (Algae)	20,000	3	2	2
RW Tank (Algae)	5,000	3	2	2
IT Tank (Algae)	400	3	2	2
Enrichment Tank (Artemia)	500	4	4	2
Hatching Tank (Artemia)	500	2	2	1
Rotifer Tank	1,200	8	6	6

Other facility requirements impacted by the change in scale of production are highlighted below in Table 14.

Table 14. Effect of scaled production on facility requirements.

	Scale of Production		
Facility Requirements	**1,200,000 Fry**	**900,000 Fry**	**600,000 Fry**
Total Area (m^2)	592.074	488.37	465.16
Avg. / Max. Water (GPM)	112.76 / 166.03	95.62 / 135.52	78.47 / 105.01
Aeration (max CFM)	48.29	43.48	32.66
Heater (annual KWH)	13,653	11,119	8,585

Nursery Period

An analysis of the effect of the length of the nursery period on the break-even price was performed for the 1,200,000 fry production level. The estimated cost per fry in this analysis assumes that cost increases result from variable expenses including labor, artificial feed, and energy (i.e., no change in capital requirements). Results from the analysis reveal that every additional Day-in the nursery increases the total production cost (Figure 3).[9] A five-Day-decrease in the length of the nursery period, for example, will yield 1.222 million 0.38-g (Day-35) fry and an annual before-tax savings of $6,400.

The break-even price was calculated by dividing the total production cost by the number of fry adjusted for mortality. The break-even price resulting from the elimination of the nursery production facility (i.e., no nursery development, operation costs, or equipment) is 17.25¢ per 0.05-g fry.[10] This represents the unit cost associated with producing 1.412 million Day-25 larvae before taxes and shipping and handling costs. Consequently, the production cost for Day-25 0.05-g fry provides a gauge for hatchery farmers in determining the extent of their production practices and may suggest transfer of nursery production to receiving facilities.

The nursery production analysis reveals increasing break-even prices at a decreasing rate for longer nursery periods. In comparison to the 1.00-g fry (Day-40) break-even price of 22.01¢, the break-even price for 0.14-g (Day-35) and 1.84-g (Day-45) fry are 21.08¢ and 22.86¢ (Figure 4).[11] The effect is largely due to the diminishing mortality rate (i.e., stable population size) on fixed costs and constant variable costs including energy and labor. The incremental change in variable costs per fry, however, increases in the nursery stage within the 20-Day-spectrum. Figure 5 exhibits the contribution of increasing feed costs on the change in variable cost per fry. Costs associated with energy and labor have a constant rate of change.

Size increases are significant after 15 days in the nursery and may demand additional requirements to support a late nursery stage. Consequently, a thorough evaluation of the effect of the change in nursery length on profitability should incorporate anticipated profits based on sale prices reflecting demand (market value) for different size fry, the effect of fry size on shipping costs, costs incurred or cost savings associated with changes in facility requirements, and opportunity costs of facility usage.

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[9]Production costs reflect annual expenses in the second year of production. Changes in contingency expenses treated as variable cost. Interest expense treated as a fixed cost.
Estimated increases in cost associated with feed are based on functions that approximate the growth, mortality, and feed rates reported by the Oceanic Institute.
[10]Fixed costs for Day-25 larvae assume that nursery development, and equipment expenses are not incurred.
[11]Production cost before tax in the second year of production.

Figure 3 - Production Cost vs. Nursery Length

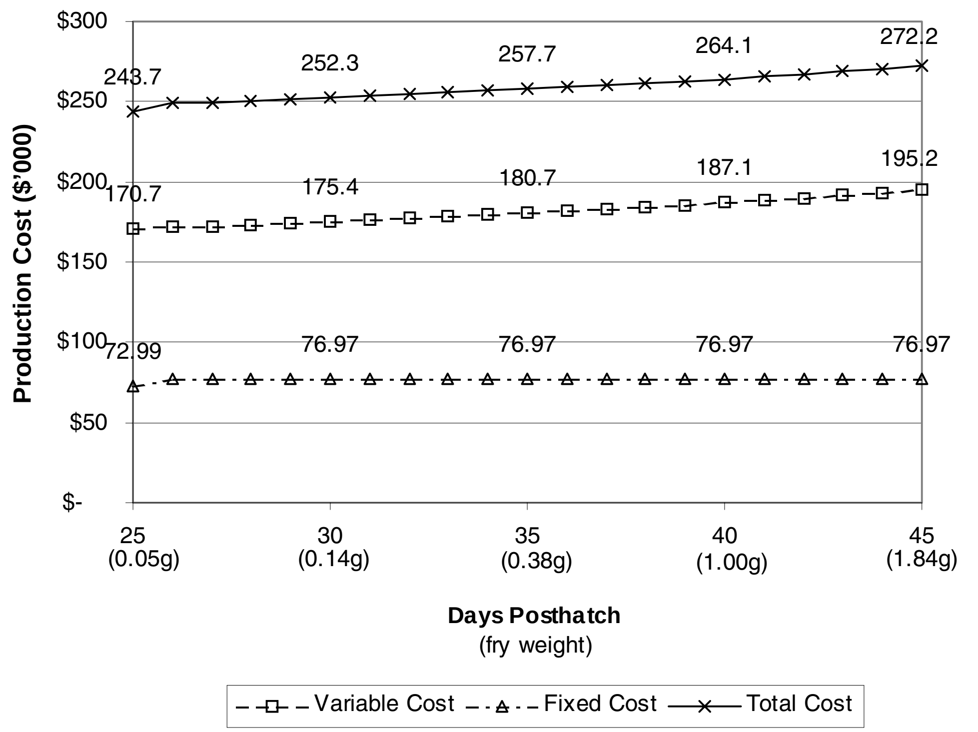
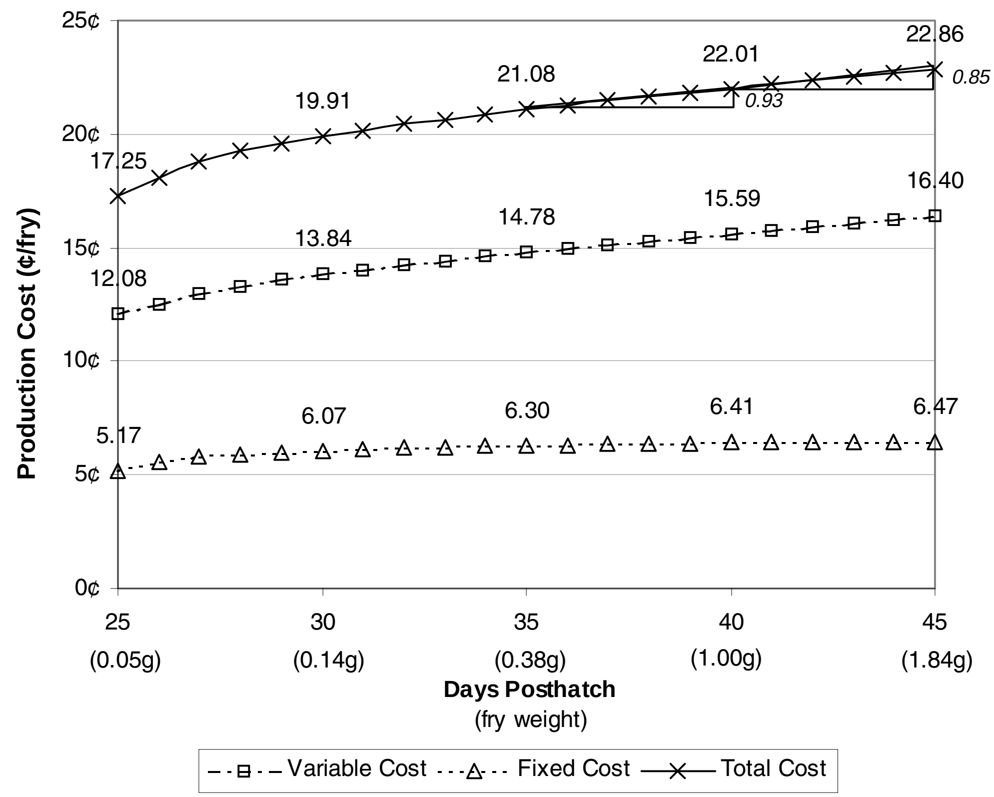
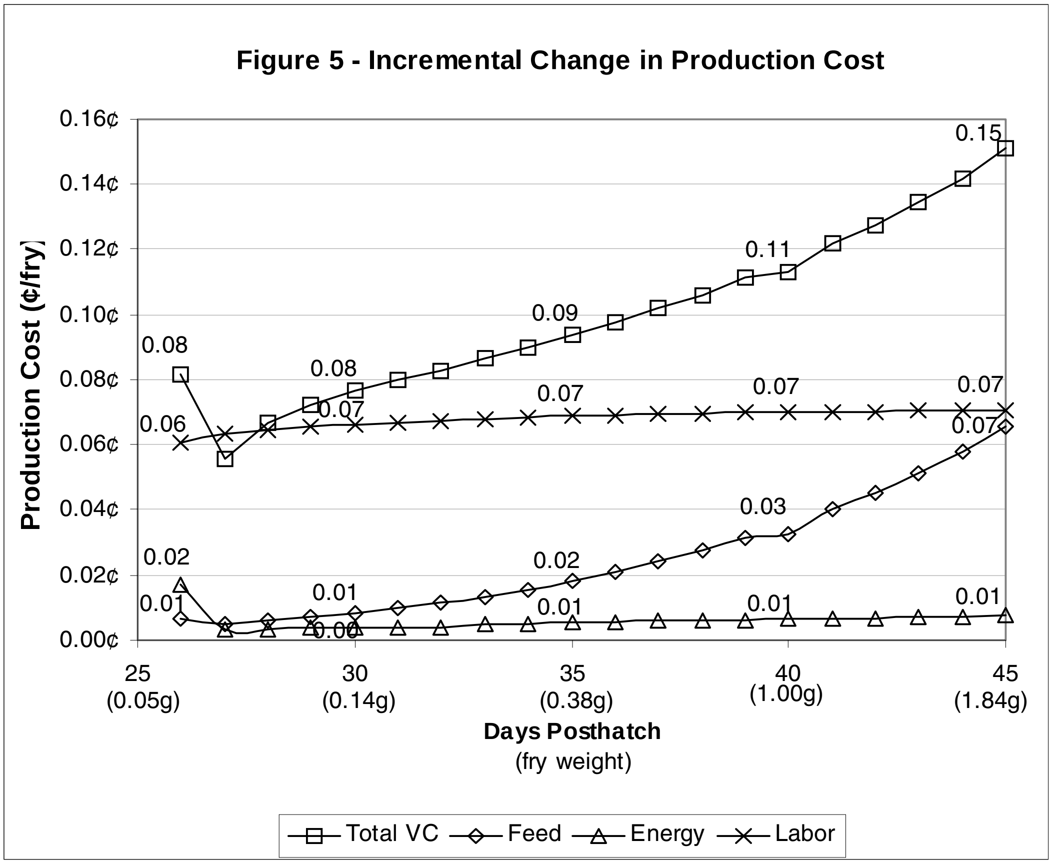


Figure 4 - Fry Production Cost





Live Feed Production

Another area investigated to improve economic efficiency was the investment in live feed production. Significant expenditures can be avoided through the elimination of live feed production. Such expenditures would include labor, equipment costs including tank requirements (Appendix C), costs associated with facility rent and development, and associated energy expenditures (Table 15). An analysis of price sensitivity in live feed production can also indicate areas and magnitude of potential losses resulting from increases in supply costs. Artemia cysts, for instance, are estimated to double in price over the next two years.

The maximum cost savings from the removal of the entire live feed production system from the base model is estimated to have an impact of $56,151 after tax.[12] Consequently, the most the farm would be willing to spend on outsourcing or the purchase of commercial live feed (microalgae, enriched artemia, and rotifer products) to support larval rearing is $56,151 per year, or approximately $4,679 per month.

[12]The total after tax expenditure in the second year is 18.02¢ per fry (in comparison to the 22.70¢ per fry estimated in the base model). The savings resulting from the elimination of live feed production is approximately $56,151 for the 1.2 million fry annual production level (or 4.68¢ per fry).

Table 15. Impact of live feed production on facility and development requirements.

	Development Estimates 1,200,000 Fry			Facility Requirements 1,200,000 Fry	
Development Requirements	**Base Model**	**No Feed Production**	**Facility Requirements**	**Base Model**	**No Live Feed Production**
Utility Installation	$ 22,000	$ 15,000	Total Area (m^2)	409.53	292.82
PVC Plumbing	$ 33,000	$ 23,000	Avg/Max Water (GPM)	112.76/166.03	111.79/166.03
Site Survey	$ 2,500	$ 1,500			
Max GPM · HP	166 · 10	166 · 10	Aeration (max CFM)	48.29	24.80
Water Pump	$ 3,500	$ 3,500	Heater (annual KWH)	13,653	0.00
Var. Freq. Drive/Control	$ 8,500	$ 8,500			
Blower Pump HP	1.5 · $ 650	1.0 · $ 500			

The total cost associated with live feed production is 4.68¢/fry or 20.61% of the total production cost. Independent analyses performed on each of the live feed modules follows. The costs per fry associated with the microalgae, enriched artemia, and rotifer feeds are 2.17¢ (9.56%), 2.18¢ (9.60%), and 1.61¢ (7.09%), respectively. These costs reflect the maximum price the hatchery is willing to pay for commercial substitutes and outsourcing. Production efficiencies, however, may vary according to the quality of the substitute and will determine the economic benefit of changes in production scope.

Microalgae Production

OI is currently exploring the use of commercial algae to replace in-house production. Eliminating the labor, energy, and capital required for microalgae (*Nannochloropsis oculata)* production, the annual after tax cost savings is estimated at $26,041. The development estimates for the scaled-down facility are listed in Table 16.[13] Based on these results, the hypothetical facility producing 1.2 million fry per year is willing to spend at most $26,041 per year (approximately $2,170 per month) on algae substitute products.

The application of commercial *Chlorella vulgaris* is dependent upon the efficiency of chlorella on rotifer production. Based on current chlorella prices, the monthly cost savings of $2,170 is equivalent

[13]The total expenditure in the second year is 20.53¢ per fry (in comparison to the 22.70¢ per fry in the base model). The savings resulting from the elimination of microalgae production is approximately 2.17¢ per fry, or $26,041 for the 1.2 million fry annual production level.

to approximately 200 *l* (6 billion cells/ml) of fresh chlorella.[14] Consequently, the maximum chlorella usage must be 1.20 x 10^{15} cells per monthly larval rearing rotifer requirement. Studies indicate that chlorella may yield significantly larger rotifer production yields in comparison to the *N. oculata* and may justify the alternate technology (Fu et al. 1997).

Tentative results from a preliminary investigation using algae paste reveals that the cost for the paste substitute exceeds the cost savings that result from the elimination of in-house microalgae production. The results estimate an annual after tax cost of approximately $5,830 per month for algae paste required to support rotifer production. Additional trials are being performed to detect improvements in production efficiency. Pending the results of further investigation, the use of algae paste is currently limited to serving as a supplement to boost algae density levels as opposed to a complete substitute for in-house microalgae production. An economic efficient level of algae paste substitution or supplementary use can be determined when more conclusive results on production efficiencies are available.

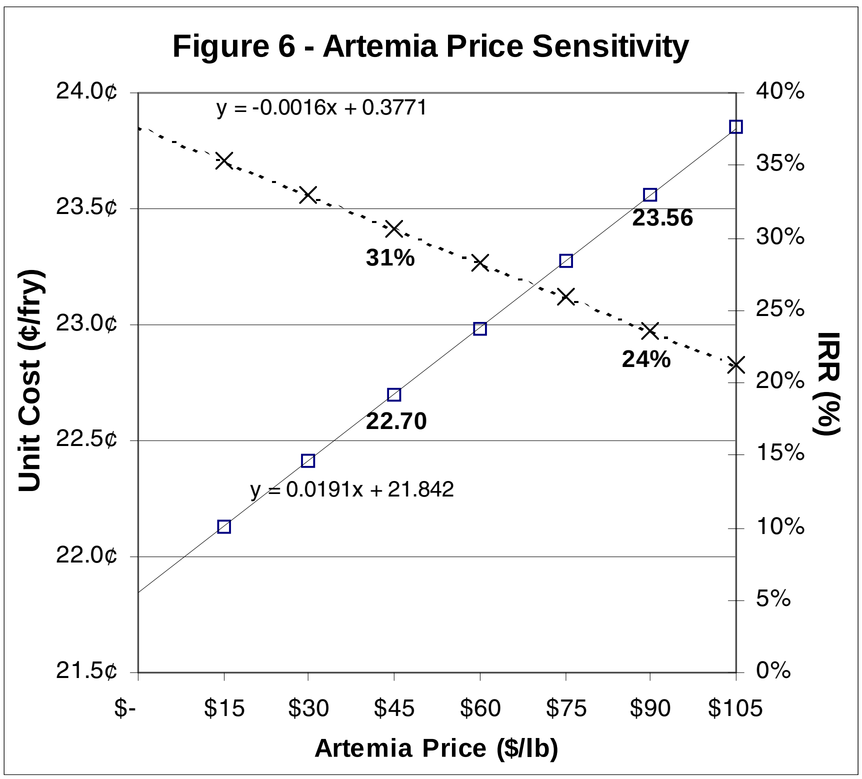
Table 16. Impact of algae production on facility and development requirements.

	Development Estimates 1,200,000 Fry			**Facility Requirements 1,200,000 Fry**	
Development Requirements	**Base Model**	**No Feed Production**	**Facility Requirements**	**Base Model**	**No Live Feed Production**
Utility Installation	$ 22,000	$ 15,000	Total Area (m^2)	409.53	317.32
PVC Plumbing	$ 33,000	$ 23,000	Avg/Max Water (GPM)	112.76/166.03	112.27/166.03
Site Survey	$ 2,500	$ 1,500			
Max GPM · HP	166 · 10	166 · 10	Aeration (max CFM)	48.29	32.76
Water Pump	$ 3,500	$ 3,500	Heater (annual KWH)	13,653	13,653
Var. Freq. Drive/Control	$ 8,500	$ 8,500			
Blower Pump HP	1.5 · $ 650	1.0 · $ 500			

[14]Based on product and shipment cost for importing two orders chlorella having a two-week shelf life.

Enriched Artemia Production

The projected rise in the cost of artemia cysts urges an investigation of the price sensitivity of fry production cost to artemia prices. By varying the price of artemia cysts, the effect of the market price of artemia cysts on the cost of fry production was examined. The increase in cost per pound of artemia cysts approximates a linear relationship to the associated increase in fry production costs. Fry production cost increases 0.0191¢/fry for every dollar/lb increase in artemia cysts. For the 1.2 million production level, this is equivalent to an annual expenses increase of $228 per dollar/lb increase in artemia. Figure 6 demonstrates the impact of artemia price on the internal rate of return if the sale price of fry remains at 25¢ per fry. The hatchery would be willing to spend at most $26,154 annually ($2,180/mo.) for a commercial substitute.[15] The estimate includes savings resulting from decreased variable costs including rent, electricity, labor, and supplies.



[15]Cost per unit fry for production without costs and capital associated with artemia production was estimated at 20.52¢/fry, a per fry cost of 2.18¢ less than the base model.

Rotifer Production

Outsourcing or purchase of commercial rotifers was also calculated using an analysis similar to the methods used to measure the effect of replacing artemia enrichment production. The most the hatchery is willing to spend on commercial rotifer products is approximately $19,320 annually ($1,610/mo.). Substitution of in-house rotifer production should also consider the effects of the substitute on hatchery production efficiencies.

Industry Climate

The market demand for Pacific threadfin may not support large-scale production. According to Hawaii Agricultural Statistics Service unpublished data for 1999, 119,568 lbs of Pacific threadfin were sold or exchanged in the market. For an average market weight of 1 lb and average growout survival rate of 87.8%, the current annual local demand is less than 150,000 fingerlings. Consequently, while Pacific threadfin hatchery production reveals significant economies of size, large-scale production may not be economically viable. In some cases, size economies may be required to keep production costs down to support alternative culture methods. An alternative to seeking economies of size is to seek efficiencies through a multi-product or multiphase approach (economies of scope). A multi-product strategy may require carefully planned production scheduling for different species of fish. A multiphase strategy, on the other hand, can combine hatchery and growout production in a single facility. The multiphase approach can also seek multi-product revenues from the sale of fry (hatchery production) and market-size Pacific threadfin (growout production).

From a marketing perspective, large-scale production may be feasible through increased consumer demand. Pacific threadfin has become a player in Hawaii aquaculture within the last three years. As the market for Pacific threadfin develops, Hawaii state officials expect to promote Pacific threadfin as a high-end export product (Wagner 1998). With the recent trend of increased consumer awareness, higher (and more efficient) fry production levels may be suitable for stock enhancement efforts and serve as seedstock to commercial growout farms. Commercial Pacific threadfin growout farms currently receive fry at a price of 25¢ per fingerling and are achieving returns of over 35% (Martinez-Cordero et al. 2001). In addition, mariculture in the form of offshore cage production may support the increased demand required for large-scale hatchery production. A production facility of six small cages, for example, is capable of providing 914,271 lbs of Pacific threadfin for market sale per year. Each cage would require seedstock of 135,000 fry (1,620,000 fry per year), suggesting that fry production facilities of the scale investigated in this study may be economically viable with cage infrastructures in place.

Conclusion

Factors contributing to economies of size for a commercial Pacific threadfin hatchery were studied. Based on the facility parameters, and estimated start-up and development costs, the unit cost before tax is estimated at 22.01¢ per fry for annual production of 1.2 million 1.00-g fry. An internal rate of return of 30.63% for the base model of 1.2 million fry is expected for seedstock sold at 25¢ per fry. Facility production was modified for 900,000 and 600,000 fry levels, and results suggest that significant economies of size exist for a commercial hatchery. At present, higher cost seedstock from smaller hatchery production systems may be prohibitive to commercial Pacific threadfin growout facilities.

Further analyses were conducted and serve as bases for managerial decision making. An analysis of nursery production revealed that the break-even price increases at a diminishing rate for longer nursery periods. The effect of nursery length on profitability, however, is contingent upon the market demand for different size fry.

Analyses on the cost savings resulting from the elimination of in-house live feed production were also calculated. The estimated production costs associated with enriched artemia, rotifer, and microalgae feeds could represent the maximum price that a commercial hatchery is willing to spend on outsourcing or investing in commercial substitutes for each type of feed. In particular, the applicability of commercial substitutes for microalgae was investigated. According to the analysis, substitute products currently available may be cost-effective if satisfactory rotifer production yields are possible. Production efficiency information was not available, but is relevant to determining the net benefit of introducing commercial substitutes to the hatchery production technology.

The effect of supply prices on production cost and profitability is also possible using the flexible spreadsheet model. A price sensitivity analysis measured the linear impact of artemia price on cost per fry. In light of the price sensitivity of hatchery production to artemia price, escalating costs for artemia cysts, and scarce supply, the consequences compel the need for an adequate substitute for enriched artemia and/or improved technology.

Appendices

Appendix A

A.1 Development Assumptions (1,200,000 fry)

DEVELOPMENT (20 Year Depreciation)	Unit	Value
Variable		
Drilling for Seawater Pump	$/ft	350
Open Area Construction	$/ft^2	10
Warehouse Area Construction	$/ft^2	50
Lab/Building Construction	$/ft^2	150
Grading (Site Preparation)	$/acre	75,000
Sea Water Pump Required		
- capacity	GPM	166
- depth of well	ft	75
- Pump Efficiency	%	70
- Total Dynamic Head	ft	100
- HP Required (min if no recommendation)	hp	10.0
- HP Source Pump Recommendation	hp	10.0
Blower Pump Required		
- recommended HP	hp	1.5
Fixed		
Utility Installation	Total $	22,000
PVC Plumbing Costs (Materials + Labor)	Total $	33,000
Site Survey	Total $	2,500

A.2 Expense Rate Assumption (1,200,00 fry)

VARIABLE EXPENSE RATES	Unit	Value
Electricity Rate	$/kwh	0.17
Rent (per acre) if greater than	$/acre/year	1,200
Or percentage of Gross Revenue	% of Gross Rev.	2
Utilities (Electricity & Water)	$/sq. m	5.00
Maintenance	%	5
Fringe Benefits	%	25
Contingency (% of Operational Expenses)	%	5
Design & Planning (% of Development)	%	12

A.3 Financial Parameters (1,200,000 fry)

FINANCIAL ANALYSIS	Unit	Value
Discount (Risk)	%	12
Sale Price per Fry	$/ea	0.25
Loan Rate, Annual	%	10
Loan Life	years	30
Capital Outlay Covered by Loan	%	80
GE Excise Tax Rate	%	0.5

Appendix B

B. Facility Area in Detail (1,200,000 fry)

AREA	Total Area (m²)	%
Fry Production		
- Nursery	31.50	5.32
- Larval Rearing	40.32	6.81
- Spawning	126.00	21.28
Subtotal: Fry Production	197.82	33.41
Live Feed		
- Algae		
Indoor Lab Culture	28.00	4.73
Outdoor Culture	246.75	41.68
Sub-Total	274.75	46.40
- Artemia	10.50	1.77
- Rotifers	14.00	2.36
Subtotal: Live Feed	299.25	50.54
Shared Area		
- Lab Space	45.00	7.60
- Office Space	50.00	8.44
Other Area Sub-Total	95.00	16.05
Total Area	592.07	100.00
Summary		
- Total Office/Lab	123.00	20.77
- Total Indoor Operations	64.82	10.95
- Total Outdoor Operations	404.25	68.28
Total Area	592.07	100.00

Appendix C

C.1 Equipment in Detail (1,200,000 fry)

SPAWNING Equipment	**Qty/Tank**	**Qty/Facility**	**Life (yrs)**	**Unit Cost ($)**	**Total Cost ($)**
Broodstock Tank	-	2	15	15,000	30,000
Airstones	6	12	5	3	36
Shadecloth (80%)	1	2	10	400	800
Transfer Tank	1	1	10	500	500
Identification Reader	1	1	15	1,500	1,500
Identification Tags	30	60	5	5	300
Quarantine Tank (10-12 ft)	1	1	15	1,500	1,500
Broodstock	30	60	5	35	2,100
Misc Equipment*	1	1	5	500	500
Other	-	-	0		
Total Equipment Cost					37,236

LARVAL REARING Equipment	**Qty/Tank**	**Qty/Facility**	**Life (yrs)**	**Unit Cost ($)**	**Total Cost ($)**
Airstones	4	16	5	3	48
Harvest Cradle	1	1	20	100	100
Heaters	2	8	15	400	3,200
Larval Rearing Tanks	-	4	15	4,000	16,000
Ring Airstones	1	4	10	15	60
Separation Tank (100*l*)	1	1	10	1,000	1,000
Misc Equipment*	1	1	5	500	500
Total Equipment Cost					20,908

NURSERY Equipment	**Qty/Tank**	**Qty/Facility**	**Life (yrs)**	**Unit Cost ($)**	**Total Cost ($)**
Nursery Tank	-	8	20	2,500	20,000
Airstones	4	32	5	3	96
Misc Equipment*	-	1	5	500	500
Total Equipment Cost					20,596

ALGAE Equipment	Qty/VT Tank	Qty/Facility	Life (yrs)	Unit Cost ($)	Total Cost ($)
VT Tank	1	3	20	7,000	21,000
RW Tank	1	3	20	5,000	15,000
IT Tank	1	3	20	300	900
Flask	2	6	5	5	30
Filter System	1	1	15	30	30
Small Submersible pump	2	2	20	125	250
Large Submersible pump	2	2	20	180	360
Misc. Equipment	1	1	5	500	500
VT Airstones	20	60	5	3	180
RW Airstones	15	45	5	3	135
IT Airstones	4	12	5	3	36
Total Equipment Cost					38,421

ARTEMIA Equipment	Qty/Enr-Tank	Qty/Facility	Life (yrs)	Unit Cost ($)	Total Cost ($)
Hatching Tanks	0.5	2	20	500	1,000
Enrichment Tanks	1	4	20	200	800
Airstones	5	30	5	3	90
Filters	1	6	5	5	30
Heater (per harvest tanks)	2	4	5	100	400
Valves	5	30	5	2	60
Stands, Enrichment Tank	1	4	20	200	800
Misc Equipment*	1	1	5	500	500
Total Equipment Cost					3,680

ROTIFER Equipment	Qty/Tank	Qty/Facility	Life (yrs)	Unit Cost ($)	Total Cost ($)
Fiberglass Tanks	-	8.0	20	400	3,200
Heaters	2.0	16.0	10	100	1,600
Airstones	3.0	24.0	5	3	72
Misc Equipment*	1.0	1.0	5	500	500
Total Equipment Cost					5,372

SHARED Equipment	Qty	Life (yrs)	Unit Cost ($)	Total Cost ($)
Water Analysis Meter (e.g. YS1)	1	5	1,500	1,500
Microscope	1	20	500	500
Macroscope	1	20	500	500
Scale, Micro (<2000 g)	1	15	1,200	1,200
Scale, Macro (<25 kg)	1	15	1,500	1,500
Hot Plate (sterilization)	1	15	300	300
Fan Filter	1	20	750	750
Blower (including back-up unit)	3	20	650	1,950
Seawater Pump (including back-up unit)	2	20	3,800	7,000
Var. Freq Drive/Controller for Pump	1	20	8,500	8,500
Trucks	1	20	10,000	10,000
Total Equipment Cost				33,700

TOTAL FACILITY EQUIPMENT COST	**159,913**

*Misc. equipment includes items such as beakers, nets, siphons, test tubes, air-tubing, buckets, counters, harvesting equipment, etc.

C.2 Supplies in Detail (1,200,000 fry)

ALGAE Supplies	Unit	Cycle Usage	Stock Unit Size	Unit Cost($)	Cycle Cost($)	Annual Cost($)
Chemical Supply Cost Summary						
Liquid Bleach (5.25% sodium hypochlorite)	l iter	0.6139	3.79	5.00	0.81	8.92
Sodium Thiosulfate	kg	0.8944	22.70	64.00	2.52	27.74
Nitrate Stock Sol (potassium nitrate)	kg	0.0313	22.70	25.00	0.03	0.38
Phosphate Stock Solution						
- Sodium Phosphate (monobasic)	kg	0.0014	22.70	118.00	0.01	0.08
- HCl (concentrated)	liter	0.0011	3.79	4.00	0.00	0.01
- Calcium Chloride	kg	0.0019	22.70	20.00	0.00	0.02
Iron Stock Solution (Fe-EDTA)	kg	0.9000	22.70	243.00	9.63	105.98
Chlorine (12% sodium hypochlorite)	liter	3.4547	56.78	96.00	5.84	64.26
Ammonium Sulfate	kg	8.1249	36.32	19.00	4.25	46.75
Monopotassium Phosphate	kg	2.4375	45.40	108.00	5.80	63.78
Urea (Prill)	kg	0.4126	18.16	18.00	0.41	4.50
Trace Metals*	kg	0.0835	4.67	207.00	3.70	40.72
Total Chemical Cost					33.01	363.14

ALGAE – Other Supplies	Unit	Tank Usage	Facility Usage	Stock Unit	Cycle Cost($)	Annual Cost($)
Carboy (polyethelene bags)	ea	1	3	200	50.00	8.80
Total Algae Supplies Cost						371.94

ARTEMIA Supplies	Unit	Cycle Usage	Facility Usage	Unit Cost($)	Cycle Cost($)	Annual Cost($)
Cysts Cans	can	6.22	24.88	45.00	1,119.49	12,314
Enrichment Bottles	bottle	0.56	18.81	46.00	865.12	9,516
Total Artemia Supplies					1,984.61	21,831

ROTIFER Supplies	Unit	Cycle Usage	Facility Usage	Unit Cost($)	Cycle Cost($)	Annual Cost($)
Bakers Yeast	case	.01126	0.87	12.00	10.50	116
Total Rotifer Supplies					10.50	116

SHARED Supplies	Qty	Unit Price($)	Annual Usage(mi)	Annual Total($)
Fuel for Truck (*qty=mi/gal)	25 gal	1.55	10,950	667
Miscellaneous Supplies	4 ea.	500		2,000
Total	-	-	-	2,667

TOTAL FACILITY SUPPLIES COST	24,985

C.3 Feed in Detail (1,200,000 fry)

SPAWNING Feed	Daily (kg)	Cycle Amt (kg)	Stock Size (kg)	Unit Price ($)	Annual Cost($)
Raw Feed	2.54	77.29	20.00	50.00	2,319
Artificial Feed	0.05	1.61	20.00	55.00	53
Total Feed Cost	-	-	-	-	2,372

LARVAL REARING Feed	Facility Usage(kg)	Stock Size (kg)	Unit Price($)	Cycle Cost($)	Annual Cost($)
Artificial Feed	4.71	20.00	55.00	12.95	142

NURSERY Feed	Tank Usage (kg)	Facility Usage(kg)	Stock Size (kg)	Unit Price($)	Cycle Cost($)	Annual Cost($)
Artificial Feed	6.45	96.78	20.00	55.00	266	2,928

TOTAL FACILITY FEED COST	5,442

Appendix D

D. Year-Round Labor Requirements and Payroll Detail (1,200,000 fry)

LABOR REQUIREMENTS	Hourly Salary($)	Benefits* (%)	Daily Hrs	Cycle Hrs	Annual Hrs	Annual Pay($)	%
Hatchery Manager	16.00	25	8.00	174	2,080	41,600	32.00
Sub-Total Administration				174	2,080	41,600	32.00
Spawning Activities	14.00	25	3.00	91	1,095	19,163	14.74
Larval Rearing Activities	14.00	25	4.00	100	1,200	21,000	16.15
Nursery Activities	14.00	25	4.00	60	720	12,600	9.69
Sub-total Production				251	3,015	52,763	40.59
Live Feed Algae Activities	14.00	25	2.00	61	730	12,775	9.83
Live Feed Artemia Activities	14.00	25	3.00	48	576	10,080	7.75
Live Feed Rotifer Activities	14.00	25	2.00	61	730	12,775	9.83
Sub-total Live Feed				170	2,036	35,630	27.41
Total				595	7,131	129,993	100.00

*Fringe Benefits = % of hourly wage

PERSONNEL BREAKDOWN	Persons	Annual Hours
Full-Time Hatchery Manager	1	2,080
Full-Time Technician	2	4,160
Part-Time Technician	1	891
Equivalent Full-Time Employees	4	7,131

Appendix E

E. Operations Associated with Energy Expenses

WATER USAGE	Gallons/Cycle	Gallons/Yr	Gallons/Minute	%
Fry Production				
- Nursery	1,020,730	11,228,026	47.26	26.18
- Larval Rearing	739,200	8,131,200	20.53	18.96
- Spawning	1,927,200	23,126,400	44.00	53.93
Sub-total	3,687,130	42,485,626	111.79	99.07
Live Feed				
- Algae	21,470	236,169	0.49	0.55
- Artemia	6,703	73,731	0.29	0.17
- Rotifers	8,208	90,290	0.19	0.21
Sub-total	36,381	400,190	0.97	0.93
Total Water Pump Usage	3,723,511	42,885,816	112.76	100.00
Maximum Water Usage				
- Nursery			63.36	38.16
- Larval Rearing			58.67	35.34
- Spawning			44.00	26.50
Total Max GPM for Facility			166.03	100.00

BLOWER USAGE	FT^3/Cycle	FT^3/Yr	FT^3/Minute	%
Fry Production				
- Nursery	172,800	1,900,800	8.00	9.23
- Larval Rearing	172,800	1,900,800	4.80	9.23
- Spawning	525,600	6,307,200	12.00	30.63
Sub-total	871,200	10,108,800	24.80	49.09
Live Feed				
- Algae	659,913	7,259,041	15.53	35.25
- Artemia	61,398	675,373	2.66	3.28
- Rotifers	231,790	2,549,686	5.29	12.38
Sub-total	953,100	10,484,100	23.49	50.91
Total Blower Usage	1,824,300	20,592,900	48.29	100.00

HEATER USAGE	**KWH/Cycle**	**KWH/Yr**	**%**
Fry Production			
- Nursery			0.00
- Larval Rearing	-	-	0.00
- Spawning			0.00
Sub-total	-	-	0.00
Live Feed			
- Algae			0.00
- Artemia	122	1,341	9.82
- Rotifer	1,119	12,312	90.18
Sub-total	1,241	13,653	100.00
Total Heater Energy Usage	1,241	13,653	100.00

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