AGRIBUSINESS

Cooperative Extension Service • Department of Agricultural and Resource Economics • University of Hawai'i at Mānoa

Number 9 • February 1995

The Economics of Revitalizing Hawaiian Fishpond Production

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Fishpond construction in Hawaii started about 1,000 years ago and reached its zenith in the early 19th-century. The ravages of great waves and storms combined with the decline of the native population left most of the ancient ponds unused by the end of the 19th-century. Today, however, there is an opportunity to revitalize these ponds and perhaps to make them productive, profitable, and culturally rewarding once again. Fishpond production has the potential to be the largest component of Hawaiian aquaculture. An economic model of fishpond production is developed. Fishpond aquaculture is shown to be profitable in some circumstances.

Archeological and historical evidence suggests that Hawaiian fishponds were constructed as early as AD 1000 and continued to be built until the 1820's. Fishpond construction intensified beginning in the late 1500's and early 1600's when the Hawaiian population was rapidly expanding and sociopolitical systems became more complex. Various estimates place the number of fishponds at one time from 300 to 500, ranging in size from less than an acre to over 100 acres.

The products of the original ponds were primarily reserved for the chiefly rank, the ali'i. However, as Hawai'i became increasingly democratized in the late 19th-century, the ponds became a valuable food source for all of the people. For complex social and physical reasons, today there are only a dozen ponds actively farmed and properly managed. However, the potential now exists for economic revitalization of neglected ponds. Revitalization involves applying modern aquaculture technology to ancient pond management skills.

AGRIBUSINESS is published by the Department of Agricultural & Resource Economics. Each issue addresses an economic or management topic of current concern to Hawai'i agribusiness.

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The challenge of fishpond revitalization is to create an economically viable and environmentally sustainable aquaculture enterprise which also provides cultural benefits to society. Productive fishponds are culturally, educationally, environmentally and aesthetically rewarding, however it is difficult to quantify these social benefits. The present analysis focuses on the profitability of operating a revitalized fishpond.

Economic considerations

Some observers have characterized the ponds as being "dormant ocean farms". This analogy helps one to view fishponds as another component of the overall agriculture economy. As in many other areas of Hawai'i's diversified agricultural economy, fishpond successes have often been small, family owned and operated farms, businesses which do not require a substantial cash flow to pay hired-labor or high ownership costs for land and capital investment.

Fishponds in a high state of disrepair may never become profitable if the capital required for restoration, including the extraordinarily complex permitting process, is excessive. *(The Proceedings of Hana Symposium II,* 1993) There is a significant cost in time and money to obtain the many permits and reviews currently required. Restoration costs can be somewhat mitigated if greater flexibility in the use of modern construction machinery and materials is permitted in building and repairing fishpond walls and gates. However, the annualized costs of this long term investment must be justified by the potential income.

The economics of fishpond production is further complicated by the absence of a well-defined market. The potential production is enormous. For example, Paul Bienfang of the Oceanic Institute reported that fishpond production on Moloka'i alone (300 acres) could produce five times the entire 1992 aquaculture output in Hawai'i. (*Proceedings*, p. 15) However, the market for this level of production must be clearly defined and carefully developed. Individual consumers, fish markets, and restaurants expect a reliable supply of a quality product at a reasonable price. Fishpond operators may find it particularly profitable to supply the out-of-season demand. There are also other potential markets that growers may wish to develop. For example, with the depletion of Hawai'i's reef population, there may be an opportunity to supply the state with fish for "stock enhancement", i.e., for re-stocking the native fish populations. Mullet and milkfish can also be used as live baitfish. Fishermen find mullet and milkfish as attractive as traditional bait and more hardy. (*Hawaiian Fishpond Revitalization: A Manual*, 1993)

Hui O Loko I'a, an association of fishpond owner/operators, has been established to share management knowledge and expertise, to encourage cultural and historical awareness, and to cooperate on market development. In light of the successful models of smaller-scale production systems in other enterprises and recognizing the inherent cultural value of traditional fishponds, economic development efforts directed toward restoration of fishpond production will likely concentrate on the scale of a "cottage industry" operated by a "multiple-income farm family" (or"miff") in close cooperation with other miffs. A plantation-scale, industrial-style, centralized approach to fishpond production would appear to be inappropriate.

Methodology

An economic model of fishpond production was created based on data from currently operating fishponds. Production practices in the operating section are typical of the well managed fishponds, but the operating input costs are *typical* rather than average. In order to use the fishpond model effectively, one needs to possess a good understanding of fishpond production practices. A technical description of the various production practices is beyond the scope of this economic analysis but is available in the *Manual* (1993).

Leung and Rowland (1989) have designed a computer spreadsheet model for the financial analysis of shrimp production. It is flexible enough to accommodate the evaluation of other aquaculture systems. The shrimp model, for example, can include a hatchery component. By contrast, the fishpond model is specific to the situations encountered by an operator of a revitalized traditional fishpond. Shrimp aquaculture is an intensive, relatively industrialized production system fundamentally different from the extensive production system of fishpond aquaculture.

The shrimp model is more comprehensive than the fishpond model. For example, the shrimp model takes into account the time value of money, providing a discounted cash flow, the internal rate of return (IRR), and the net present value (NPV) for a proposed investment. The fishpond model, by contrast, focuses on a typical year of operation before tax. Therefore, the fishpond model should be viewed primarily as a management tool. If one needs to obtain financing or evaluate a proposed investment, the fishpond economic analysis functions only as the first step in the process of a complete financial or investment analysis, an example of which is well articulated by the shrimp model.

Producers need to decide which variety or varieties of fish to raise and how often and to what degree to stock the pond. The varieties raised will usually include one or more of the highly desirable traditional species: mullet ('ama 'ama), milkfish (awa), and moi. The different feeding habits of mullet and awa make them a compatible combination for our example pond. The pond is stocked two times a year at the rate of 1,000 fingerlings per acre/stocking. We are assuming a 60% survival rate (*i.e.*, a 40% mortality rate), thus 2,000 fingerlings would yield 1,200 fish for market. These would average about .75 pounds each, or 900 pounds per acre per year.

Most traditional fishpond production will not involve feeding a supplement to fish beyond the early "starter" stage. In our example the nursery stock is fed for 90 days. Users of this economic model can choose either to feed or not to feed, and if feeding, to feed either a starter or a grower supplement.

Finally, the producer must decide upon a marketing plan. Some may choose a batch processing strategy, that is, stocking a pond, growing and harvesting the entire crop at one time, and marketing the fish all at once. The marketing plan will of course depend upon the nature of the market demand. A more difficult although potentially more profitable management strategy would be to harvest and market weekly, and to include fish for both direct consumption and bait. This management plan is the strategy illustrated in the fishpond economic model. The computer program calculates harvest costs based on the yield assumptions and the preferred marketing plan.

The ownership arrangements in the ownership part of the model are also meant to reflect a typical situation. Currently, much of the land devoted to traditional fishponds is leased. The example pond assumes leased land, but any ownership structure can be used. Fishpond production is relatively labor intensive, but there may be some opportunity for mechanization. The example farm is not mechanized, but a wide range of production techniques can be considered.

The "bottom line" for the operations component of the model is *gross margin*, the gross revenue minus all of the operating costs, the amount available to pay for the ownership costs. The ownership "bottom line" is *economic profit*, the gross margin minus the value of all of the ownership resources (i.e., the management, capital and land resources) and an appropriate adjustment to account for the riskiness of the enterprise.

Most farmers (whatever their business enterprise) do not include the full value of their labor, management and owner equity in their profitability calculations. They often think of their "profit" as the residual of their farming effort. However, economic profit includes the value of *all* productive resources. The return to the farmer should equal or exceed the value of his labor, management, and owner equity. If these returns are at least equal to their values, the

TABLE 1. GROSS MARGIN Typical annual (1994) gross income, operating costs and gross margin.

ASSUMPTIONS:

1 Annual stocking rate	2,000	fish/acre/year	9 Ave. harvest size	0.75	lb.
2 Stock pond	2	times/year	10 No. of harvests	52	times/yr.
3 Survival rate	60%	fish stocked	11 Size of pond	16	acres
4 Ave. size fingerling	2	ounces each	12 Labor wage rate	$7.50	per hour
5 Feed fingerlings @	3%	of body wt.	13 Benefits as %	33%	of wage
6 Feed fingerlings for	90	days	14 Debt/asset ratio	40%	
7 Ave. grow-feed conv.	2.85	#feed/#gain	15 Bank loan rate	10.0%	*calc. wt. ave. cost of*
8 Feed growers for	0	days	16 Return on equity	5.0%	*money = 7.0%*

I. GROSS INCOME:	*% of mix:*	*# of units:*	*units:*	*$/pound*	*$/acre:*	*$/pond*	*% gross*
A. Mullet	***70%***	630	lbs./acre/yr.	***$3.00***	$1,890	$30,240	66.7%
B. Milkfish (awa)	30%	270	lbs./acre/yr.	***$3.50***	945	15,120	33.3%
I. Total gross income =	100%	900	lbs./acre/yr.	**$3.15**	2,835	**$45,360**	**100.0%**

II. OPERATING COSTS:		*# of units:*	*units:*	*$/unit:*	*$/acre:*	*$/pond*	*% gross*
A. Growing costs:	*Per pond/yr basis*						
1 **Stocking**	*Hrs./stocking:*		*$/lb. sold =*	**$0.56**	**$503.74**	**$8,060**	**17.8%**
a. Mullet		1400	fingerling/ac.	***$0.25***	350.00	5,600	12.3%
b. Milkfish		600	fingerling/ac.	***$0.25***	150.00	2,400	5.3%
c. Labor to stock	***3.0***	6	hrs./pond/yr.	$9.98	3.74	60	0.1%
2 **Feeding**	*Min./day/pond:*		*$/lb. sold =*	**$0.12**	**$103.57**	**$1,657**	**3.7%**
a. Feed for nursery stock		675.0	lbs./pond/yr.	***0.46***	19.41	311	0.7%
b. Feed for finishing stock		0.0	lbs./pond/yr.	***0.46***	0.00	0	0.0%
c. Labor to feed	***45***	135.0	hrs./pond/yr.	$9.98	84.16	1,347	3.0%
3 **Maintenance**	*Min./day/pond:*		*$/lb. sold =*	**$0.26**	**$233.17**	**$3,731**	**8.2%**
a. Supplies	*Enter total $/fishpond/year =>*			N.A.	62.5	***1,000***	2.2%
b. Labor	***45***	273.8	hrs./pond/yr.	$9.98	170.67	2,731	6.0%
4 **Operating interest**		***10.0%***	*$/lb. sold =*	**$0.05**	**$42.02**	**$672**	**1.5%**
	Total growing costs =			**$0.98**	$882.50	$14,120	31.1%
B. Harvesting costs:	*Per pond/yr basis*						
1 **Harvesting**	*Hours/harvesting:*		*$/lb. sold =*	**$0.07**	**$64.84**	**$1,037**	**2.3%**
a. Harvest labor	***2.0***	104.0	hrs./pond/yr.	$9.98	64.84	1,037	2.3%
b. Miscellaneous	*Enter total $/fishpond/year =>*			N.A.	0	***0***	0.0%
2 **Packing & shipping**			*$/lb. sold. =*	**$0.05**	**$46.39**	**$1,169**	**2.6%**
a. Ice		25	lbs./harvest	***$0.50***	40.63	650	1.4%
b. Packing labor	***1.0***	52.0	hrs./pond/yr.	$9.98	5.76	519	1.1%
3 **Marketing**			*$/lb. sold. =*	**$1.02**	**$915.60**	**$14,650**	**32.3%**
a. Excise tax		$45,360	gross /pond	4.17%	118.22	1,892	4.2%
b. Transportation to market		52	trips/year	***$25.00***	81.25	1,300	2.9%
c. Marketing labor	***4.7***	244.4	hrs./pond/yr.	$9.98	716.13	11,458	25.3%
	Total harvesting costs =			**$1.14**	$1,026.83	$16,856	37.2%
	II. TOTAL OPERATING COSTS =			**$2.12**	**$1,909**	**$30,976**	**68.3%**
III. GROSS MARGIN	*Gross income minus operating costs =*			**$1.03**	**$926**	**$14,384**	**31.7%**

TABLE 2. ECONOMIC PROFIT Typical annualized ownership costs, economic & financial profits, and gross margin & economic profit break-even analysis.

III. GROSS MARGIN	*Gross income minus operating costs =*			**$1.03**	**$926**	**$14,384**	**31.7%**
IV. OWNERSHIP ("Fixed") COSTS:			*Pond basis*	*$/unit:*	*$/acre:*	*$/pond*	*% gross*
A. Management resource			*$/lb. sold =*	**$0.22**	**$198.45**	**$3,175**	**7.0%**
1. Management fee	$45,360	gross /pond		***5.0%***	141.75	2,268	5.0%
2. Office overhead	$45,360	gross /pond		***2.0%***	56.70	907	2.0%
B. Capital resources	*cost:*	*life:*	*Repairs, tax, ins.*	**$0.51**	**$460.62**	**$7,370**	**16.2%**
1. Permits & reviews	***$5,000***	***10***	***0.0%***		44.49	712	1.6%
2. Pond restoration	***$15,000***	***10***	***0.0%***		133.48	2,136	4.7%
3. Other start-up exp	***$2,000***	***10***	***0.0%***		17.80	285	0.6%
4. Pen encl.. & nets	***$4,000***	***3***	***5.0%***		82.76	1,324	2.9%
5. Oxygen meter	***$1,200***	***5***	***3.0%***		16.04	257	0.6%
6. Other equipment	***$1,000***	***5***	***4.0%***		12.74	204	0.4%
7. Truck	***$7,000***	***3***	***5.0%***		144.84	2,317	5.1%
8. Other machinery	***$1,000***	***7***	***5.0%***		8.47	136	0.3%
9. Other cap. expens	***$0***	***5***	***4.0%***		0.00	0	0.0%
Total capital investment =	**$36,200**	5.0% rtn. on equity of		$21,720	$67.88	$1,086	2.4%
C. Land resource	*value:*	*term:*	*interest:*	**$0.14**	**$125.00**	**$2,000**	**4.4%**
a. Mortgage paymen	0	20	10.0%		0.00	0	0.0%
b. Base lease rent payment	*Enter total $/fishpond/year =>*				93.75	***1,500***	3.3%
c. Percentage of gross over	***0.00%***	***$0.00***			0.00	***0***	0.0%
d. Imputed lease rent	*Enter total $/fishpond/year =>*				0.00	***0***	0.0%
e. Property tax, etc.	*Enter total $/fishpond/year =>*				31.25	***500***	1.1%
D. Risk contingency	$45,360	gross /pond	***4%***	**$0.13**	**$113.40**	**$1,814**	**4.0%**
IV. TOTAL OWNERSHIP COSTS =				**$1.00**	**$897**	**$14,360**	**31.7%**
V. TOTAL COST OF PRODUCTION =				**$3.12**	**$2,807**	**$45,335**	**99.9%**
VI. ECONOMIC PROFIT =				**$0.03**	**$28**	**$25**	**0.1%**

Financial "Profit":		*$/unit:*	*$/acre:*	*$/pond*	*% gross*
Value of labor, assuming	815 hrs./yr. =	$0.56	$508.20	**$8,131**	17.9%
Return to labor, management, owner equity & risk =		$0.93	$832.76	**$13,324**	29.4%

BREAK-EVEN ANALYSIS: Gross margin = μ; economic profit = π	*μ /ac./yr.=$0*	*π /ac./yr.=$0*	
In order to cover operating & total costs, μ & π, respectively, must be >= $0:	*when:*	*when:*	
given the current ave. yield of **900** lbs sold/ac/yr, break-even ave. PRICE =	**$2.12**	**$3.12**	$/lb sold
given the current ave. price of **$3.15** /lb. fish, the break-even YIELD/acre/yr. =	**606**	**891**	lbs sold

fishpond can be considered to be "profitable". (In practice, the actual receipt of these returns may need to be postponed in order to "cash flow" a fishpond operation.)

Economic profit, as opposed to "accounting" or "financial" profit, is a better measure of true farm profitability because it is net of *all* costs, not simply cash costs. In the long run we would expect economic profit to equal zero because all "out-of-pocket" expenses will have been paid and all productive resources, such as land, labor, management, and the owner's capital investment, will have received a "fair" return, *i.e.*, a return at least equal to their value. We would therefore expect that significantly positive economic profitability would attract more producers into the industry, and that negative economic profitability would encourage producers to exit the industry.

Results

The complete results are provided as Tables 1 and 2, the computer printout of the model and example calculations. The "basic assumptions" and the bold italicized figures represent data entries provided by growers. However, any of these entries (variables) can be altered to fit another user's situation. The results are specific to the growers who provided information, and they may be viewed as fairly typical but not necessarily average. By contrast, the non-italicized (i.e., upright) figures indicate computer calculated results or fixed categories for which no entry is necessary or possible. The model must be used with the appropriate data to obtain meaningful results for a specific fishpond.

The summary results (Table 3) are obviously easier to read than the complete results provided in Tables 1 and 2. However, the detailed results have two important advantages. First, the "transparency" of the spreadsheet approach allows one to observe exactly how each of the costs were calculated. And secondly, the greater detail enables a current or prospective fishpond operator to see what kinds of data are needed in order to calculate the profitability of a specific fishpond operation. With the appropriate data growers can use the economic model, with a university extension agent, a consultant, or on their own, to calculate enterprise profitability and to consider the economic impact of proposed or anticipated production, marketing, or policy changes, that is, to answer strategic "what if?" questions.

The question most commonly asked of an economic profitability analysis is, "How much money could an owner/operator typically expect to earn annually from this enterprise?" In other words, what is the financial profit (the returns to owner equity, management, labor and risk), given a specific set of assumptions?

(a) *Value of equity:* This grower invested 60% of his own money into the total investment of $36,200, that is, $21.720. (This investment allocates only $5,000 for the permitting process, perhaps an unrealistically low figure given the high level of regulation.) The grower feels he only needs to receive 5% on his equity, therefore his annual return to equity is $1,086. (If any land were owned, an imputed rent would be included here.)

(b) *Value of management:* He will provide all of the management, and the value of management is estimated to be 5% of the total annual gross sales ($45,360), which amounts to $2,268 annually.

(c) *Value of labor:* It is assumed that he will provide all required labor, estimated to be 815 hours per year. The annual value of this labor, assuming $7.50 per hour, plus benefits at 33% of the wage rate, is

TABLE 3: SUMMARY OF RESULTS (from Tables 1 & 2 above)

Gross Income:	*Lbs sold/yr:*	*$/pound*	*$/pond:*
Total sales =	14,400	**$3.15**	**$45,360**
Operating costs:		*$/pound*	*$/pond:*
Growing costs:			
1. Stocking		$0.56	$8,060
2. Feeding		$0.12	1,657
3. Maintenance		$0.26	3,731
4. Op. interest		$0.05	672
Total growing costs =		$0.98	$14,120
Harvest costs:			
1. Harvesting		$0.07	$1,037
2. Packing		$0.05	$1,169
3. Marketing		$1.02	$14,650
Total harvesting costs =		$1.14	$16,856
Total operating costs =		**$2.12**	**$30,976**
Gross Margin =		**$1.03**	**$14,384**
Ownership costs:			
1. Management		$0.22	$3,175
2. Capital		$0.51	$7,370
3. Land		$0.14	$2,000
4. Risk contingency		$0.13	$1,814
Total ownership costs =		**$1.00**	**$14,360**
Total costs =		**$3.12**	**$45,335**
Economic profit =		**$0.03**	**$25**
Financial profit:	*hours:*		
Value of labor	815	$9.98	$8,131
Value of owner equity		$21,720.00	$1,086
Rtn. to labor, mgmt., equity & risk		$832.76	**$13,324**

$8,131. Finally, as the risk-taking entrepreneur, he is entitled to the return to risk. (d) *Value of risk-taking:* This value is the allowance for risk (estimated as 4% of the gross sales or $1,814) plus the economic profit, in this case $25. (If the economic profit were negative, the returns to equity, management and labor would be reduced after the risk contingency was used up.) In our example total returns equal $13,324.

A break-even price is the price required to cover costs given a specific yield; a break-even yield is the yield required to cover costs, given a specific price. This analysis calculates the break-even price (per pound of fish sold) required to cover the operating costs and the total costs, given the assumed yield. It also calculates the break-even yield required to cover operating and total costs, given a specific price per pound. When the gross margin equals zero, all operating costs will have been paid. In the short run, growers will continue to produce as long as the gross margin is positive. When the economic profit is zero or greater, all costs of production will have been paid. We would expect growers to continue producing in the long run as long as the economic profit is positive. In our example the annual marketable yield per acre is 900 pounds (i.e., pounds of fish sold) and the weighted average price for each pound of yield is $3.15. Therefore, in order to cover all operating costs, a producer would have to receive at least $2.12 per pound or 606 pounds per acre; in order to cover total costs, he would need to receive at least $3.12 per pound of fish sold or 891 pounds per acre. Since he is receiving 3¢ per pound more than his minimum break-even price, we may assume that he would be inclined to remain in the industry.

Summary and conclusions

Functioning traditional Hawaiian fishponds have cultural, environmental, educational, aesthetic, and economic benefits. This paper focuses solely on the economic profitability aspects; it does not consider either liquidity (i.e., cash flow) or solvency. Fishpond production provides a highly desirable food source for the community and offers an income for the fishpond operator. Today, a few fishponds are operating successfully, but the current state permitting process forces most to remain dormant, to continue as a part of one of Hawaii's more important underdeveloped economic resources.

The fishpond model is intended as a management tool. To the extent that it better enables one to organize fishpond production data into useful economic information, it can lead to better economic decision-making. It allows one to quantify the actual economic performance and to project the potential economic profitability. It is not however a substitute for a full investment analysis.

While fishpond production is potentially profitable, profit margins are small, as they often are with agricultural enterprises. The profitability of any particular operation will depend upon the quality of the owner/ operator's management and marketing efforts. The operating costs are quite variable and must be closely monitored and controlled. The annual ownership costs are relatively more fixed because they are largely a function of the initial capital investment. Therefore, the start-up costs (which include the costs of completing the permitting process and complying with the attendant regulations) must be reasonable. The market must be well defined. Marketing will in most cases involve more than simply providing a commodity. It will include more creative possibilities, such as meeting the specific demands of chefs, of fisherman (for baitfish), and of agencies interested in restocking. Finally, these markets must be carefully developed and maintained.

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ACKNOWLEDGEMENTS:

The authors are grateful to the following people and organizations who helped to make this publication possible: the cooperative fishpond operators, who patiently explained their production practices and economic concerns; Dr. Richard Bowen and Dr. PingSun Leung of the Department of Agricultural & Resource Economics, both of whom reviewed this paper in its earlier stages and made constructive comments; the Hawai'i Fishpond Revitalization Project, for helping to fund the applied economic research; and the Hawai'i Island Economic Development Board for helping to fund the printing of this publication.

AGRIBUSINESS is published by the Department of Agricultural & Resource Economics. Each issue addresses an economic or management topic of current concern to Hawaii agribusiness. The primary purpose of this extension series is to provide decision-makers with information essential for sound economic choices. Each number in the series is reviewed by at least three qualified people representing one or more CTAHR departments and the potential users in the agribusiness community.

The "agribusiness community" is defined broadly to include agricultural producers and all of those who directly support them: legislators, policy-makers, and relevant government agency personnel; agricultural lenders, suppliers, consultants, applied researchers, and educators; chefs, food wholesalers, retailers, exporters and processors; public and private economic development board members; and the many others who provide the necessary infrastructure for sustainable agricultural production in Hawaii.

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The computer model used in the economic analysis was developed using Excel 5 on a Macintosh computer. The spreadsheet template is freely available in this format to anyone with access to a similar system or who can import an Excel 5 file into their preferred spreadsheet program. To obtain a free copy of the computer template or to comment on this publication, contact the editor directly at UH–Manoa, Kealakekua, HI 96750-0208. *Tel: (808) 322-9136* . Internet e-mail: fleming@uhunix.uhcc.hawaii.edu