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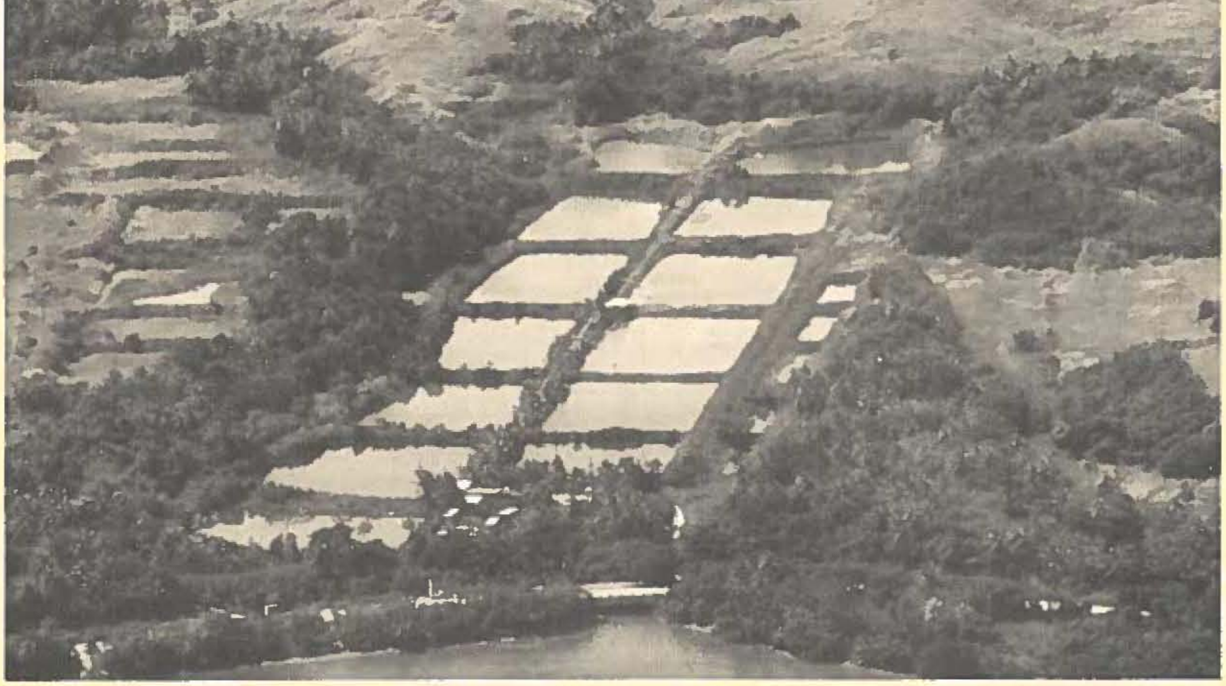

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Introduction

An aquaculture farmer is faced with a number of decisions, both short-term and long-term, in the operation of his farm. Some of the more fundamental questions include: Which species to culture? What culture method to use? What equipment to purchase? What size farm to operate? How much and what kind of feed? What type of pond design? A decision to implement various operational alternatives requires an understanding of the possible effects through time of biological and financial alternatives, and their interactions. This will allow maximization of the economic benefit to the aquaculture operation. Furthermore, by knowledgeable application of management tools in decision making, the risk in operating an aquaculture farm can be reduced.

This paper examines the means of evaluating some of the above questions and provides a cost analysis of culture methods currently utilized for the primary species harvested on Guam. Data from past and ongoing operations are utilized to determine break-even points and other economic measures for these species. The analysis should help identify options available when considering the risk factors involved in aquaculture.

The farmer will then be better able to judge the potential returns available from various aquaculture species and make informed decisions regarding alternative uses of capital, land and labor resources.

This paper addresses the economics of aquaculture production on Guam. Even though the data and the results are specific to Guam, the decision process and the techniques used to evaluate the data are universally applicable. The paper illustrates the major components of information needed by a farmer to make rational decisions in the operation of an aquaculture farm. Other authors have reviewed the concepts of applying economic measures in feasibility analysis of aquaculture (Shang, 1981 and 1982; Smith, 1982) and the socio-economic considerations that effect the development of the industry (Panayotou, 1982).

Methods

Break-even analysis is an important calculation in planning any small business operation. It indicates the sales-volume at which the business will break-even; that is, the level of production at which the project can just cover its total costs. Sales revenue is the product of two factors, namely, the volume of production and the price per unit of production. The farm's volume of production can be controlled to a certain extent by the manager through the manipulation of inputs and quality control mechanisms. The price per unit in an ideal market is set through an interaction of the demand and supply for the product; however, due to the relatively small number of suppliers, this ideal interaction is distorted as will be discussed below.

Break-even analysis is a means for integrating costs, revenues, and output in order to illustrate the probable impacts of alternative courses of action upon net profits. The economic basis of break-even analysis stems from the cost-to-output and revenue-to-output functions of the farm. The difference between the two is the net profit or loss at specific output levels. The break-even analysis presented in this paper represents short-run (one year) costs and revenue data for each farm under static conditions of farm size and technology.

An objective of management is to maximize net profit subject to the given physical structure and assets of the farm. This maximum occurs when the difference between total revenue and total cost attains the greatest positive value within the range of specific feasible outputs.

A ten-acre (four-hectare) farm was chosen as a representative size of a commercial aquaculture farm on Guam. The total manager's salary was charged to the aquaculture operation, since 100% of the manager's work time was required. On farms much smaller than ten acres, the manager's time may be divided among additional activities which generate income (e.g., vegetable or fruit farming).

Data presented in this paper (Table 1) are based upon the actual costs and production figures collected through interviews with the owners, managers and accountants, from three farms ranging in size from 9 to 11 acres (3.6 to 4.5 ha). Calculations are presented on a per-acre basis so that the results can be compared through a common unit of measurement. The range in farm size in this study is small, so the comparisons are not considered to be influenced by economies of scale.

The species to be considered are the freshwater prawn (*Macrobrachium rosenbergii*), tilapia (*Oreochromis mossambicus* x *O. niloticus*), milkfish (*Chanos chanos*), catfish (*Clarias batrachus*) and Chinese carps (*Hypophthalmichthys molitrix*, *Aristichthys nobilis* and *Ctenopharyngodon idella*). The carps are raised as secondary species.

In the polyculture system with *Macrobrachium rosenbergii* as the primary species (Farm 3), the secondary species consists of three species of Chinese carps. The carps are either planktivorous or herbivorous and consume only a minimum amount of the supplemental feed. A second polyculture system is also represented in the data (Farm 2). This system is comprised of tilapia as the primary species and *Clarias batrachus* as the secondary species. The production of these secondary

TABLE 1

COST ANALYSIS FOR DIFFERENT SPECIES AND CULTURE METHODS

ANNUAL OPERATING COST BASED ON ONE POND ACRE (0.405 HA) UNITS

BREAK DOWN OF COSTS	TILAPIA MONOCULTURE FARM #1		TILAPIA POLYCULTURE WITH CATFISH FARM #2		CATFISH SECONDARY SPECIES FARM #2		MILKFISH MONOCULTURE FARM #2		PRAWN POLYCULTURE WITH CARP FARM #3		CARP SECONDARY SPECIES FARM #3		CATFISH MONOCULTURE FARM #3	
VARIABLE COSTS														
Supplies	10,883.00		6,231.00		110.00		6,659.00		5,006.00		20.00		24,106.00	
Feed		9,900.00		4,622.00		0.00		5,200.00		2,160.00		0.00		20,000.00
Fertilizer		0.00		0.00		0.00		0.00		180.00		0.00		0.00
Fry & Post Larvae		100.00		1,200.00		110.00		1,050.00		2,560.00		20.00		4,000.00
Miscellaneous		833.00		409.00		0.00		409.00		106.00		0.00		106.00
Electrical/Fuel	1,920.00		1,527.00		0.00		1,527.00		480.00		0.00		480.00	
Labor	3,193.00		3,600.00		0.00		3,600.00		1,875.00				1,875.00	
Occassional Labor		500.00		0.00		0.00		0.00		375.00		0.00		375.00
Full Time Staff Salary		2,693.00		3,600.00		0.00		3,600.00		1,500.00		0.00		1,500.00
Miscellaneous	933.00		981.00		0.00		981.00		400.00		123.00		400.00	
Maintenance		400.00		545.00		0.00		545.00		300.00		0.00		300.00
Marketing Costs		533.00		436.00		0.00		436.00		100.00		123.00		100.00
TOTAL VARIABLE COSTS	$16,879.00		$12,339.00		$110.00		$12,767.00		$7,761.00		$143.00		$26,861.00	
FIXED COSTS														
Salary Personnel	2,693.00		2,215.00		0.00		2,215.00		2,313.00		0.00		2,313.00	
Full Time Manager Salary		2,693.00		2,215.00		0.00		2,215.00		2,313.00		0.00		2,313.00
Land	1,333.00		1,272.70		0.00		1,272.00		525.00		0.00		525.00	
Depreciation	4,696.00		1,535.00		0.00		1,535.00		1,201.00		0.00		1,201.00	
Ponds		3,704.00		555.00		0.00		555.00		569.00		0.00		569.00
Housing		22.00		97.00		0.00		97.00		89.00		0.00		89.00
Storage		37.00		13.00		0.00		13.00		38.00		0.00		38.00
Equipment		889.00		850.00		0.00		850.00		438.00		0.00		438.00
Miscellaneous		44.00		20.00		0.00		20.00		67.00		0.00		67.00
Interest	0.00		809.00		0.00		809.00		463.00		0.00		463.00	
License Fee	18.00		15.00		0.00		15.00		6.00		0.00		6.00	
Insurance & Acctg.	911.00		1,000.00		0.00		1,000.00		125.00		0.00		125.00	
TOTAL FIXED COSTS	$9,651.00		$6,846.70		$0.00		$6,846.70		$4,633.00		$0.00		$4,633.00	
TOTAL ANNUAL COSTS	$26,530.00		$19,185.70		$110.00		$19,613.70		$12,394.00		$143.00		$31,494.00	
VALUE OF PRODUCTION	$39,600.00		$18,165.40		$1,737.50		$25,064.00		$16,800.00		$2,000.00		$48,000.00	
Production (Pounds)		19,800.00		8,257.00		695.00		10,400.00		2,400.00		1,000.00		24,000.00
Farm Gate Value ($/lb)		2.00		2.20		2.50		2.41		7.00		2.00		2.00
NET PROFIT	$13,070.00		($1,020.30)		$1,627.50		$5,450.30		$4,406.00		$1,857.00		$16,506.00	

species represents additional revenue (Table 1). Variable and fixed costs are not separately allocated to secondary species, but are combined as part of the total polyculture system. However, costs which can be totally attributed to the secondary species (e.g., fry and species-specific feed) are separately allocated. Incorporation of the secondary species into the culture systems in this study had little effect on operating costs.

The production and cost data utilized in this study covered a period of operation during 1984 and 1985. Production figures were determined for a 365-day/year period. Production is not seasonally determined on Guam, since temperature variation throughout the year is minimal. The production costs are composed of variable costs (supplies, electricity/fuel, labor and miscellaneous) and fixed costs (salary, land, depreciation, interest, license fee, insurance and accounting).

Labor represents a mixed cost. A fixed portion consists of labor costs which are incurred regardless of the level of operation; thus, it is assumed that the working farm owner or manager receives an annual salary. The variable portion of labor costs consists of the temporary/occasional labor that is hired on a daily basis for harvest, major pond maintenance or stocking activity, plus full-time labor, exclusive of management. Labor costs include wages, workman's compensation insurance and other benefits. Electricity/fuel is also a mixed cost; however, the fixed portion is relatively small, it is therefore treated as a variable cost.

In Farm 2, the land was owned instead of leased. The other farms were leased. The land purchase price for Farm 2 was $25,373 per pond acre. Of this amount, $12,646 was paid as part of the capital investment; the balance, $12,727, was paid through a loan (Table 6). The operating cost (Table 1) for land was charged the annual principal payment on this 10-year loan ($1,272.70 per pond acre). The capital investment in land ($12,646) and the annual loan payments were considered as land salvage at a constant dollar value to determine the net present value.

Taxes are not included in the calculations in order to eliminate distortions resulting from differences in operational tax rates due to the business's organizational structure (e.g., corporation or proprietorship). Furthermore, a percentage of the production from all farms in the study is sold directly to the consumer. The Guam tax code stipulates that a primary product (agriculture, aquaculture or fisheries) sold directly from the producer to the consumer is not subject to Gross Receipts Tax. Since the farms market different proportions of their total harvests directly to consumers, variations in marketing practices should be considered separately by each farmer in light of his unique alternatives. However, the impact of tax expense should not be overlooked by an entrepreneur when calculations are made to determine the profitability potential for an individual farm.

The depreciation schedules (presented below) are based upon the straight-line method, which is a conservative method to depreciate capital expenses. For comparison, identical depreciation schedules were used for each farm.

Item	Depreciation Period	Salvage
Ponds		
Earthen	10 years	-0-
Concrete	15 years	-0-
Storage	10 years	-0-
Housing	15 years	-0-
Equipment	5 years	-0-
Miscellaneous	5 years	-0-

Working capital (Table 6) is calculated as 50% of the total annual costs minus depreciation. This is based on the assumption that it would take six months for the cash inflow from harvest sales to meet or exceed the cash outflow. Working capital needs vary slightly between the species and management practices. For example, cost and revenue differences depend on growth rates of the species, stocking rates and schedules, feeding practices and feed quality, pond design and size, and the degree of automation.

Results and Discussion

In evaluating the potential for new investment in a particular aquaculture operation, the break-even volume can be compared to the expected industry-average production to determine the relative degree of risk involved in a new operation. A break-even point that is near the expected industry-average production level would indicate a high risk. Factors (costs or revenues) that contribute to a variation from an industry standard would have to be weighed by the entrepreneur in an overall evaluation. For example, if the cultivation of a tropical species (e.g., Macrobrachium rosenbergii) on Guam is compared to an established industry-average production level in Hawaii the result would be an undervaluation of the production capability (revenue source) for that species on Guam. The year-round temperature is closer to optimal for tropical species on Guam (FitzGerald, 1975) than Hawaii and results in an increased production rate.

The linear break-even charts (Figures 1 thru 5) represent the production volume break-even points for the various species cultured in the three farms. It should be stressed that these figures are specific to the individual farms, which have differences in structure (physical, management and capital), thereby limiting the direct comparison of the break-even points between the three farms. However, these break-even points are useful

Figure 1

Break-Even Analysis

Monoculture Tilapia, Farm 1

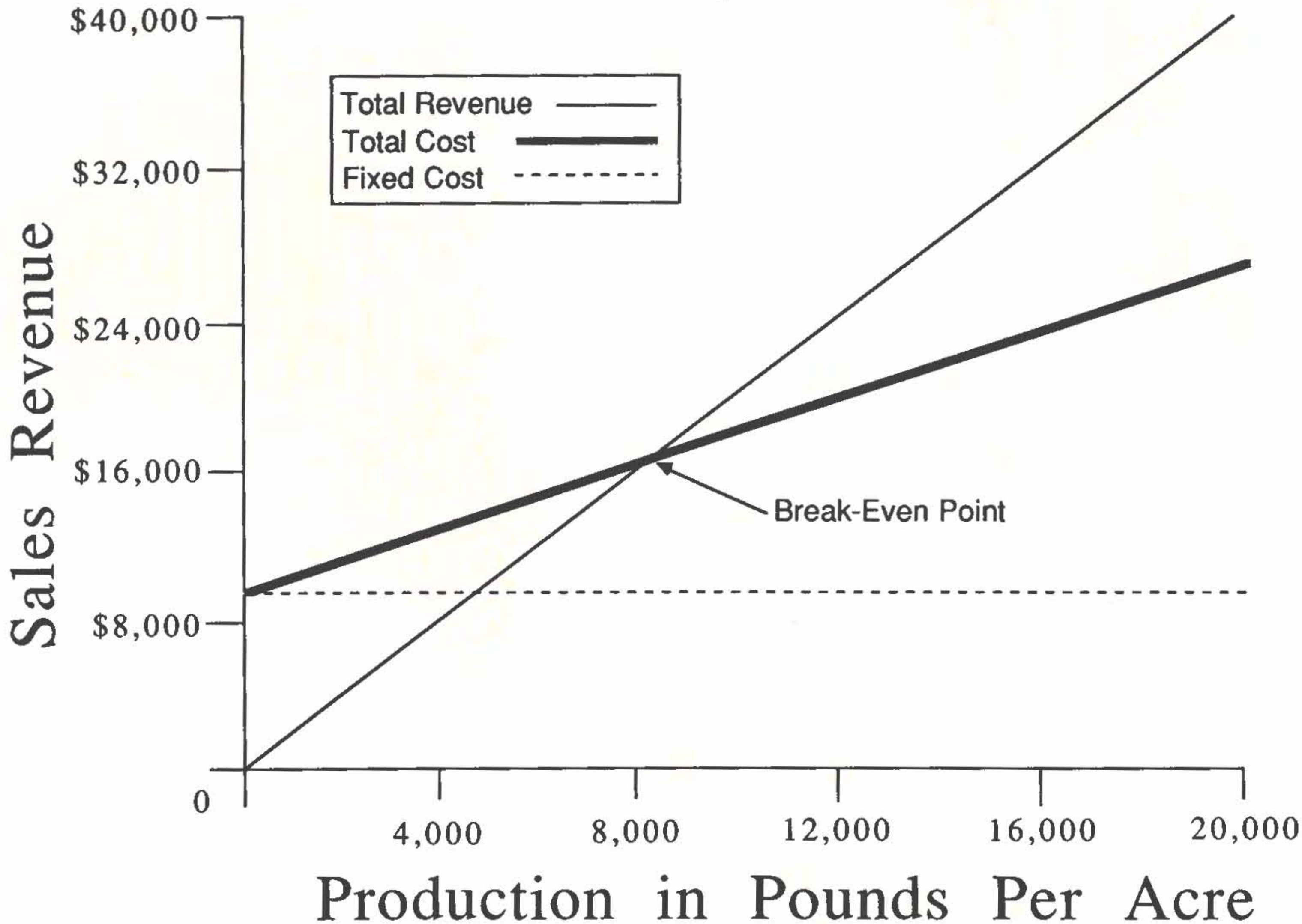


Figure 2

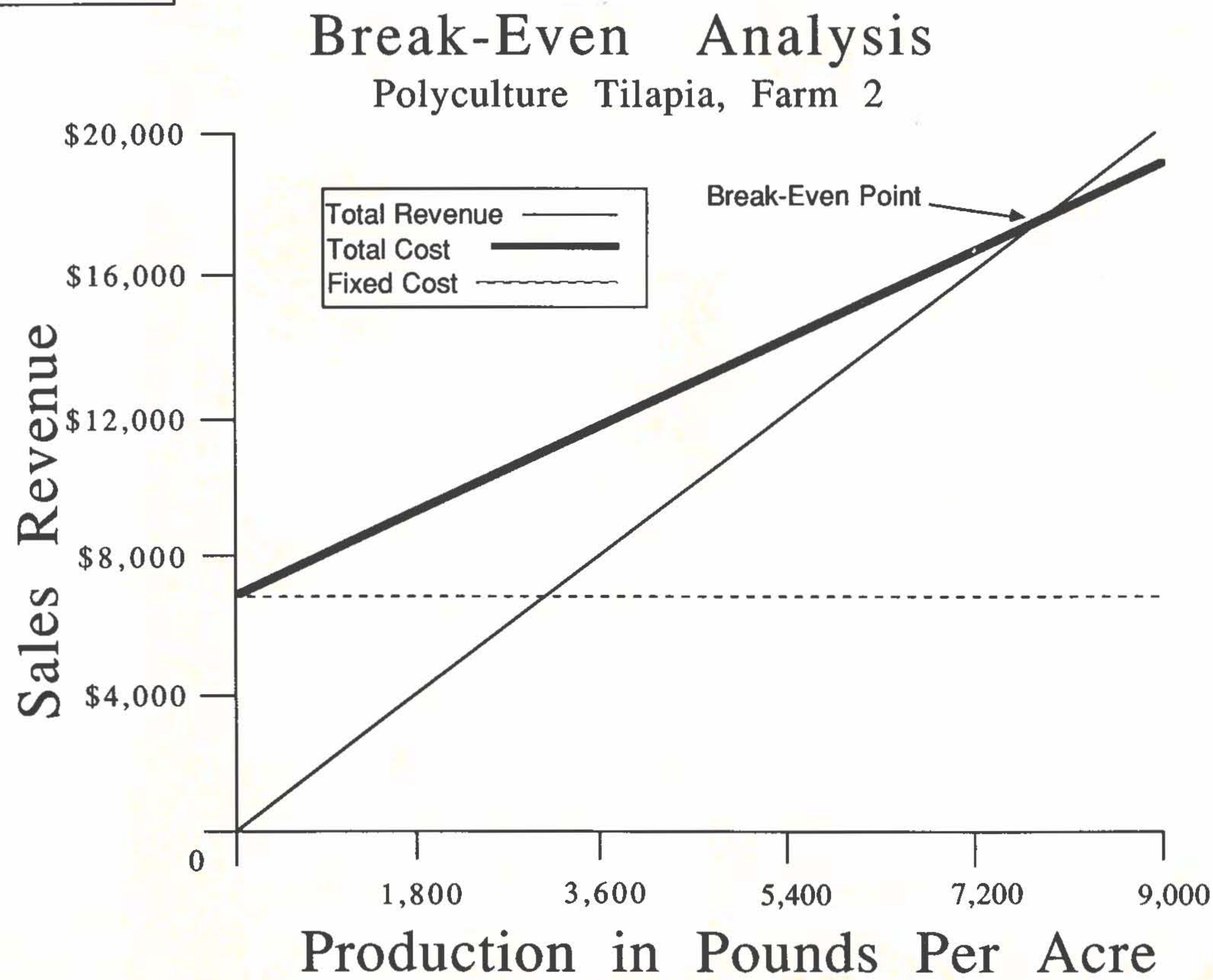

Break-Even Analysis
Polyculture Tilapia, Farm 2
$20,000
$16,000
$12,000
$8,000
$4,000
0
Sales Revenue
Total Revenue
Total Cost
Fixed Cost
Break-Even Point
1,800
3,600
5,400
7,200
9,000
Production in Pounds Per Acre

Figure 3

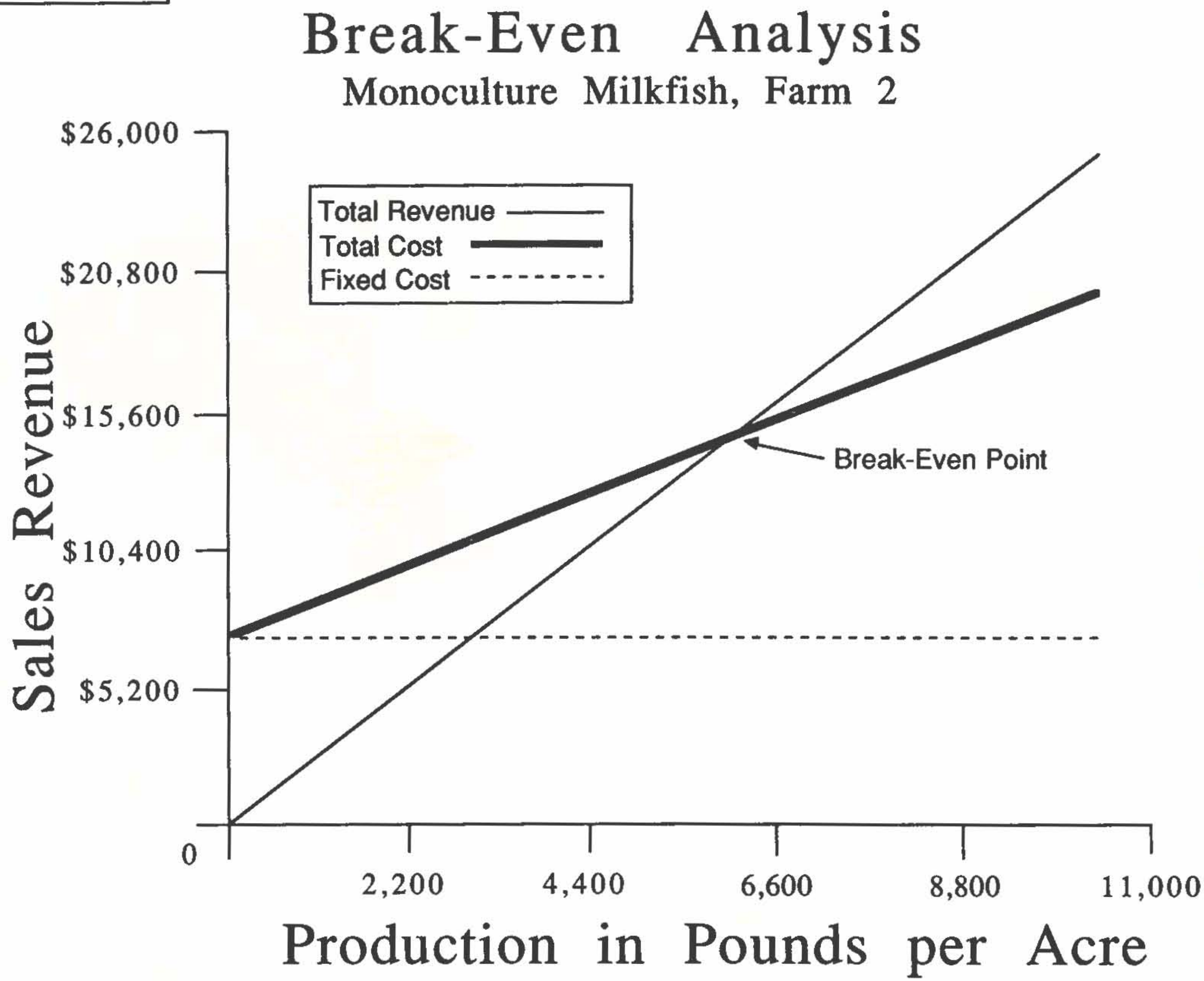
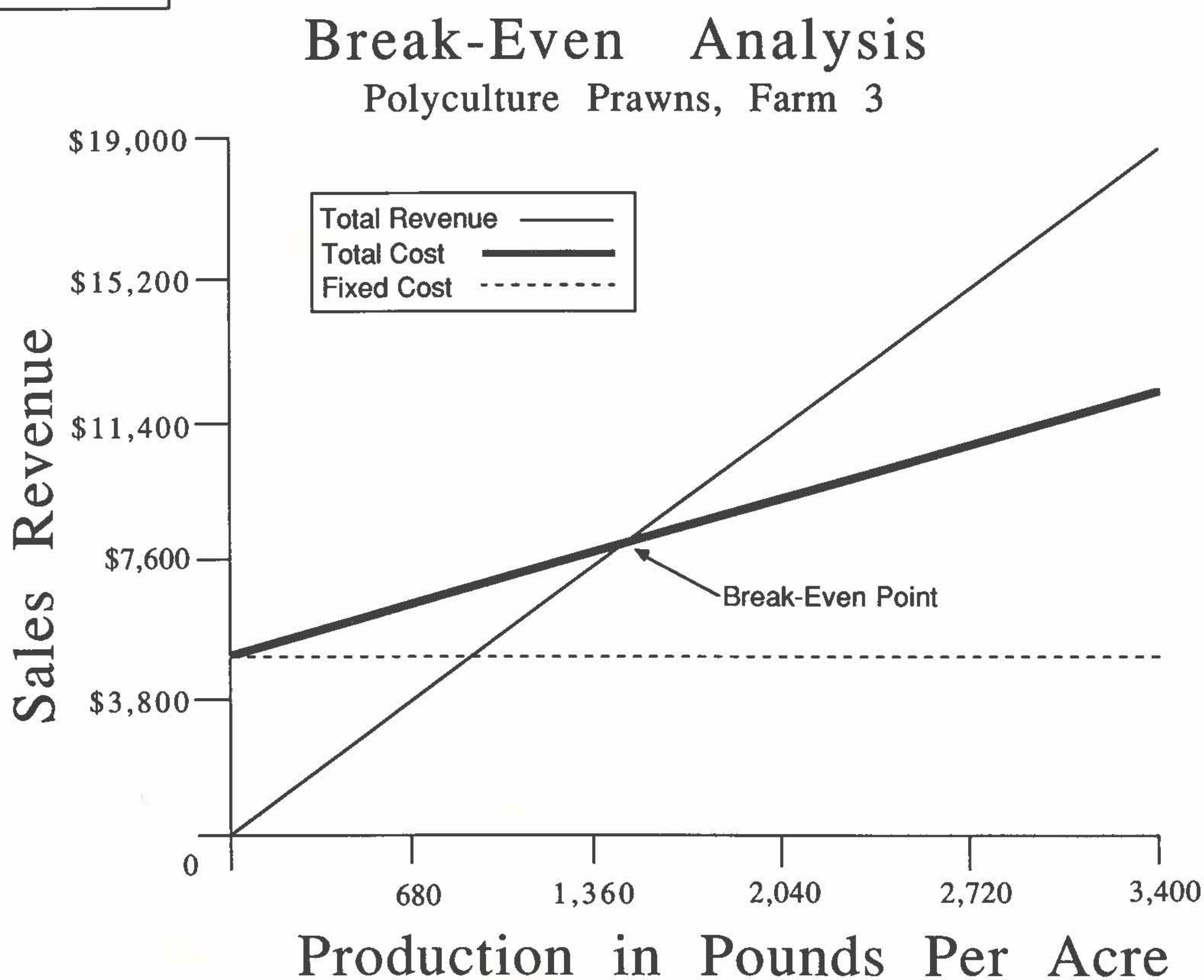

Break-Even Analysis
Monoculture Milkfish, Farm 2
$26,000
$20,800
$15,600
$10,400
$5,200
0
Sales Revenue
Total Revenue
Total Cost
Fixed Cost
Break-Even Point
2,200
4,400
6,600
8,800
11,000
Production in Pounds per Acre

Figure 4

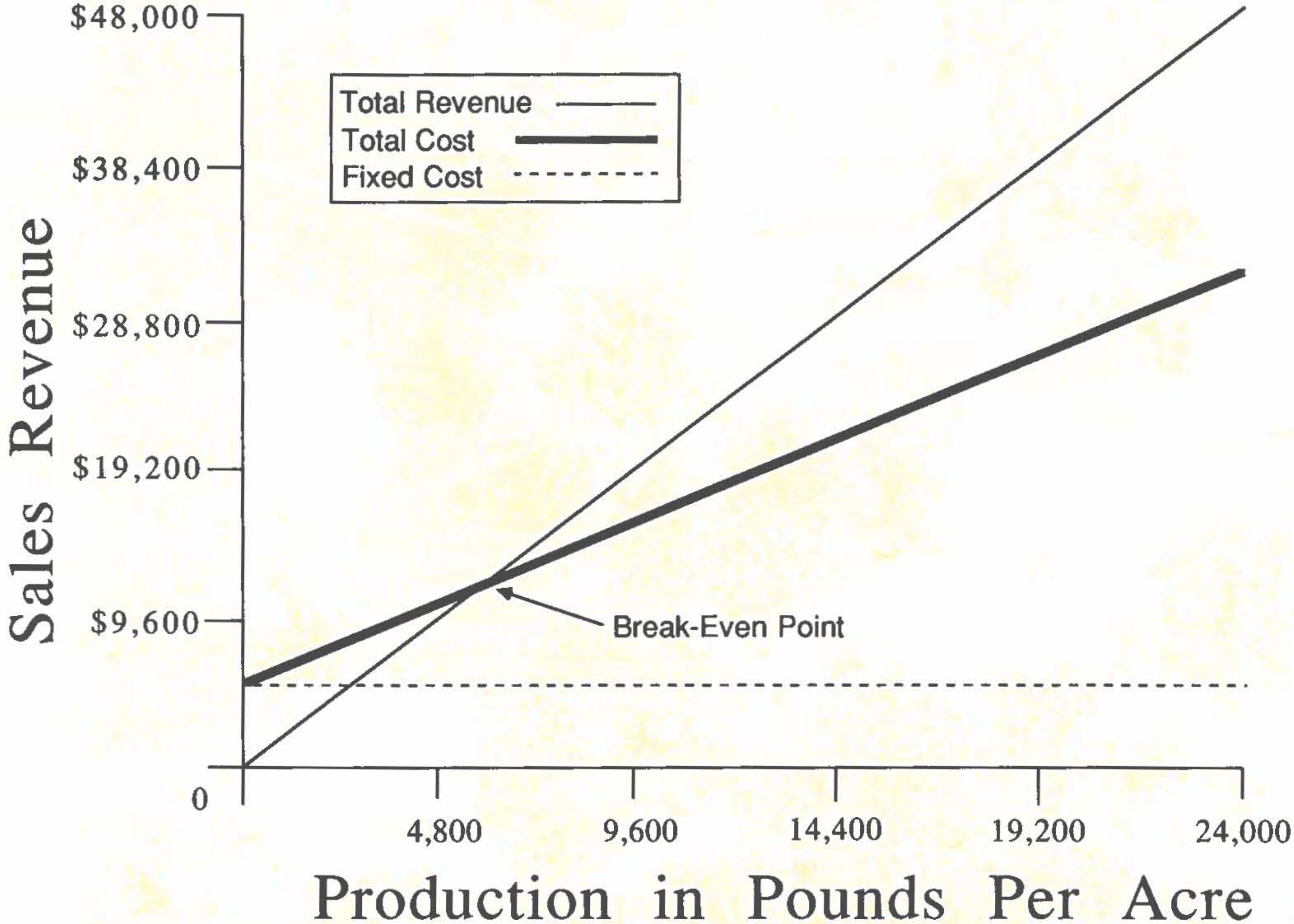


Break-Even Analysis
Polyculture Prawns, Farm 3
$19,000
$15,200
$11,400
$7,600
$3,800
0
Sales Revenue
Total Revenue
Total Cost
Fixed Cost
Break-Even Point
680
1,360
2,040
2,720
3,400
Production in Pounds Per Acre

Figure 5

Break-Even Analysis

Monoculture Catfish, Farm 3



on an individual basis as indicators of profitability and risk. The results presented in Table 2 indicate that the break-even point, as a percent of the actual production, is the lowest for catfish monoculture (22%). The break-even points for the tilapia monoculture, milkfish monoculture and the prawn polyculture approach 50% of production, while 92% of production of the tilapia polyculture is required to reach the break-even point. Catfish monoculture affords the greatest margin of production above the break-even point while tilapia polyculture affords the least. Thus, the latter represents a high risk situation where a small decrease in production could prevent the farm from being profitable. In the case of M. rosenbergii, Samples and Leung (1985) found the financial risk associated with production variability in prawn culture to be significantly higher in larger ponds (greater than 0.8 ha). The relationship between profitability and production level is further illustrated in Tables 3a & 3b.

An important component of the break-even analysis is the sales price per unit (price per pound). It is important to know how the break-even point will be affected by price fluctuations. The lower the price the more critical the production level becomes, especially as it approaches the production capacity of the system for that particular species. It is also useful to compare

TABLE 2

BREAK-EVEN ANALYSIS OF SPECIES AND CULTURE METHODS
PER POND ACRE PER YEAR

	TILAPIA MONOCULTURE FARM #1	TILAPIA POLYCULTURE FARM #2	MILKFISH MONOCULTURE FARM #2	PRAWN POLYCULTURE FARM #3	CATFISH MONOCULTURE FARM #3
ACTUAL PRODUCTION (POUNDS)	19,000	8,952[a]	10,400	3,400[b]	24,000
BREAK-EVEN POINT (PRODUCTION IN POUNDS)	8,410.46	8,222.29	5,790.51	1,445.69	5,259.99
BREAK-EVEN POINT AS % OF ACTUAL PRODUCTION	42.48%	91.85%	55.68%	42.52%	21.92%
SALES REVENUE AT BREAK-EVEN POINT	$ 16,820.92	$ 18,280.61	$ 13,955.13	$ 7,993.79	$ 10,519.98

a - Represents 8,257 lbs. tilapia plus 695 lbs. catfish.

b - Represents 2,400 lbs. prawns plus 1,000 lbs. carp.

TABLE 3a

COST-VOLUME PROFIT ANALYSIS OF SPECIES AND CULTURE METHODS
PER POND ACRE PER YEAR

PRODUCTION (lbs)	TILAPIA MONOCULTURE FARM #1			TILAPIA POLYCULTURE FARM #2			MILKFISH MONOCULTURE FARM #2			CATFISH MONOCULTURE FARM #3		
	SALES	TOTAL COST	PROFIT	SALES	TOTAL COST	PROFIT	SALES	TOTAL COST	PROFIT	SALES	TOTAL COST	PROFIT
2,500	$ 5,000.00	$11,782.25	($ 6,782.25)	$ 5,558.25	$10,323.20	($ 4,764.95)	$ 6,025.00	$ 9,915.70	($ 3,890.70)	$ 5,000.00	$ 7,431.00	($ 2,431.00)
3,750	$ 7,500.00	$12,847.88	($ 5,347.88)	$ 8,337.38	$12,061.45	($ 3,724.08)	$ 9,037.50	$11,450.20	($ 2,412.70)	$ 7,500.00	$ 8,830.00	($ 1,330.00)
5,000	$10,000.00	$13,913.50	($ 3,913.50)	$11,116.60	$13,799.70	($ 2,683.20)	$12,050.00	$12,984.70	($ 934.70)	$10,000.00	$10,229.00	($ 229.00)
6,250	$12,500.00	$14,979.13	($ 2,479.13)	$13,895.63	$15,537.95	($ 1,642.33)	$15,062.50	$14,519.20	$ 543.30	$12,500.00	$11,628.00	$ 872.00
7,500	$15,000.00	$16,044.75	($ 1,044.75)	$16,674.75	$17,276.20	($ 601.45)	$18,075.00	$16,053.70	$ 2,021.30	$15,000.00	$13,027.00	$ 1,973.00
8,750	$17,500.00	$17,110.38	$ 389.63	$19,453.88	$19,014.45	$ 439.42	$21,087.50	$17,588.20	$ 3,499.30	$17,500.00	$14,426.00	$ 3,074.00
10,000	$20,000.00	$18,176.00	$ 1,824.00	$22,233.00	$20,752.70	$ 1,480.30	$24,100.00	$19,122.70	$ 4,977.30	$20,000.00	$15,825.00	$ 4,175.00
11,250	$22,500.00	$19,241.63	$ 3,258.38	$25,012.13	$22,490.95	$ 2,521.17	$27,112.50	$20,657.20	$ 6,455.30	$22,500.00	$17,224.00	$ 5,276.00
12,500	$25,000.00	$20,307.25	$ 4,692.75	$27,791.25	$24,229.20	$ 3,562.05	$30,125.00	$22,191.70	$ 7,933.30	$25,000.00	$18,623.00	$ 6,377.00
13,750	$27,500.00	$21,372.88	$ 6,127.13	$30,570.38	$25,967.45	$ 4,602.92	$33,137.50	$23,726.20	$ 9,411.30	$27,500.00	$20,022.00	$ 7,478.00
15,000	$30,000.00	$22,438.50	$ 7,561.50	$33,349.50	$27,705.70	$ 5,643.80	$36,150.00	$25,260.70	$10,889.30	$30,000.00	$21,421.00	$ 8,579.00
16,250	$32,500.00	$23,504.13	$ 8,995.88	$36,128.63	$29,443.95	$ 6,684.68	$39,162.50	$26,795.20	$12,367.30	$32,500.00	$22,820.00	$ 9,680.00
17,500	$35,000.00	$24,569.75	$10,430.25	$38,907.75	$31,182.20	$ 7,725.55	$42,175.00	$28,329.70	$13,845.30	$35,000.00	$24,219.00	$10,781.00
18,750	$37,500.00	$25,635.38	$11,864.63	$41,686.88	$32,920.45	$ 8,766.42	$45,187.50	$29,864.20	$15,323.30	$37,500.00	$25,618.00	$11,882.00
20,000	$40,000.00	$26,701.00	$13,299.00	$44,466.00	$34,658.70	$ 9,807.30	$48,200.00	$31,398.70	$16,801.30	$40,000.00	$27,017.00	$12,983.00
21,250	$42,500.00	$27,766.63	$14,733.38	$47,245.13	$36,396.95	$10,848.17	$51,212.50	$32,933.20	$18,279.30	$42,500.00	$28,416.00	$14,084.00
22,500	$45,000.00	$28,832.25	$16,167.75	$50,024.25	$38,135.20	$11,889.05	$54,225.00	$34,467.70	$19,757.30	$45,000.00	$29,815.00	$15,185.00
23,750	$47,500.00	$29,897.88	$17,602.13	$52,803.38	$39,873.45	$12,929.92	$57,237.50	$36,002.20	$21,235.30	$47,500.00	$31,214.00	$16,286.00
25,000	$50,000.00	$30,963.50	$19,036.50	$55,582.50	$41,611.70	$13,970.80	$60,250.00	$37,536.70	$22,713.30	$50,000.00	$32,613.00	$17,387.00

PRODUCTION COMPOSITION BY WEIGHT	TILAPIA MONOCULTURE FARM #1	TILAPIA POLYCULTURE FARM #2	MILKFISH MONOCULTURE FARM #2	CATFISH MONOCULTURE FARM #3
PRIMARY SPECIES	100.00%	92.20%	100.00%	100.00%
SECONDARY SPECIES	0.00%	7.80%	0.00%	0.00%

TABLE 3b

COST-VOLUME PROFIT ANALYSIS

OF SPECIES AND CULTURE METHODS

PER POND ACRE PER YEAR

PRODUCTION (LBS.)	PRAWN - POLYCULTURE FARM #3		
	SALES	TOTAL COST	PROFIT
400	$2,211.60	$5,562.88	($3,351.28)
800	$4,423.20	$6,492.76	($2,069.56)
1,200	$6,634.80	$7,422.64	($787.84)
1,600	$8,846.40	$8,352.52	$493.88
2,000	$11,058.00	$9,282.40	$1,775.60
2,400	$13,269.60	$10,212.28	$3,057.32
2,800	$15,481.20	$11,142.16	$4,339.04
3,200	$17,692.80	$12,072.04	$5,620.76
3,600	$19,904.40	$13,001.92	$6,902.48
4,000	$22,116.00	$13,931.80	$8,184.20

PRODUCTION COMPOSITION BY WEIGHT	
PRIMARY SPECIES	70.60%
SECONDARY SPECIES	29.40%

the prices of competing products with the break-even sales price (Table 4) to obtain a perspective on the feasible competitive price ranges for the species being considered for production.

The sensitivity of profits to a change in unit sales price will increase as the unit sales price approaches the unit variable cost (Total Variable Cost/Production). This becomes evident in the case of tilapia (Table 4). As the total production of tilapia increases on Guam and markets become saturated, prices will fall. The degree to which falling prices are expected to impact on profits is presented in Table 4. Falling prices may not stimulate demand sufficiently to allow producers to attain break-even output levels. Little is known about demand elasticities for the species under discussion.

Farm management needs to know how low it can reduce its unit price while at least maintaining a break-even operation. Management can also utilize the information presented in Table 4 to determine the operation's ability to compete in a market with declining product prices. Switching production from one species to an alternative with more favorable revenue generating capability can be an option available to the farmer.

The interaction of biological, managerial and external variables influences the success of an aquaculture operation. This is exemplified by the interaction between the operations of aquaculture farms

TABLE 4

BREAK-EVEN PRODUCTION AT VARYING UNIT PRICES
PER POND ACRE PER YEAR

UNIT PRICE PER POUND	BREAK-EVEN PRODUCTION POUNDS TILAPIA MONOCULTURE FARM #1	TILAPIA POLYCULTURE FARM #2	MILKFISH MONOCULTURE FARM #2	PRAWN POLYCULTURE FARM #3	CATFISH MONOCULTURE FARM #3
$1.00	65,431	---	---	---	---
1.25	24,279	---	---	---	35,420
1.50	14,905	62,584	25,135	---	12,166
1.75	10,753	19,050	13,106	---	7,345
2.00	8,410	11,235	8,864	---	5,260
2.25	6,906	7,967	6,697	---	4,097
2.50	5,858	6,172	5,381	26,429	3,355
2.75	5,086	5,037	4,497	10,893	2,841
3.00	4,494	4,254	3,863	6,861	2,463
3.50	---	---	3,013	3,942	1,946
4.00	---	---	---	2,765	1,608
4.50	---	---	---	2,130	1,370
5.00	---	---	---	1,732	1,194
5.50	---	---	---	1,459	---
6.00	---	---	---	1,261	---
6.50	---	---	---	1,110	---
7.00	---	---	---	991	---
7.50	---	---	---	895	---
8.00	---	---	---	816	---
UNIT VARIABLE COST	$0.8525	$1.3906	$1.2276	$2.3247	$1.1192
CURRENT UNIT PRICE	$2.0000	$2.2233	$2.4100	$5.5294	$2.0000

NOTE: Current unit price for the polyculture operations represent a price based on weighted contribution of all species cultured in that system.

and the limited domestic market on Guam. This limited market affects the operation, including the pond size, labor cost and harvest procedure. Management of those species which have fairly uniform growth and which therefore reach harvest size at the same time are most affected by this limited market. With a restricted market size, only a limited quantity of a given species can be harvested without exceeding market demand. In addition, the requirement of maintaining a consistent supply usually demands harvesting on a weekly basis. This necessitates either the use of smaller ponds or the staggered partial harvesting of larger ponds to correspond with the potential market demand. Each of these options has different advantages and disadvantages, along with associated costs. For example, a small pond has higher costs of operation per unit area through increased labor, electrical, water flushing, construction and capital equipment costs (e.g., aerators and automated feeders). On the other hand, frequent harvesting of larger ponds negatively influences the growth of the species due to the frequent disturbances (physical and biological) associated with dragging a net through the pond. Such disturbances decrease feed conversion and total production which subsequently decreases financial returns.

Various economic measures help to define specific characteristics of a farm's operations. They also assist in identifying areas of the operation that can be improved, along with the means of evaluating alternative scenarios through the use of "what if" inquiries and the means for determining the influence of these actions on the profitability.

The ratio of net profit to variable cost (Table 5) removes from consideration differences in costs of construction and other fixed costs among farms. This allows a comparison between the species without possible bias introduced by the difference in the capital investment. These figures indicate that tilapia monoculture (77.4%) and prawn polyculture (79.2%) have the highest net profit to variable cost ratio. These systems are followed by catfish monoculture (61.5%), milkfish monoculture (42.7%) and tilapia polyculture (4.9%).

The ratio of contribution to margin (Table 5) allows a comparison of the different species and culture methods on a relatively equal basis, since the variation in the operations introduced by the structure of the company with regard to fixed costs is eliminated. Some farms may incur high fixed costs (land, management salary, equipment interest) that do not contribute proportionately to the total revenue. This is evident in Farm 2, Tilapia Polyculture, where the profit margin to gross revenue ratio (includes fixed costs) drops to

TABLE 5

PROFIT ANALYSIS OF SPECIES AND CULTURE METHODS
PER POND ACRE PER YEAR

	TILAPIA MONOCULTURE FARM #1	TILAPIA POLYCULTURE WITH CATFISH FARM #2	MILKFISH MONOCULTURE FARM #2	PRAWN POLYCULTURE WITH CARP FARM #3	CATFISH MONOCULTURE FARM #3
GROSS REVENUE	$ 39,600.00	$ 19,902.90	$ 25,064.00	$ 18,800.00	$ 48,000.00
TOTAL COSTS	26,530.00	19,295.70	19,613.70	12,537.00	31,494.00
VARIABLE COSTS	16,879.00	12,449.00	12,767.00	7,904.00	26,861.00
FIXED COSTS	9,651.00	6,846.70	6,846.70	4,633.00	4,633.00
DEPRECIATION	4,696.00	1,535.00	1,535.00	1,201.00	1,201.00
OPERATING PROFIT	22,721.00	7,453.90	12,297.00	10,896.00	21,139.00
NET PROFIT (BEFORE TAXES)	13,070.00	607.20	5,450.30	6,263.00	16,506.00
CASH FLOW	17,766.00	2,142.20	6,985.30	7,464.00	17,707.00
RATIO OF CONTRIBUTION TO MARGIN	57.38%	37.45%	49.06%	57.96%	44.04%
RATIO OF NET PROFIT TO GROSS REVENUE	33.01%	3.05%	21.75%	33.31%	34.39%
RATIO OF NET PROFIT TO VARIABLE COSTS	77.43%	4.88%	42.69%	79.24%	61.45%
RATIO OF NET PROFIT TO TOTAL COSTS	49.26%	3.15%	27.79%	49.96%	52.41%
RETURN ON TOTAL INVESTMENT	17.87%	0.83%	34.76%	39.94%	65.60%
PROFIT ON CAPITAL EMPLOYED	27.97%	6.05%	69.46%	74.22%	90.64%
PRODUCTIVITY ($ PRODUCT/$ FEED)	4.00	4.31	4.82	8.70	2.40

Operating Profit = Gross Revenue - Variable Costs
Net Profit = Gross Revenue - Total Costs
Ratio of Contribution to Margin = (Gross Revenue - Variable Cost)/Gross Revenue
Cash Flow = Net Profit + Depreciation
Return on Total Investment = (Net Profit + Provision for Taxes + Interest Expense)/Total Invested
Profit on Capital Employed = (Net Profit + Provision for Taxes + Interest Expense)/Capital Invested
Return on Equity = (Net Profit + Provisions for Taxes + Interest Expense)/Owner's Capital Investment

3.05% while the contribution to margin ratio is 37.45% (Table 5).

The profit margin (ratio of net profit to gross revenue) represents the cost-price effectiveness of the operation and indicates management's ability to meet operational expenses and generate a margin of compensation to the owners. It should be noted that the profit margin ratios (Table 5) for Farm 1, Tilapia Monoculture; Farm 3, Prawn Polyculture; and Farm 3, Catfish Monoculture, fall within a very narrow range (33.01% - 34.39%).

As can be seen in Table 6, the capital investment for the three farms considered varied substantially. The major factor contributing to this variability was that Farm 2 purchased land while the other two farms leased land. Secondly, Farm 1 built concrete ponds; the other two farms built earthen ponds. (Farm 1 was originally designed for eel culture.) Different levels of capital investment can have an impact on the production; however, most importantly, they have an impact on the profitability of the farm, as can be seen by the Return on Total Investment and Return on Equity for the different farms (Table 5). The investment into capital assets of the farm (ponds, equipment, etc.) cannot be completely divorced from the degree of productivity and profitability of the species and the method of cultivation. Therefore, the decision on the degree of

TABLE 6

CAPITAL INVESTMENT
PER POND ACRE

	TILAPIA MONOCULTURE FARM #1	TILAPIA POLYCULTURE WITH CATFISH FARM #2	MILKFISH MONOCULTURE FARM #2	PRAWN POLYCULTURE WITH CARP FARM #3	CATFISH MONOCULTURE FARM #3
FIXED CAPITAL					
LAND	$ -0-	$ 25,373.00	$ 25,373.00	$ -0-	$ -0-
PONDS	55,556.00	6,917.00	6,917.00	5,688.00	5,688.00
STORAGE	555.00	127.00	127.00	375.00	375.00
HOUSING	333.00	1,455.00	1,455.00	438.00	438.00
EQUIPMENT	5,555.00	5,310.00	5,310.00	2,638.00	2,638.00
MISCELLANEOUS	222.00	100.00	100.00	875.00	875.00
TOTAL	$ 62,221.00	$ 39,282.00	$ 39,282.00	$ 10,014.00	$ 10,014.00
WORKING CAPITAL					
TOTAL	$ 10,917.00	$ 8,880.35	$ 9,039.35	$ 5,668.00	$ 15,146.50
TOTAL INVESTED PER POND ACRE	$ 73,138.00	$ 48,162.35	$ 48,321.35	$ 15,682.00	$ 25,160.50
LONG TERM DEBT PER POND ACRE	0.00	12,727.00	12,727.00	5,625.00	5,625.00
CAPITAL INVESTED PER POND ACRE	73,138.00	35,435.35	35,594.35	10,057.00	19,535.50
PRESENT VALUE OF NET CASH INFLOW[a,b]	116,363.12	38,724.03	68,484.88	45,922.64	108,865.88
PRESENT VALUE OF NET CASH OUTFLOW[c]	78,915.00	53,572.35	53,731.35	19,195.00	28,673.50
NET PRESENT VALUE[a]	37,448.12	(14,848.32)	14,753.53	26,727.64	80,192.37
PRESENT VALUE INDEX (BENEFIT/COST)	1.47	0.72	1.27	2.39	3.80
INTERNAL RATE OF RETURN	19.50%	---	5.20%	37.50%	61.50%
PAYBACK PERIOD	4.12	22.48	6.92	2.10	1.42

a - Net Present Value assumed a constant cash flow over a 10 year period with a 10% discount rate.

b - Includes salvage, Land savage assumed to maintain a constant dollar value.

c - Includes the reinvestment (at constant dollar value) in equipment and miscellaneous items as identified in the depreciation schedule during the 10 year project life.

Total Invested = Owners + Long Term Debt + Short Term Debt
Capital Invested = Total Invested - Long Term Debt
Total Net Cash Inflow (10 year life) = Net Profit x 10 years
PVI = PV of Net Cash Inflows/PV of Net Cash Outflows
IRR = Discount Rate where PV of Net Cash Inflows - PV of Net Cash Outflows = 0
Payback period = Total Investment/Average Annual Net Cash Inflow

investment in the various components of the farm must be weighed against revenue generation and, ultimately, return on investment.

When an investor is faced with alternative projects, the choice should be based on the present value of the project over its economic life. By the use of present value computations, the time-value of money is accounted for in the figure. That is, a lower value is assigned to a dollar flow that occurs at future intervals. This allows the investor to compare the cash flows through the life of the project to the present dollar equivalent. The net present value, present value index and internal rate of return incorporate present value calculations. Each of these values has advantages and disadvantages that should be realized. These results should be cross referenced with profit criteria already discussed in order to identify areas where input adjustments or alternatives may improve the revenue return.

Table 7 shows the ranking of the different species at the specific farms based on the decision criteria of net present value (NPV), present value index (PVI), internal rate of return (IRR) and payback period (Table 6). The PVI, IRR and payback allow for the comparison of projects of different size or length of economic life. One discrepancy occurs in the ranking between Prawn Polyculture (Farm 3) and Tilapia Monoculture (Farm 1), with the NPV being the reverse of the rankings of the

TABLE 7

RANKING OF SPECIES AND CULTURE METHODS

FOR SPECIFIC SITES AND CONDITIONS

SPECIES	NPV	PVI	IRR	PAYBACK
CATFISH MONOCULTURE (FARM #3)	1	1	1	1
PRAWN POLYCULTURE (FARM #3)	3	2	2	2
TILAPIA MONOCULTURE (FARM #1)	2	3	3	3
MILKFISH MONOCULTURE (FARM #2)	4	4	4	4
TILAPIA POLYCULTURE (FARM #2)	5	5	5	5

PVI, IRR and payback. The NPV (Table 6) for Tilapia Monoculture ($37,448.12) is greater than that for Prawn Polyculture ($26,727.64). A factor that should be taken into consideration is the size of the investment and possible limitations in investment capital. The investment size for Tilapia Monoculture (Farm 1) is greater than Prawn Polyculture (Farm 3) by a factor of 4.66.

The fry and postlarvae costs for the different species constitute a wide range of the total variable costs, from less than 1% for tilapia monoculture to 32.8% for prawn polyculture. Two different stocking rates were utilized at Farm 3 (prawn polyculture), depending on the source of the prawn postlarvae. Postlarvae obtained from a temporary, local hatchery were stocked at 80,000 postlarvae/acre/year (recommended stocking density), while postlarvae obtained from Hawaii were stocked at 150,000 postlarvae/acre/year. Stocking rates were adjusted to compensate for mortality that occurred during shipping and shortly after stocking the stressed animals in the ponds. As a result, there was a substantial increase in cost associated with importing postlarvae (150,000 x $32.00/1000 = $4,800.00 vs. 80,000 x $32.00/1000 = $2,560.00). Cost calculations in the analysis were based on the stocking rate from a local source. It is evident that a local supply of postlarvae would significantly improve the potential return in

Macrobrachium rosenbergii culture. In addition to eliminating the need to compensate for transport-related mortality (increased stocking rate), the unit cost should be reduced to $22-$26/1000 postlarvae, since transportation expenses ($6 to $10/1000 postlarvae) would be avoided.

Feed constitutes a major expense in the cultivation of most aquaculture species. Feed costs for the farms considered ranged from 27% to 75% of the total variable costs. Catfish culture had the highest feed cost (75% of total variable costs). Similarly, Wattanutchariya and Panayotou (1982) found feed to be the predominant cost with the culture of catfish (Clarias) in Thailand, at 72.8% to 78% of the total variable cost. In Table 5, the measure of productivity of the different species examined in this study is based on a ratio of the value of the product to the cost of the feed input. This measures the relationship between the product value and the predominant variable cost factor, feed input. The figures indicate prawn polyculture (8.70) is almost twice as productive as that of the nearest species, milkfish monoculture (4.82). This occurs despite the lower feed-conversion efficiency (weight of feed required to produce one pound of product) for prawns and is due to the substantially higher value of prawns.

The optimization of the feed input to the product output needs to be determined in order to further optimize the production capacity of the systems. The differences in feed input observed in the farms studied is partially attributable to the difference in dietary requirements of the species cultured and to management practices. However, the efficient use of feed to maximize the production function of the product value output to the feed cost input can significantly affect the economic viability of the aquaculture operations where feed constitutes a major operating expense.

Conclusion

In summary, to evaluate the various alternatives in the operation of an aquaculture farm, the entrepreneur should consider the following:

- Volume break-even.

  To determine the volume of production that covers total costs of production.

- Sales price break-even.

  To determine the degree of flexibility in pricing and the impact of a price change on the production required to break-even.

- Profitability Ratios.

  Return on Equity (ROE) - measures the return on the capital supplied by the owner.

  Ratio of Net Profit to Gross Revenue - represents the cost-price effectiveness of the operation and indicates management's ability to meet operational expenses and generate a margin of compensation to the owners.

Ratio of Net Profit to Variable Costs - removes from consideration differences in costs of construction and other fixed costs among farms. Allows for a comparison between species without the possible bias introduced by the difference in the capital investment.

Ratio of Net Profit to Total Costs - provides a measurement of profitability that accounts for all costs and can be used as a general comparison of profitability between species/methods and farms.

Return on Total Investment - this indicates management success in utilizing the total assets under their control.

- Decision between alternative strategies (e.g., methods or species) that accounts for the time value of money.

Net Present Value

Present Value Index

Internal Rate of Return

Payback Period

Applying these techniques would help to identify factors of production that are most sensitive to change and could be subject to modification, resulting in improved profitability.

The financial risk associated with the farms and species/culture methods evaluated in this study was found to be the highest for the Tilapia Polyculture system of Farm 2, while the Catfish Monoculture system of Farm 3 had the lowest financial risk. Return on investment was also the greatest in Catfish Monoculture system. Sensitivity to changes in market price were greatest for those species/culture systems with break-even points nearest to the actual production.

A break-even analysis of the various species cultured that takes into consideration the significant variable and fixed costs associated with each species will contribute a needed component in evaluating alternative species. It is important that this component of the decision process not be taken out of context and isolated from the whole analysis spectrum which runs from consideration of all the input factors through the output product and the market structure.

There are biological, physical and economic considerations that are required in the overall decision process in entering an aquaculture venture. Furthermore, numerous factors contribute to the decision as to which species to raise. These factors include site location, water quality, physical parameters affecting the species growth, availability of postlarvae or fry, nutritionally suitable feed available at a reasonable cost, management capability and experience, and market structure. All of these factors must be considered by the farmer in his decision of which species to raise.

A word of caution must be expressed concerning the overreliance on models to simulate the complex and dynamic interactive system that occurs in an aquaculture operation. As more biological and market data become available, more precise economic models will be possible.

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LITERATURE CITED

FitzGerald, Jr., W.J. 1975. A completion report of project 4-23-D-3, a study to determine the aquaculture potentials of Guam. Aquatic and Wildlife Resources, Government of Guam, USA.

Panayotou, T. 1982. Social welfare economics and aquaculture: issues for policy and research. Proceedings, Aquaculture Economics Research in Asia, Singapore, June 2-5, 1982. International Development Research Center & International Center for Living Aquatic Resources Management.

Sample, K.C. and P. Leung. 1985. The effect of production variability on financial risks of freshwater prawn farming in Hawaii. Canadian Journal of Fisheries and Aquatic Sciences 42 (2): 307-311.

Shang, Y.C. 1981. Aquaculture economics: basic concepts and methods of analysis. Westview Press, Boulder, Colorado.

Shang, Y.C. 1982. Microeconomic analysis of experimental aquaculture projects: basic concepts and definitions. Proceedings, Aquaculture Economics Research in Asia, Singapore, June 2-5, 1982. International Development Research Center & International Center for Living Aquatic Marine Resources.

Smith, I.R. 1982. Microeconomics of existing aquaculture production systems: concepts and definitions. Proceedings, Aquaculture Economics Research in Asia, Singapore, June 2-5, 1982. International Development Research Center & International Center for Living Aquatic Marine Resources.