Response of Costs and Returns to Alternative Feed Prices and Conversions in Aquaculture Systems

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INTRODUCTION

Aquaculture, the grow-out of fish and shellfish in managed systems, has received increasing attention in recent years as an alternative source of fish[1]. Several species are currently cultured in the United States, the most notable being catfish and trout (Madewell, 1971; Klontz and King, 1975). Many argue that fish will supply an increasing share of the world's protein while aquaculture will supply an increasing share of fish available for consumption (e.g. Ronsivalli, 1976). Whether this transpires will depend in part on production efficiency in culture systems. The purpose of this paper is to examine the effects of changes in feed conversion ratios and feed prices on costs and returns in trout production.

In discussions with North Carolina mountain trout growers, the price of feed and additional marketing outlets were cited as two of the major problems encountered. While the individual grower cannot affect feed prices, he does have some control over the feed conversion ratio (pounds of feed per pound of fish-weight gained). Hence an opportunity to reduce costs is available through improved management practices. The following trout feed conversion ratios are among those reported in the literature: 1.29:1 (Hill, Chesness, and Brown, 1972:374); 1.27:1 (Brown, Hill, and Chesness, 1974:5); and 1.54 (Collins, 1972:5).

A feed conversion ratio of 2.0:1 was often mentioned as a general guide in conversations with growers. The evidence suggests that a feed conversion ratio of 2.0:1 can be reduced significantly through more careful monitoring of fish weight and feeding practices. Feed adjustments resulting from changes in fish size and/or water temperature over the growth cycle can reduce the final feed conversion ratio attained. These adjustments can be refined by sampling fish size and water temperature (Hill, Chesness, and Brown, 1972:369–373). The effects on costs and returns are estimated for alternative feed conversion ratios and compared with two different feed prices as a reference.

Budgets have been developed for three alternative raceway systems, with an initial 2.0:1 feed conversion ratio assumed (Easley, 1976). Alternative feed conversion ratios are analyzed and compared with the different feed prices through their impacts on unit costs and the internal rate of return to investment in the facilities. The internal rate of return is included as it allows the estimation of the impact of a potentially permanent reduction in costs over the life of a project. It is computed from income and expense cash flows projected over the assumed life of the raceway systems; hence it differs from the simple rate of return on investment, usually computed on the basis of one year's net return.

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Table 1.—Trout production budgets for three raceway systems, 1975.

Item	Unit production size I	II	III
Pounds harvested	25,000	55,000	120,000
Total facilities investment	$27,039	$56,795	$112,664
Overhead costs[1]	3,586	7,475	14,756
Operating costs			
Fingerlings[2]	8,900	19,560	42,660
Feed[3]	6,650	14,631	31,924
Labor[4]	1,625	3,575	7,800
Chemicals[5]	175	385	840
Utilities[5]	1,000	1,500	3,000
Interest on operating capital[6]	1,026	2,225	4,840
Total operating costs	19,376	41,876	91,064
Total overhead & operating costs	22,962	49,351	105,820
Costs/lb harvested	0.92	0.90	0.88
Overhead	(0.14)	(0.14)	(0.12)
Operating	(0.78)	(0.76)	(0.76)

[1]Includes: 1) amortization of raceways, building, and distribution/collection boxes at 9 percent for 25 years; pipes and miscellaneous construction and handling equipment at 9 percent for 10 years; 2) assumed maintenance of 0.5 percent per year of investment in facilities; and 3) estimated yearly taxes and insurance of 2 percent of total investment in facilities.
[2]Fingerlings are 5- to 6-inch trout: a 10-percent mortality rate, 9 months' grow-out, and a price of $200 per 1,000 are assumed.
[3]Estimated with a 2.0:1 feed conversion ratio and a price of $300 per ton.
[4]Hours of labor estimated from Brown, Hill, and Chesness (1974), with $2.00 minimum wage applicable to agricultural labor as of January 1976 employed to obtain costs.
[5]Estimated.
[6]Interest on operating capital assumed to be 9 percent of the operating capital estimate of 0.75 (fingerling cost) +0.5 (cost of feed + labor + chemicals + utilities). Interest on operating capital computed at 9 percent for 9 months is equivalent to a 12 percent annual rate.

GROW-OUT SYSTEMS

Investment and operating costs are based on information obtained in 1975 from growers and specialists working with the industry (Easley, 1976). The total investment in each of the three concrete raceway systems and assumed harvest poundage is shown in Table 1. Overhead costs are based on an assumed 25-year life of the raceways and building; 10 years for pipes and miscellaneous construction[2].

[1]A recent example underscoring interest in aquaculture was the Workshop to Identify Aquaculture Economics Research Needs held 23 April 1976 (Smith and Roberts, 1976).

[2]The decline in overhead costs per pound is largely attributable to the estimates included for the utility buildings and miscellaneous construction. No relationship between output and this construction emerged from the survey, but the estimates themselves account for the apparent economies. The same holds true for the reduction in operating costs between systems I and II, where estimates for utilities account for the reduced operating costs.

Neither land nor management costs are included in Table 1; the net return is viewed as a return to management and land. Imputing costs to these, especially management, is difficult as a result of their variability. At the same time, it is not crucial to the analysis: we are interested in the effect of feed usage and price fluctuations on the net return regardless of whether that return is distributed between one or more factors of production.

Note that the variable input, feed, makes up 34–35 percent of the total operating costs. While the fingerling outlay is larger, it may not be as amenable to further reductions as feed. Fingerling outlays could be reduced by reducing mortality rates; however, because of the risks associated with spreading disease in intensive culture systems, the mortality rate is perhaps currently scrutinized more carefully than feed usage.

EFFECTS OF ALTERNATIVE FEED CONVERSION RATIOS AND PRICES ON UNIT COSTS

Using Table 1 as a reference point, we now turn to the effects on unit costs of a reduction in the feed conversion ratio and in the feed price. An alternative feed price of $250 per ton is selected, while the feed conversion ratio assumed is varied from 2.0:1 to 1.5:1 by tenths. Table 2 summarizes these results for unit operating costs. Though the assumed grow-out period is 9 months, a 1-year accounting period is employed.

The $50 per ton reduction in the price of feed, for any given feed conversion ratio, lowers unit operating costs $0.04–$0.05 per harvested pound in system I, and $0.03–$0.05 per pound in systems II and III. The $50 per ton reduction in the price of feed is a substantial one, representing a 16.7 percent reduction (as a percent of the original feed price). On the other hand, comparable reductions in unit costs could be achieved by reducing the feed conversion ratio by approximately 0.3 pounds in all three systems. For example, under a 2.0 conversion in system I at the higher feed price, unit operating costs are $0.78. Unit costs drop to $0.73 at a feed price of $250 per ton. However, at the higher feed price of $300 per ton, the same reduction in unit costs could be achieved by lowering the feed conversion ratio to 1.7:1. A 0.2 pound change in the feed conversion

Table 2.—Unit operating costs for alternative feed prices and conversion ratios.

Feed Price (ton)	System[2]	Feed conversion[1] 2.0	1.9	1.8	1.7	1.6	1.5
		Cents					
$300	I	78	76	75	73	72	71
250	I	73	72	71	69	68	67
300	II	76	75	73	72	71	69
250	II	72	70	69	68	67	66
300	III	76	75	73	72	70	69
250	III	71	70	69	68	67	65

[1]Pounds of feed per pound of net weight gained. Note: Unit overhead costs are 14 cents in Systems I and II, 12 cents in System III.
[2]Systems same as those reported in Table 1.

ratio lowers unit operating costs by either $0.02 or $0.03, depending upon the system, feed price, and original feed conversion ratio. Hence, improved management practices in feeding could reduce costs considerably with small or negligible increases in labor required to periodically sample fish sizes and growth rates. An example is hypothesized below.

Since feed consumption of trout is dependent on fish size and water temperature, both should be sampled throughout the growth cycle. Adjustments in feed can then be made utilizing standard feed tables relating feed as a percent of body weight to fish size and water temperature. Weekly feed adjustments have been reported based on fish samples and expected weight gain, with water temperature controlled in a recirculating system (Hill, Chesness, and Brown, 1972:369–373). Fluctuations in water temperatures from stream sources increase the importance of such sampling. One might experiment with the frequency of sampling, however; at least monthly would probably be desirable as both fish size and water temperatures can change significantly over this length of time[3].

To gain some understanding of the potential magnitude of net cost savings (reduced feed costs, increased labor costs) from improved feeding practices, the following example is hypothesized. Assumed are a 9-month grow-out period, monthly sampling, increased time required to sample of 20 minutes per raceway, and a resulting reduction in the feed conversion of 2.0 to 1.9. Reductions in feed outlays at feed price of $300 per ton for systems I, II, and III are $333, $731, and $1,596, respectively. Labor outlays would be increased in the three systems by $43, $101, and $213. Net cost savings (ignoring small changes in interest on operating capital) would be $290, $630, and $1,383. While the hypothesized reduction in the feed conversion ratio may be overly optimistic, net cost savings are substantial[4].

EFFECTS OF ALTERNATIVE FEED CONVERSION RATIOS AND PRICES ON RATES OF RETURN

Changes in unit operating costs are important barometers of profitability; however, they do not fully illustrate the impact of potentially permanent changes in costs on net revenue. To incorporate the effects on profitability over time of a reduction in the feed conversion ratio, internal rates of return on investment are computed for the same feed prices and conversion ratios shown in Table 2. These were estimated by a computer program from projected cash flows over the assumed 25-year life of the raceways.

Several assumptions were necessary to develop the cash flows. First, in order to generate revenues, a product price of $0.95 per pound (live weight) was assumed. This price was selected because it is slightly above the highest total unit costs computed and in the range of prices received by growers in 1975. Revenues were assumed to begin in the second year and continuing through year 25, with salvage of equipment and land (valued at $2,000 per acre) included in the final year[5].

The cost or outlay stream is assumed to begin the first year with the investment in facilities. A land value (at $2,000 per acre) is included as it represents part of the initial

[3]Monitoring fish growth by sampling raises the question of how large a sample to take. A technique is available for estimating sample size when the population variance is unknown (Steele and Torrie, 1960:86–87).

[4]The results suggest perhaps that biologists and economists should more closely examine the tradeoffs between labor requirements in feeding and growth responses to feed. Along the same lines, could more selective grading based on growth rates reduce total feed requirements? What are additional costs with these refinements? Answers to these types of questions might well allow further improvements in feed conversion ratios. While much work has been done with feed response, little has been done in correlating these responses to possible changes in costs (other than feed) and rates of return. Possible improvements in expected rates of return are important to commercial attempts at culturing new species as well as existing ones.

[5]Salvage values (estimated at book value using simple straight-line depreciation) may be understated if the raceways in fact have a longer productive life than the 25 years assumed. If this is the case, the rates of return would be somewhat higher than those reported. However, the emphasis is on comparisons of rates and not the absolute levels.

outlay[6]. Beyond the first year, actual outlays by year consist of the following: 1) operating and overhead expenses computed using Table 1 as a base and incorporating the feed prices and conversion ratios shown in Table 2; 2) replacement of equipment at succeeding 10-year intervals; and 3) estimated income tax payments. Tax payments were estimated using an assumed, simplifying tax schedule and an investment tax credit of 10 percent with a 3-year carryover[7].

Table 3 presents the internal rates of return computed from the cash flows. The rates exhibit a similar pattern to that in Table 2; they increase for a reduction in feed price and for lower feed conversion ratios. Note that the increase in the rate of return is smaller for a reduction in the price of feed, at the lower feed conversion ratios. This is true for any one of the three systems. There are two reasons for this pattern. First, at the lower

[6]No land appreciation or product-price/cost inflation if assumed as the primary concern is to isolate the effects of the different cost conditions on the rate of return.

[7]Taxes were computed directly from the net profits of the trout enterprise. Assuming that most operations would be individually owned, the tax rates applied may appear low compared to Federal rates; however, personal deductions and exemptions have not been taken into consideration. Hence, rates applied directly to net profits for computing taxes that would be filed under a sole proprietorship status would be lower to attain comparable taxes. The assumed tax rates (percent of net business income) by business income are as follows: $10,000 or less, 10 percent; $10,001–15,000, 15 percent; $15,001–25,000, 20 percent; $25,001–40,000, 25 percent; Greater than $40,000, 30 percent.

Table 3.—Internal rates of return.

Feed price (ton)	System[2]	Feed conversion[1] 2.0	1.9	1.8	1.7	1.6	1.5
		Percent					
$300	I	7.9	9.2	10.3	11.2	12.2	13.2
250	I	11.6	12.4	13.2	14.0	14.8	15.6
300	II	9.9	11.0	12.1	13.1	14.1	14.7
250	II	13.5	14.3	14.7	15.5	16.4	17.2
300	III	11.7	12.9	14.0	15.1	16.2	17.2
250	III	15.5	16.2	17.2	18.1	18.0	18.8

[1]Pounds of feed per pound of net weight gained.
[2]Systems same as those reported in Table 1.

feed conversion ratio, less feed is used, hence a given change in the price of feed has less impact. Second, at successively lower feed conversion ratios, taxes take a proportionately larger share of an increase in net profits that results from a decrease in the price of feed.

The rate of return shows some interesting patterns in moving to lower feed conversion ratios. A reduction in the feed conversion ratio of approximately 0.3 pounds has an effect comparable to the 16.7 percent decrease in the price of feed. Note also that the rates increase more at the higher feed prices than at the lower one for given reductions in the feed conversion ratios. This is not surprising.

The pattern of rates should furnish growers (and educational specialists working with them) some additional incentive to feed more efficiently. Not only do profits and rates of return increase, variations in net returns are also cushioned somewhat from fluctuations in feed prices.

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