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Chapter 17

Economic Analysis for Walleye Aquaculture Enterprises

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Introduction

This chapter provides an introduction and/or review of some of the basic budgeting tools and analytical methods that may be useful in evaluating the potential economic viability of a current or planned walleye aquaculture enterprise. There are few references to actual "costs and revenues," because there have been few reports of actual or simulated economic performance of walleye aquaculture enterprises. However, the economic analyses of walleye aquaculture enterprises by Edon (1994) and Makowieclu (1995) have been used as a frame of reference for the present study.

Basic budgeting

Enterprise budgets, sometimes called "production budgets" or "partial budgets", provide a framework within which one can explicitly recognize the facts, assumptions, and uncertainties involved in a current or planned production operation or enterprise. This budgeting process is often referred to as an "enterprise budget" or "partial budget", because it represents part of a larger agribusiness. For example, many farmers construct enterprise or partial budgets for each of their crop and livestock operations. These budgets help identify enterprise specific problems and opportunities, while also contributing to comparisons among enterprises and constructing overall or total budgets for the total farm.

Constructing an enterprise budget (henceforth called "budget") for a current or anticipated walleye aquaculture operation should be done by those who are or will be involved in operating and managing the operation. This is important, because they know how the system operates and, as in the case of planning a new operation, they bear the final responsibility for the assumptions used in constructing the budgets. Assistance from the Extension Aquaculture Specialist and other aquaculture producers may be helpful for those with limited experience in walleye aquaculture.

Budgets may be constructed on an annual basis, or on a production cycle basis if the production cycle is not a year. The following discussion assumes an annual budget construction. The primary focus of this process is on developing sound estimates of the costs of the operation. While marketing, prices, and revenues are obviously important, the range of possible or likely revenues are not as difficult to document and estimate as are the costs of operating a walleye aquaculture operation.

The components for a budget include: (1) size of operation, investment required and investment related costs and; (2) other costs, sometimes called operating costs. These costs must be organized in a manner that supports critical analysis of assumptions, uncertainties, break-even market prices and potential economic viability of the operation.

Size of operation

The initial size of an operation depends on a number of factors, includmg:

1. Owner's objective: hobby, evaluation, or profit?
2. Assets available: hard (land, equipment, and financial sources) and soft (knowledge and experience).
3. Initial estimate of market potential.

If the owner's objective is to evaluate his/her ability to operate an aquaculture operation or just to raise some walleye as a hobby, it would probably be reasonable to size the operation to existing hard assets. On the other hand, if the primary objective is to have a profitable commercial operation, it would be more reasonable to size the operation to fit the estimated market potential, as well as the available hard and soft assets.

In either case, one needs either the upper limit of hard assets, or the goal for annual production to estimate the initial size of the operation and the initial investment. If one begins with a hard asset limit, such as an existing pond and/or tank system, the production capacity of the pond or tank system can be estimated, based on the biological needs of the fish. If one begins with a predetermined amount of annual production, the size of ponds or tanks can be estimated based on the biological needs of the fish. These biological requirements are discussed in other chapters.

Initial investment and related expenses

A list of items that must be considered when estimating the initial investment for a fry to fingerling production operation is shown in Table 1. Investment related expenses are operating expenses that depend, at least in part, on the capital invested in the assets of the operation. These expenses may also be classified as fixed expenses. Fixed expenses are those expenses that can be estimated before production begins, as they do not vary with the volume of production from the given assets. Typically, the two most significant such expenses are depreciation and interest on invested capital. Also of importance are property taxes, fixed maintenance and repair expenses and property insurance expense.

Depreciation and interest

Depreciation and interest may be estimated using actual interest expense and the "allowable depreciation" expense accounting rules used by the Internal Revenue Service, or, especially in cases where there is little experience with the production process, by using straight-line depreciation over the estimated economic life of assets and estimated opportunity costs for interest on invested capital. The second approach involves fewer calculations and is usually the preferred approach for the novice or for the first estimates of production expenses. This approach is discussed in this section, while the first approach is illustrated in an example application shown later in the chapter.

Annual depreciation on all assets (except land which is not depreciable) with expected useful lives of more than one year is estimated by dividing the initial investment price by the number of years the asset is expected to be useful (expected useful life). Annual interest expense is estimated by multiplying one-half the total initial investment by the opportunity cost of the funds invested. In simple terms, the opportunity cost is the annual interest which could be earned by capital in the next best alternative investment. For example, if the next best investment opportunity were in a mutual fund with an expected annual return of 12% then the annual opportunity cost of investing that capital in a walleye production operation would be considered to be 12%.

Table 1. Potential initial investment items for tank- or pond-based walleye production systems.

Item	System
Land	Both
Pond and levee renovation or construction	Pond
Tractor	Pond
Building space renovation or construction	Tank
Pumps	Tank
Plumbing and piping	Tank
Heating/cooling Equipment	Tank
Tanks, troughs and reservoirs	Tank
Particle removal filter equipment	Tank
Utilities	Tank
Biofilter equipment	Tank
Feeding equipment	Both
Feed storage	Both
Aeration equipment	Pond
Oxygen injection equipment	Tank
Testing equipment	Both
Monitoring and alarm system	Tank
Emergency oxygen equipment	Tank
Harvesting equipment	Both

That annual interest expense rate is multiplied by one-half the initial investment because, when using straight-line depreciation, the average annual investment would be one-half the initial investment.

Property taxes

Property taxes can be estimated using local property tax rates, and an estimate of what local authorities would estimate the assessed value to be for taxable property. While this is a measurable expense, it typically is not a major expense in rural taxing districts.

Fixed maintenance & repair

Most facilities and equipment require annual maintenance and repair which is not directly related to the amount of product moved through the system. These expenses are best estimated using historical records. When such records are not available, rules of thumb and manufacturer guidelines may be used. These annual expenses may be estimated as a percentage of initial investment in each asset. Assets with many moving parts and exposure to corrosion may have an annual rate as high as 5%. Assets without moving parts and less exposure to corrosion may have an annual rate as low as 1%.

Table 2. Other operating expense items for tank- or pond-based walleye production systems.

Inputs	System
Employee salaries/wages	Both
Employee fringe benefits	Both
Fry	Both
Feed	Both
Water	Tank
Chemicals	Both
Oxygen	Tank
Electricity/gas	Both
Variable maintenance and repairs	Both
Fees and licenses	Both
Miscellaneous expenses	Both
Operating interest expense	Both

Property insurance

Estimates of property insurance rates may be obtained from insurance agents. This expense is not typically a major expense, but should be included because it is a real expense and it also provides the opportunity to discuss insurance with providers.

Other operating expenses

Operating expenses other than those listed above are listed in Table 2. In evaluating whether an enterprise is likely to be economically viable in the long-run, one should include as expenses all inputs used in the enterprise that have some value if used in another enterprise (opportunity cost). For example, the operator/owner may be tempted to assume that his/her own labor and time carries no expense. This is usually based on the assumption that his/her time has no value. While this may be an acceptable assumption for a hobby enterprise it is generally not acceptable for a commercial enterprise, because it assumes the operator/owner has no marketable talent or skill. The same logic holds for interest expense on operating capital. This represents the cost of funds tied up in supplies and other cash expenses during the production period. These funds could earn interest if invested in stocks, a savings account, or other interest bearing opportunity.

The assumptions used in estimating the operating expenses are important. These assumptions should be recorded in order to facilitate analysis and to support evaluation of the cost of production if any of the assumptions are changed. The first assumptions recorded for each input should be those concerning the quantity of the input required for the enterprise, in relation to units of product or units of time. For example, labor requirements may be estimated based on number of hours needed per day or week. These estimates also depend on the degree of automation and cultural practices, such as number of feedings per day.

Feed expense, on the other hand, will be related to several performance assumptions, including: assumed feed conversion ratio, the rate of gain, survival rate, starting weight, and target harvest weight. All factors impact the quantity of feed required to grow a fish to target harvest weight.

The second series of assumptions that should be recorded concern the likely prices to be paid for each input. The prices of most, if not all inputs vary over time and cannot be forecasted with certainty. The uncertainties regarding future prices paid may be recognized by doing budgets which use high, low, and most likely estimates of the uncertain prices. A more complex method of incorporating uncertain prices and production relationships is shown in the example discussed later in this chapter.

The final series of assumptions that should be recorded are those that concern the expected prices and the quantity of the product produced by the enterprise that can be sold. These arc also uncertain, and may be incorporated by completing multiple estimates of revenues based on low, high, and most likely estimated prices and quantities.

The following sections illustrate the use of two analytical tools that can be used to evaluate walleye aquaculture enterprises: the profitability linkage model and volume-cost analysis model. These models are useful only after enterprise budgets have been completed. They provide two methods to evaluate the potential profitability of an enterprise based on the budgets and underlying assumptions.

Analytical tools for walleye aquaculture enterprises

This section describes analytical tools which may improve business decisions. It outlines some of the data that provide useful management information, and discusses a framework in which management information may be used in decision malung.

What is management information? Management information is information that is useful for making management decisions. One of the challenges in managing a business is to select the information that may be useful in profitably managing a business. To be successful you and your employees must keep up to date on biological, chemical, and other technical information related to the products you produce and sell. You and your employees must have some technical expertise and must continually update your knowledge and information in these areas. If this is not done, the business will not succeed. Being prepared to utilize management information, means collecting and assembling useful information in a decision making framework so that it can be used effectively to influence management decisions.

Management information may be classified into two broad categories: internal information and external information. Internal information includes operating and financial records for your business and operating and financial records for similar businesses.

There are many forces impacting businesses over which the owner/manager have little control. However, effective manager/operators prepare to act as these forces cause or indicate changes affecting the business. External information includes inflation and trends in prices, interest rates and federal monetary policy, government and regulations, market and competitive forces, includmg competitors' strategies. External information also includes current and projected input prices; qualified and trained supply of labor; technological changes that have potential impact on you, your competitors, or your customers; weather/climate; and changes in consumer values and attitudes that may have sustained or short term or long term impact on demand for fish products.

The art and science of profitably operating a walleye aquaculture enterprise calls for the utilization of the types of management information discussed above in making decisions in the areas of purchasing, investments, marketing/distribution, and production. It requires setting goals and objectives. The goals and objectives set by management will be more realistic when they are based on sound information. One can never eliminate the risk and uncertainty inherent in an aquacultural production enterprise, but the risk and uncertainty can be reduced with a better understanding of the business and the internal and external forces that impact it.

Two analytical tools (or models) provide a framework to analyze the potential impact of internal or external factors on the profitable operation and financial performance of a business. Those two models are: the profitability linkage model and the break-even analysis model.

Profitability linkage model

The basic profitability linkage model (Figure 1) is a conceptual framework linking the operating statement and balance sheet to ascertain the profitability of the firm and illustrate how profitability is related to revenues, expenses, assets, and equities. The example used in Figure 1 to illustrate the profitability linkage

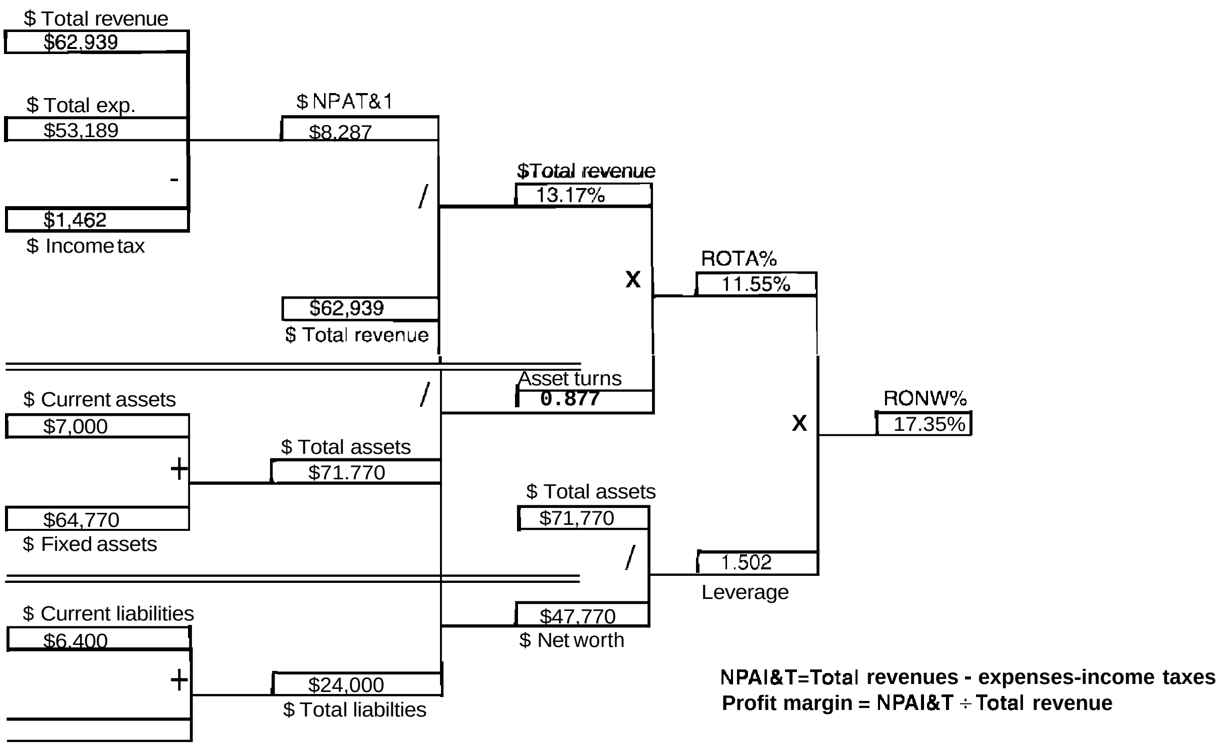

Table 3. Beginning pro forma balance sheet for a hypothetical, intensive walleye fingerling tank system.

Assets			Equities	
Cash		$1,000	Accrued expenses	**$2,000**
Accounts receivable		$0	Accounts payable	$0
Inventory		$6,000	Notes payable	**$4,400**
Total current assets		$7,000	Total current liabilities	$6,400
Equipment	$33,440		Long-term liabilities	$17,600
Less depreciation	**$0**	**$33,440**		
Facilities	$28,200		Total liabilities	**$24,000**
Less depreciation	$0	$28,200		
Land	$3,130	$3,130		
Fixed assets		$64,770	Net worth	$47,770
Total assets		$71,770	Total liabilities + Net worth	$71,770

Balance sheet ratios

Net profit	13.17%
Return on total assets	11.55%
Return on net worth	17.35%
Asset turnover	0.877
Leverage	1.502

Table 4. Pro forma income statement for break-even analysis for a hypothetical, intensive walleye fingerling tank system.

Item	Total dollars	% Total revenue	Fixed expense $ per year	Variable expense % of Total Revenue
Cycles per year **2**				
Price per fingerling	0.84			
Total revenue	62,939	100.0		
Operating expenses:				
Employee wages	14,660	23.3	14,660	
Employee fringe	4,398	7.0	4,398	
Eggs	1,664	2.6		2.6
Feed	9,463	15.0		15.0
Water	470	0.7	470	
Oxygen	1,165	1.9	160	1.6
Electricity	8,221	13.1	8,221	
Maintenance and repair	2,879	4.6	2,879	
Depreciation	5,107	8.1	5,107	
Fees and licenses	50	0.1	50	
Insurance	324	0.5	324	
Property tax	196	0.3	196	
Miscellaneous	629	1.0		1.0
Operating interest	1,324	2.1	1,324	
Total operating expenses	50,549	80.3		
Capital interest expense	2,640	4.2	2,640	
Total expenses	53,189	84.5	40,428	20.3
Net profit before taxes	9,750	15.5		
Taxes (Corp. rates)	1,462	2.3		
Net profit after tax and interest (NPAT&I)	8,287	13.2		

model is based on the assumptions and data used in the example discussed later in this chapter. The information contained in the model comes from the pro forma income statement (Table 4) and the pro forma balance sheet (Table 3). These financial statements represent a likely scenario for the Mathias and Moodie (1994) tank system analysis simulated by Edon (1994) and discussed later in this chapter.

The top third of the profitability linkage model in Figure 1 contains the expense and revenue information from the pro forma income statement. The arrangement illustrates the relationships between expenses, revenue and the resulting profit margin for one year. In summary the relationship is as follows:

Revenue - Expenses - Tax = Net Profit after Tax and Interest (NPAT&I)

NPAT&I ÷ Total Revenue = Percent Profit Margin

The focus is on profit margin percentage and the factors that affect it. The profitability linkage model helps illustrate the impact of a change in any item on the pro forma income statement (Table 4) on the percentage profit margin. For example, an increase in the cost of feed (or other input) or a decrease in revenue will reduce the profit margin, while a decrease in any cost item or an increase in revenue will increase the profit margin.

The middle section of the model in Figure 1 contains the asset side of the pro forma balance sheet. Current and fixed assets may be listed in as much detail (or breakdown) as desired to track their impact on the business. The focus of this section of the model is on the efficiency of asset usage measured by asset turns, which is the ratio of total revenue to total assets. An asset turns of 2.5 means there was $2.50 of revenue for each dollar invested in assets. **A** change in any asset category and its impact on asset turns can be traced and understood in this section of the model. For example, if there were a decrease in the investment in a fixed asset, the result would be an increase in asset turns. Similarly, if there were an increase in any asset category the result would be a decrease in asset turns. To see how important these lunds of changes may be, the first two sections of the model are linked to produce the return on total assets percentage (profit margin percentage **X** asset turns). The income statement analysis and the asset analysis become even more useful when they are linked in this manner, because it focuses attention on the return on investment, where investment is represented by the value of total assets.

The bottom third of the profitability linkage model in Figure 1 provides details on investment in the business by the owners (net worth) and by outsiders (liabilities). The ratio of total assets (which equals total investment) to net worth produces a measure of relative owners' investment known as financial leverage. Leverage illustrates how many dollars of total investment there are for each dollar invested by the owners (net worth or owners equity). For example, the leverage ratio in Figure 1 of about 1.5 means for each dollar of owner investment there is $1.50 total investment or $0.50 invested by outsiders. These "outsider" investments are listed on the balance sheet in Table 3 as liabilities for the business.

The linkage of leverage to the return on total assets percentage produces the final and most important measure of profitability: return on net worth. This final linkage allows one to trace the impact of changes in revenues, expenses, assets, liabilities, or net worth on the return on net worth. In the final analysis, most businesses must provide the owners with an acceptable return on their investment to retain that investment. If returns are not acceptable, investment dollars will flow to similar investments with higher returns or lower risk. The acceptability of returns depends on the risk and returns on alternative investment opportunities.

The profitability linkage model illustrated in Figure 1 may be changed to include as much detail as is desired, and it may be adapted to contain multiple years of data, thus allowing the tracking of profitability performance over time. The profitability model can be expanded to incorporate other internal or external factors or forces which may have an impact on the business.

Volume cost analysis

T h e volume of business relative to expenses has an important influence on economic and financial viability. Understanding the relationship between volume and expenses plays a key role in achieving profitability objectives. Research has shown, and common sense tells us, that much of the difference in expenses as a percent of sales, among similar businesses, results from differences in volume.

When volume is less than anticipated, expenses as a percent of sales can be much higher than anticipated. However, increasing volume can be fairly simple: just lowering the price on items you sell may lead to increased sales volume. However, this might reduce profits. To be more profitable, an enterprise must increase sales or decrease expenses or both. The relationship between sales and expenses is very important. This relationship will be examined after a discussion about classifying expenses.

There are many ways to classify expenses: variable and fixed; controllable and non-controllable; selling and administrative; etc. Each breakdown is useful for different reasons. The variable - fixed breakdown is the one most useful for purposes of volume analysis. It shows the relationship between sales volume and costs, and it lays the basis for the use of an important management tool known as "volume-cost" or "break-even analysis''.

A fixed expense or fixed cost is present even if there are no sales. It doesn't automatically increase as sales increase. The definition for fixed cost (or expense) is those costs that do not fluctuate with the volume of business. Fixed costs are considered the cost of being in business. **A** variable expense or variable cost changes in direct relationship with sales; in fact, sales cause variable expenses. The definition of variable cost (or expense) is those costs which vary directly with the volume of sales. Variable costs are considered the cost of doing business. For instance, the cost of goods sold is a variable expense. Sales cause cost of good sold. Employee expenses, however, are not a variable-expense, if they are predetermined by agreement or contract rather than directly caused by selling product.

Some expenses may be a mixture of fixed and variable expenses. For instance, an initial/permanent labor force is necessary for doing business, so they represent a fixed cost. Additional people may be needed to perform selected duties during shorter peak sales or stocking or harvesting; this labor is a variable cost since it is directly related to the volume of business.

Judgments must be made about the breakdown of expenses into fixed and variable categories. Volume cost analysis, when correctly applied, can help answer a number of important questions concerning the impact of size of business and changes in costs or prices on the profit of the business.

There are four basic steps in determining the break-even volume for an aquaculture production business.

STEP 1. Identify fixed and variable costs.
STEP 2. Summarize fixed and variable costs.
STEP 3. Calculate the contribution to overhead
STEP 4. Calculate the break-even volume.

These four steps are further defined in the following discussion and illustration. Table 4 contains the pro forma income statement for the simulated walleye fingerling tank production system. **A** potential break-down into fixed and variable costs is shown in the two right hand columns labeled "Fixed expense $ per year" and "Variable expense % of total revenue"" (Step 1). This step is important, because mistakes in categorizing costs produces misleading results. The income statement also shows total costs expressed in total dollar terms and as a percent of total revenues for each category.

When the last two columns in Table 4 are completely filled, variable costs can be determined as a percentage of total revenue and fixed costs can be determined as total dollars for the year (Step 2). Volume cost analysis is based on the assumptions that selling price and cost relationships are constant. **As** conditions change, costs and the fixed/variable breakdowns should be re-estimated to more accurately reflect the operating environment. By keeping the analysis current, one can satisfy the assumptions and use volume cost analysis as a powerful planning tool.

In Table 4 the variable costs were 20.3% of revenues or about $0.203 per dollar of sales revenue. We can now calculate the contribution to overhead (CTO) per dollar of sales revenue (Step 3). The contribution to overhead is defined as the portion of revenue from each unit or dollar of sales that remains after variable costs are covered. This portion of revenue is applied toward covering fixed costs. For each dollar of sales revenue in this example:

CTO = $1.00 -$0.203 = $0.797

Variable costs are covered before fixed costs when revenue comes into the business. What remains after variable costs are covered is known as a contribution to overhead (CTO) which goes to cover or pay fixed costs. When all fixed costs are covered, the business is at "break-even," and it then begins to make a profit as volume increases beyond the break-even volume of business. The Break-even point (BEP) for a business is the total revenue volume at which total fixed costs are just covered by the contribution to overhead (Step 4). It is calculated as follows:

BEP = $Fixed cost ÷ $CTO per dollar revenue =
$40,428 ÷ $0.797 = $50,725

This is the dollar volume of business at which total revenues equal total costs and profits equal zero. Each dollar of sales revenue above $50,725 generates profit. The amount of profit generated for each dollar of sales above the break-even point in this example is $0.797.

The following exercises illustrate the uses of volume cost analysis in :profit planning; analyzing the impact of change in a product price; analyzing the impact of a change in fixed cost; analyzing the impact of a change in variable cost.

Example: Profit planning

Volume cost analysis can be used to estimate the sales volume required to achieve the desired profit. For example, assume that the profit goal equals the net profit before taxes in Table 4 ($9,750). Each dollar of sales over and above the break-even point generates $0.797 (CTO) in profit. What dollar volume of sales is required to cover all fixed costs and achieve the profit goal? The equation for profit planning using break-even analysis is:

Volume required (VR) = ($profit goal + $fixed cost) ÷ $CTO per dollar revenue = ($9,750 + $40,428) ÷ $0.797 = $62,959

The calculated sales volume required is about equal to the total revenue shown in the pro forma income statement in Table 4 (the difference is due to rounding errors).

Example: Analyzing the impact of a change in price

One of the most powerful uses of break-even analysis is to determine the impact of changes in price of the product sold. Decreasing the price per fingerling decreases the CTO. As the CTO gets smaller, the BEP gets higher. With break-even analysis, you can determine how many more sales dollars must be generated before a decrease in price is a profitable decision. For example, if you decrease the price 1%, how would it affect the BEP? Remember CTO = sales dollar - variable cost per dollar

Old CTO = $1.00 - $0.203 = . $0.797 per $1.00 of sales
Old BEP = $fixed cost ÷ Old CTO = $40,428 ÷ $0.797 = $50,725

New CTO = $0.99 - $0.203 = $ .787
New BEP = $fixed cost ÷ New CTO = $40,428 ÷ $0.787 = $51,370

The new BEP is $645 higher than the old BEP. The sales volume required to achieve the previous $9,750 profit goal would be:

Volume required (VR) = ($fixed cost + $profit goal) ÷ New CTO = ($40,428 + $9,750) ÷ $0.787 = $63,759

This is an $800 higher sales volume than the original volume required prior to the reduction in price.

Example: Analyzing the impact of a change in fixed cost

Volume costs analysis can help determine the additional volume necessary to support the purchase of more assets or other fixed cost changes. A way to calculate the additional sales volume required is:

$ Additional fixed costs ÷ CTO = $ Additional sales required

For example, how much additional volume will be required to cover the cost of an addtional pick-up truck? Assume a new pick-up truck costs $15,000 and has an expected life of 5 years. Assume a straight line depreciation of the truck with no salvage value; insurance, taxes, etc. are $1,000 per year; and any other operating costs are the same as for other trucks. The annual fixed cost increase caused by the purchase of the truck would be:

depreciation ($15,000/5 years) = $3,000, other fixed costs = $1,000, total additional FC = $4,000

Additional FC ÷ $ Original CTO = $5,019 in additional sales needed

Note: these additional $5,019 in sales are needed every year for the next 5 years. If a new employee is needed to drive the truck, a new fixed cost for his salary must also be included.

Example: Analyzing the impact of a change in variable cost

Variable costs can also change. When variable costs change, the CTO changes and when the CTO changes, the BEP changes. What happens to the BEP if variable costs increase by $0.02 per dollar of sales?

CTO = sales dollar - variable cost per dollar = $ 1.00 - $0.223 = $0.777

BEP = $ Fixed Cost ÷ $ CTO = $40,428 ÷ $0.777 = $52,031

This is $ 1,306 higher than the original break-even volume. Further, if one wished to maintain the original profit goal of $9,750, the sales volume required would be:

Volume required (VR) = ($fixed cost + $profit goal) ÷ New CTO = ($40,428 + $9,750) ÷ $0.777 = $64,579

Therefore, if variable costs increase by $0.02 per dollar of sales, the volume required to maintain the original profit goal would be $1,620 higher.

Table 5. Break-even analysis scenario for a hypothetical, intensive walleye fingerling tank system.

	Total dollars	Per kilogram	Per fingerling	Per dollar of total revenue
Total fixed cost	$40,428	$17.99	$ 0.54	$0.642
Total variable cost	$12,761	$5.68	$ 0.17	$0.203
Break-even volume: (BEV)	$50,710	1,811 kg.	60,369 fing.	
		Change in Bev:		
Per $1,000 increase in fixed cost	$1,254	45 kg.	1,493 fing.	
Per $0.01 increase in variable cost per kg	$23	1 kg.	27 fing.	
Per $0.01 increase in variable cost per dollar total revenue	$644	23 kg.	767 fing.	

Table 5 shows additional statistics for the break-even analysis of the example discussed above. It illustrates the three views one could take in calculating break-even. Break-even is shown in dollars, lulograms, and fingerlings. This type of analysis may be applied to one's own business by following the procedures outlined and discussed above.

Example application of economic analysis tools

T h e economic model that will be presented for intensive production of walleye fingerlings in a tank system is based on a study by Mathias and Moodie (1994). That study was the most complete and the most recent source of information concerning input and yield data, as well as prices and cost structure for such a system. Operating cost data came from studies of past and current production systems. The operating costs consisted of: labor, feed, energy, water, egg cost, oxygen, interest on operating capital, maintenance and repairs, fees and licenses, insurance, property tax, depreciation, and miscellaneous expenses. It was assumed in the model that the production system allowed two production cycles per year. Walleye eggs were assumed to be available as early as March in the South, until late June or early July in the North. The availability of walleye eggs during these periods allows two production cycles per year.

An investment which provides future streams of revenues and costs is inherently risky if the outcomes are not known with certainty. When analyzing the potential profits from a risky investment, such as a commercial recirculating aquaculture system, collection of the most accurate and up-to-date cost and revenue data **is** absolutely necessary. Past economic analyses have utilized measures of central tendency or expected values because of limited information and limited ability to incorporate risk into the framework of an income statement. As more commercially derived cost data become available, information about expected values and measures of variation can be extracted. Also, PC software such as @RISK[1], which was used in this analysis, allows relatively easy analysis of investments with multiple sources of uncertainty.

Initial investment

Information on initial investment costs in land, buildings, fixed equipment, and system components is relatively easy to obtain from the marketplace once the components of the system are identified. Contractors and vendors of fixed equipment can provide up-to-date estimates and price lists. The cost information provided here is based upon a $3,130 investment in land, a 1,504 ft^2 building at a cost of $28,200, and a $33,440 invest-

Table 6. Investment related costs of equipment for walleye fingerling intensive tank system.

Item Description	Initial investment $	Estimated life (Yrs)	Annual depreciation $	Repair and maintenance $
Land	3,130			0
Building @ $18.75/ft^2	28,200	25	1,128	1,410
Total land and building	31,330		1,128	1,410
Equipment				
System for egg incubation:				
Incubator jars (4)	360	10	36	7
Pumps (2)	110	5	22	2
Reservoir plumbing	725	15	48	15
Heaters (3)	580	5	116	120
Holding tank	360	15	24	7
System forrearing larvae				
Troughs (3)	6,280	15	419	126
Particle remover	2,540	5	508	51
Biofilter	580	15	39	12
Reservoirs (2)	290	15	19	6
Heater	2,080	5	416	420
Feeders (10)	1,460	5	292	29
Feeder cont.	180	10	18	4
Piping	800	15	53	16
Screen box(5)	1,090	5	218	22
Pumps (3, 1/3hp)	650	5	130	13
Pumps (2, 1/2hp)	560	5	112	11
System forfingerlings				
Tanks (2)	4,500	15	300	90
Swirl separator	2,900	15	193	58
Biofilter	580	15	39	12
Oxygen tower	145	15	10	3
Heater	1,900	5	380	380
Feeders (2)	290	5	58	6
Controller	220	5	44	4
Oxygen meter	1,800	5	360	36
Alarm system				
	430	5	86	9
Emergency oxygen system	580	15	39	12
Pumps (4, 2hp)	1,450	5	290	29
Equipment total	33,440		3,979	1,469

ment in fixed equipment and utilities (Table **6).** Total initial investment is estimated to be $64,770.

Depreciation

Estimation of annual depreciation costs for buildings, fixed equipment, and system components requires information about expected economic lives and salvage values. Until various production systems have been up and running for a number of years, useful economic lives and salvage values of various fixed equipment will not be known with certainty. Such data are based upon engineering estimates for longer-lived equipment and actual observations for shorter-lived equipment. Data presented in Table 6 are estimates, based upon the best available information. The resulting figures represent straight-line depreciation costs over the estimated lives of the building and equipment.

Operating costs

A key variable in the estimation of operating costs is the selected level of technology or the mix of fixed equipment. Choice of technology may have a significant effect on profits; therefore, it is important to have information on operating costs as they vary with the level of technology. Such information may come from studies of actual production systems or from simulation analysis based upon engineering data. Due to the relative infancy of intensive aquaculture, much information from private companies has been restricted for proprietary reasons. Publicly available cost data from

Table 7. Values for uncertain input variables for a hypothetical, intensive walleye fingerling tank system.

Stage	Variable	Low	Likely	High
All stages:	Fingerling price	$0.600	*$0.800*	$1.000
	Oxygen price	$1.219	$1.444	$1.670
	Labor wage	$7.00	$8.00	$10.00
	Electric charge	$0.0500	$0.0600	$0.0800
	Eggs to incubate	360,000	400,000	440,000
Stage IA:	Feed price	$20.00	$30.00	$50.00
	Survival rate	20.00%	30.00%	40.00%
	FCR.	0.90	1.50	1.70
	Rate of gain/d	0.008	0.010	0.020
Stage IB:	Feed price	$3.50	$4.00	$5.70
	Survival rate	60.00%	*70.00%*	80.00%
	FCR.	0.90	1.50	1.70
	Rate of gain/d	0.050	0.050	0.065
Stage II:	Feed price	$1.20	$1.40	$1.50
	Survival rate	85.00%	85.00%	93.00%
	FCR.	0.90	1.50	1.70
	Rate of gain/d	0.120	0.120	0.125
Stage III:	Feed price	$1.20	$1.40	$1.50
	Survival rate	90.00%	90.00%	96.00%
	FCR.	0.90	1.30	1.40
	Rate of gain/d	0.200	0.200	0.250
Stage **IV:**	Feed price	$1.20	$1.40	$1.50
	Survival rate	85.00%	88.00%	95.00%
	FCR.	0.90	1.60	1.60
	Rate of gain/d	0.40	0.40	0.51

Table 8. Simulation results for walleye fingerling hypothetical ntensive tank system (2500 observations).

	Total Expense Cents/Fingerling	Net present value @ 15%	Net profit after tax and interest
Minimum	$0.4737	-$87,851	-$23,119
Maximum	$1.1595	$168,681	$54,606
Mean	$0.7191	$8,909	$6,319
Std Deviation	$0.1034	$32,556	$9,834
Variance	$1.0695	$1,059.9 mil	$96.7 mil

actual production systems are therefore limited. Currently available data for walleye production systems have come mainly from universities, which have constructed and operated commercial scale production systems and from research experts such as Mathias and Moodie (1994).

Data used in this analysis indicate that feed costs represent 15.0% of total revenues (Table 4), but prices fluctuate. Labor is another major cost factor. Employee wages and employee fringe benefits were near 36.3% of total revenues. Labor costs may vary significantly from region to region. Electricity is the third largest operating cost at 13.1% of total revenues. Depreciation and maintenance and repair account for about 12.7% of total revenues and it can vary due to the cost of equipment. Interest on operating capital and interest on capital investment account for about 6.3% of total revenues.

Interest on operating capital was determined by multiplying one quarter of total operating expenses less depreciation by an interest rate of 12.0%.Interest on capital investment was figured at 12.0% times one-half the total initial investment in buildings, fixed equipment, and system components plus 12.0% times the initial investment in land.

Revenue

Total revenue is dependent upon total annual production and net price received. Expected annual production is affected by feed conversion ratio, rate of gain, mortality, and the number of days required to reach market size. The expected price for walleye fingerlings was assumed to be $0.84 per fish or $28.00/kg for this simulation.

Risk analysis

To assess the risk and uncertainty arising from the inability to accurately predict certain price and production variables, the pro forma income statement in Table 4 was generated 2,500 times using the Latin Hyperbola iteration procedure in @RISK. To reflect uncertainty, triangular distributions with minimum, likely, and maximum values were assigned to five general or global variables and four other variables in each of the five production stages as shown in Table 7.

The general goal of this study was to determine if the commercial production of advanced, 6 inch walleye fingerlings, reared intensively in a tank system in the north central region, would be economically viable. The simulation produced 2,500 observations for the total expense per fingerling produced, the net profit after taxes and interest, and the net present value (Table 8). The simulation generated: 1) a mean expense of $0.7191/fingerling with a standard deviation of $0.1034, a minimum expense of $0.4737 and a maximum expense of $1.1595/fingerling produced; 2) an expected net profit of $6,3 19 with a standard deviation of $9,834, a minimum profit of -$23,119, and a maximum profit of $54,606; and 3) a mean net present value of $8,909 with a standard deviation of $32,556, a minimum net present value of -$87,851, and a maximum net present value of $108,861. The positive expected net present value generated by the simulation, along with an expected net profit of **$6,319** indicate that investment in this "hypothetical" enterprise may be acceptable at the discount rate of 15 percent.

Net Present value

The net present value which was calculated for the investment in the simulated walleye fingerling system assumed a weighted cost of capital of 15%. All fixed equipment and components were assumed to be sold for salvage value at the end of a 5-year period.

Generating pro forma income statements with estimates of expected net profit after taxes provides one measure of the potential profitability of an investment. However, such estimates do not provide enough information to make the investment decision. Rational investors will invest their money where it is expected to produce the highest return for any given level of risk. Because fish production and marketing on a commercial scale is still a very risky business, one would expect an investment in such systems to produce a higher return than investments in less risky opportunities in order to attract the necessary investment. The net present value method of investment analysis is one of the best methods used to evaluate investments in business ventures.

The results shown in Table 8 are greatly impacted by the quality and accuracy of the data used in the analysis. Persons interested in investing in a commercial aquaculture investment opportunity should consider this type of analysis prior to accepting or rejecting such an investment opportunity.

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Cooperative Walleye Culture Programs in Michigan

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Introduction

In 1970, the Michigan Department of Natural Resources (MDNR) started a pond-rearing walleye program. In the first year, 45,500 fingerlings were produced. To expand production, the MDNR has established a cooperative walleye culture program, with more than 100 cooperators by 1990. The scope of this program varies from landowner permission for the MDNR to use barrow pit ponds, to well-organized sportfishing groups conducting their own walleye culture with guidance from MDNR. In 1978, the program was expanded substantially with the completion of a 15-acre (6.07-ha) $88,000 walleye culture pond on the Muskegon River, Muskegon County, Michigan. In the first year production was 133,000 walleye fingerlings. This was a cooperative venture between MDNR and Muskegon Sportfishing Association (MSA). This program re-established the major walleye spawning runs in the Muskegon River that had not occurred since the late 1950's. The success sparked interest by other communities to duplicate the walleye culture program and create a walleye fishery for their communities. By 1982, the large spawning runs up the Muskegon River provided a source of eggs for MDNR to expand culture programs for these communities.

Currently, MDNR faces limited finances, manpower, and natural resources to produce the present statewide demand for **6** million walleye fingerlings. Local communities have human and natural resources which can be tapped by well-organized sportpersons and MDNR. The size of the contribution and the duties performed by the parties may vary, but cooperative walleye culture programs can be successful and walleye fisheries can be established.

MDNR receives requests from many communities for fish plantings, especially walleye. Local sportfishmg groups also request walleye culture ponds for their communities. MDNR must first determine if walleye should be a part of the local management plan by reviewing lake selection criteria. If walleye cannot be provided from existing culture, then MDNR must decide if a culture pond is feasible, using pond site criteria.

MDNR criteria used to select a lake for a walleye fishery include:

1. Physical/chemical characteristics favorable to walleye;
2. Waters that historically contained good populations that naturally reproduced;
3. Presence of appropriate forage base;
4. Waters that have produced a fishery by stocking in the past;
5. Public access to the lake;
6. Riparian/angler desire for walleye fishery; support should come from the lake riparians first and local anglers second;
7. Natural reproduction potential.

The following criteria are used to determine if a site is suitable for a walleye culture pond:

1. The pond site is accessible to fisheries workers and vehicles as large as a fish hauling truck. Authorized personnel must have 24-h access. Ideally, the site should be on state owned land, but a long-term lease agreement may be a option. Because walleye fingerlings can be transported by truck, the site need not be located near the body of water to be planted;
2. The area adjacent to the pond site must be clear of brush and/or trees. Land clearing cost must be considered when selecting pond sites;
3. To hold water, the soil profile should have a layer of clay at least 12 in (0.3 m) thck near the soil surface;
4. To obtain an acceptable cost/benefit ratio for walleye fingerling production, the minimum pond size is 5 acres (2.02 ha) and a minimum depth is 5 ft (1.52 m). Larger ponds 8–20 acres (3–8 ha) with a maximum depth of 8 ft (2.4 m) are acceptable.

5. Water must be available to fill the pond initially and to maintain the pond at full level through July. An impoundment with any stream flow through it is not acceptable because the flow will flush the plankton and nutrients out of the pond.

The last drainable walleye pond built by the MDNR in the mid 1980's cost about $10,000/acre ($24,710/ha). The MDNR ponds are amortized for a 20-year life ($500/acre/year, $1,2350/ha/year), and have an annual operating cost of about $250/acre ($618/ha). The statewide walleye production cost is $0.107/fish. Broken down to size range, from fry to fall fingerlings, fish production cost are $0.0003 for 4-day old fry, $0.06 for 3-in (7.62 cm), $0.09 for 5-in (12.7 cm), and $0.15 for 8-in (20.32 cm) fingerlings. The following are MDNR approximations of expectations from a 1-acre (0.4 ha) culture pond, using 1993 data:

average number of 2-in (5.08-cm) fingerlings	7,000
survival to catchable 15-in (38.1-cm) size	10%
rate of angler harvest	20%
number of walleye harvested/yr	140
catch/walleye/angler-day	0.67
angler-days provided/yr	209
expenditure/angler-day	$57.00
expenditure/year	$11,913.00

The cost-benefit ratio of a walleye culture pond is estimated at about 1:16 ($750:$11,913).

This paper will profile two successful cases of cooperative culture programs. The White Lake Area Sportfishing Association (WLASA), Muskegon County, Michigan, will represent a low-investment, nondrainable pond operation, with a walleye hatchery. The Mason County Walleye Association (MCWA), Mason County, Michigan, will represent a large-investment, state-of-the-art drainable pond operation. The two associations utilize different organizational structures to tap financial, human, and natural resources. They reside in adjoining MDNR districts which have different management styles for their cooperative programs.

White Lake Area Sportfishing Association (WLASA)

WLASA was established in 1981 as a chapter of MSA with a $1500 gift from MSA to expand the walleye fishery. In 1982 WLASA became a independent tax exempt organization with a walleye culture program and returned the monetary gift.

Thomas E. Hamilton (fishery biologist) and Dr. Kenneth J. Linton (biology professor) guided the walleye culture program of WLASA from 1982 to 1995, The WLASA walleye hatchery consisted of two 8-acre (3.24 ha) freeway barrow ponds for fingerling production from 1982–1993. Only one pond was used in 1994-1995. Duties and responsibilities for walleye culture are divided as follows:

1. MDNR applied rotenone to the pond(s) in the late fall after the fall fingerling harvest and just before ice formation to eliminate predators.
2. MDNR supplies 1.O–1.2 million fertilized walleye eggs from the Muskegon River stock. WLASA incubates the eggs using Plexiglas jars at 48°F (9°C) to obtain hatchng in 24–26 d.
3. MDNR supplies a 50/50 mixture of soybean meal and alfalfa meal which WLASA personnel applies weekly at 100lb/acre (45.4 kg/0.4 ha) for 6 or 7 weeks.
4. MDNR stocks the pond at 40,000 fry/acre (98,840/ha). During the following week, WLASA will monitor fry survival using floating crappie lights after dark.
5. Fry produced by the WLASA hatchery are used to replace dead fry in other ponds within the MDNR District 9. If those ponds don't need restocking, fry from the WLASA hatchery are stocked by WLASA into lower White River Marsh.
6. WLASA applies #1 fuel oil to control air-breathing predaceous insects at rate of 2.5 gal/acre (9.5 L/0.4 ha), if necessary.
7. WLASA monitors fingerling growth, zooplankton density, and determines harvest date.
8. WLASA harvests their ponds using six large fyke nets. A concentration of 0.15–0.30 PPM copper sulfate crystals are mixed in the center of the pond to stimulate fingerling movement to the nets.
9. WLASA transports spring fingerlings to White Lake. Total number and length/weight data are reported to MDNR.
10. A fall fingerling harvest is conducted by WLASA in October using the same netting procedure. The fall fingerlings are transported by WLASA to White Lake or a lake designated by MDNR.

The 8 x 10 ft (7.5 m^2) hatchery building, equipment, and start up cost was less than $2,000 using local donations and materials. Because all equipment is paid for, WLASA's annual budget for the walleye program is $100, the budget is rarely exceeded, and usually only for emergency repair. Excluding startup, annual cost is $0.002/spring fingerling. Fall fingerlings are considered to be a bonus.

Mason County Walleye Association (MCWA)

MCWA was incorporated in 1987 as a board of directorship with no general members. MCWA is a tax exempt organization. **A** gift to MCWA of 43 acres was used as the site for construction of a 7-acre (2.83-ha) drainable culture pond. The acreage included a 10-acre (4.0-ha) pond which could be used to fill the 7-acre culture pond (Figure 1). Later a 0.5-acre (0.2-ha) zooplankton production pond, which drains to the culture pond, a 0.5-acre (0.2-ha) zooplankton experiment pond, and a 1-acre (0.4 ha) fathead minnow culture pond were constructed. **A** 24 **x** 24 ft (53.5 m^2) building was added to house a wet lab, electrical room, and equipment storage.

The 10-acre (4.05-ha) culture pond is filled to an average depth of 5 ft (1.52 mj in 67 h using a 75-hp electric pump. Depth at the control structure is 8 ft (2.44 m). Liquid fertilizer is applied via slip-stream injection system at 26–28 psi. It is distributed through 1,500 ft (457.2 m) of polyplastic pipe containing 200 holes 0.10 in^2 (0.65 cm^2). A 5 hp electric pump used for fertilization also can be used to replace water lost to evaporation. The control structure includes two dewatering chambers to discharge excess water past the harvest structure. A permanent cement harvest structure is accessible to large MDNR trucks and includes lights for night harvesting. Responsibilities for this culture program arc divided between the MCWA and MDNR:

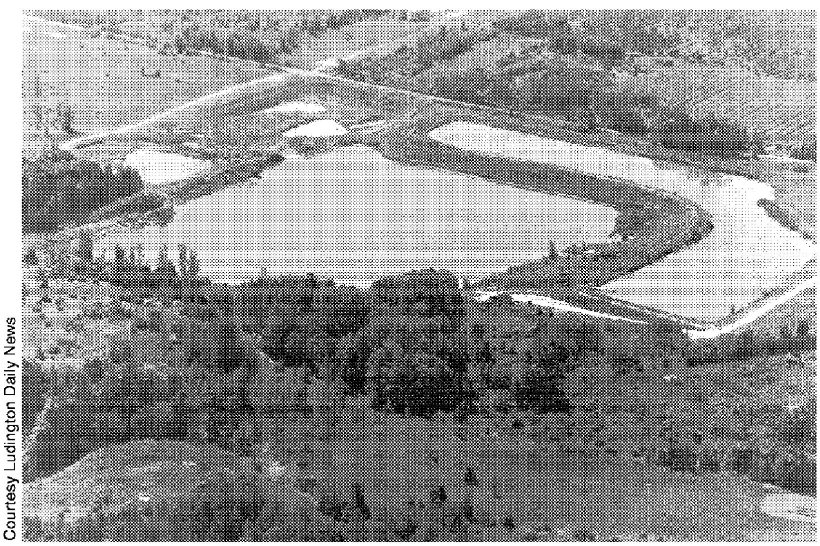
1. The culture pond and zooplankton production pond are filled by MCWA the last week of April. MDNR provides walleye fry from Upper Peninsula Michigan stock in mid-May.
2. MCWA fertilizes both ponds once with soybean meal at 200 lb/acre (494.2 kg/ha). The injection system is used to distribute 28-0-0 liquid fertilizer for a total nitrogen to phosphate ratio 20:1. Nitrogen and phosphorus levels are monitored daily and maintained at 0.6 mg N/L and 0.03 mg P/L by adding additional fertilizer as needed on odd days.
3. MDNR stocks fry at 40,000/acre (98,840/ha).
4. MCWA drains the culture ponds to time fingerling harvest for a date agreed upon with MDNR.
5. MDNR transports fingerlings to lakes in several counties,

Initial land, pond construction, and utilities cost about $250,000. Annual operating budget is $1,500, yielding a spring fingerling cost of $0.0075/fish.

Discussion

MDNR is charged with the responsibility of providing the most fishing opportunities within a limited budget. They recognize there will be competition between communities for fishing opportunities and related tourist dollars.

MDNR may accept support from sportfishing clubs, but this can also turn into a public relations problem. Fish planted in public waters are the property of the state and must be in conformity with the district fishery management plan. Sportfishing clubs must take this into consideration when contemplating plantings. The



Courtesy Ludington Daily News

Figure 1. Mason County Walley Association culture ponds.

working members of the clubs cannot become too attached to "their" fish which may not get planted in "their" local lake, In 1991,WLASA fish were not planted in the White Lake system to determine if natural reproduction had been re-established, but WLASA continued raising walleye fry and fingerlings for other communities in the fishery district. The walleye culture programs of WLASA and MCWA demonstrate benefits of cooperative state rearing programs.

In some cases, MDNR may not have the personnel to serve the outlying communities of their districts. The WLASA hatchery effectively operates as a small backup walleye hatchery for Muskegon River stock and the White Lake system. MCWA found that the success of their liquid fertilization injection system required daily analysis and odd-day fertilization adjustments. In both cases MDNR benefited by having volunteer labor on site.

WLASA is an example of a low budget-operation utilizing a simple hatchery and a freeway barrow pond. MCWA uses an expensive drainable pond operation which is more complicated to manage. Neither format can guarantee a successful production year. MDNR, WLASA, and MCWA have all agreed the long-term cooperative benefits out weigh the occasional pond failures. MCWA is planning to collaborate with the MDNR to test new walleye culture technologies. This collaboration will save the MDNR money, and it will provide students at the local community college research experience by participation with future MCWA projects.

There are two actions sportfishing groups can take to enhance their effectiveness:

1. New sportfishmg organizations should initially form with a board-of-directors structure to facilitate decision making during the construction phase of the walleye program. If possible, people with specific talents should be asked to serve on the board to cover management, finance, law, biology, and engineering. The social membership structure can come after the walleye fishery develops.
2. Obtain a tax exempt status. This will expand opportunities for financial, material, and land contributions from corporations, local businesses, and private citizens. It will simplify fund-raising activities, and the tax status will allow acceptance of excess government equipment from state and federal agencies.

The most important benefit of a cooperative walleye production program is the improved walleye fishery. No agency or interest group is expected to create a walleye fishery by itself, but cooperatively the future for the walleye fishery looks promising.

Buttner, J. K. 1996. Cooperative walleye culture programs: the New York state and province of Ontario experiences. Pages 389–393 *in* R. C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series 101. North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Cooperative Walleye Culture Programs: the New York State and Province of Ontario Experiences

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Introduction

Throughout much of the United States and Canada the walleye is considered a premier recreational fish. However, its abundance has been reduced in many areas by habitat degradation, over-exploitation, and competition from exotic species. To enhance diminished populations and, where needed, to re-establish extirpated populations during a period of fiscal austerity, state and provincial agencies charged with the management of natural resources have pursued innovative solutions. Facilitated by advances in pond culture of walleye fingerlings (Richard and Hynes 1986; Buttner 1989; Fox 1989; Harding et al. 1992) cooperative programs have been employed successfully to produce fish for introduction into public waters (Buttner et al. 1991). The composition and operation of cooperatives vary, but they characteristically include trained specialists and motivated lay people working together to enhance a public fishery. **As** observed by Festa et al. (1987), "cooperative programs involving sportsman's groups can play a meaningful role in increasing walleye fingerling production."

Cooperative walleye culture programs have existed and functioned effectively since the early/mid-1980s in New York State and the Province of Ontario. The goal of both efforts is enhancement of walleye populations in specifically designated public waters. However, the mechanisms employed to achieve their common objective differ. Characterization of the two approaches provides insight into the formation, operation, and impact of cooperative programs.

New York experience

Cooperative walleye culture programs in New York State are administered by the Department of Environmental Conservation (NYSDEC), coordinated by extension specialists, and operated by members of angler associations. NYSDEC approves applications submitted by angler associations, usually provides fry, and oversees stocking of fingerlings into public waters. Extension specialists, often in concert with research scientists from universities and NYSDEC, provide technical guidance in the development of applications, management of ponds, harvest and stocking of fingerlings, and assessment of each year's effort. Angler associations complete and submit applications, provide daily maintenance, harvest and stock fish. Additionally, angler associations must keep good records, submit an annual report, and obtain funds to finance their efforts (via grants, donations, raffles, industry/community sponsorship, association funds).

A cooperative effort begins in the late fall/early winter when a sportsman's group submits an application to the NYSDEC to cultivate walleye fingerlings for introduction into a public water. **A** 10-page packet, "Criteria and Procedures for the Distribution of Walleye Fry to Non-DEC Fingerling Rearing Projects," is provided that identifies guidelines for eligible projects, provides general information on pond design and fish maintenance, and includes a 2-page application form (Festa and Colesante 1988). First-time participants must describe in detail their proposed project. Veteran participants only provide information on their organization (name, person in-charge of culture effort, address, telephone number), identity of approved target water(s) for walleye fingerlings, ownership of the culture ponds, and description of any changes in their project. The application is reviewed by NYSDEC for consistency with their programmatic objectives and technical feasibility (e.g., suitability of ponds, access to expertise). Applicants are contacted if additional information is required or if the proposed approach requires modification. Once approved, the applying organization becomes part of a larger cooperative team that has grown to include 9–12 organizations and thousands of sportsmen (Table 1).

Table 1. Number of sportsman's associations producing walleye fingerlings and number of walleye fingerlings produced by these associations that were released into public waters of NewYork.

Year	Number of Sportsman's Associations	Number of Walleye Stocked
1986	1	20,000
1987	3	12,500
1988	5	69,533
1989	6	85,074
1990	12	156,810
1991	12	152,810
1992	12	133,365
1993	11	126,076
1994	9	23,092
TOTAL		778,775

In March, representatives from angler associations and personnel from NYSDEC discuss and coordinate pond preparation and fry transfer. Most fry introduced into ponds that are managed by cooperative participants are spawned from Oneida Lake walleye by personnel at the Constantia Hatchery. Walleye are spawned in early to mid-April. Eggs are incubated, hatched, and distributed as 1–2-day old fry by hatchery personnel in late April to early May. Modest numbers of fry are also obtained by spawning walleye from Lake Erie and the St. Lawrence River for sportsman's projects that will release fingerlings into these respective waters or aquatic habitats within their watersheds.

Angler associations prepare, stock and manage their ponds. Typically, an extension specialist and/or university scientist provides on-site assistance, particularly during the initial attempt(s) to culture walleye. Pond management involves fertilization and monitoring of water quality, zooplankton populations, and walleye fry. Detailed records of observations and activities are maintained. Walleye fingerlings (1.25–2 in, 30–50 mm TL) are harvested in late June to early July, 40–60 d after stoclung (Figure 1). Fingerlings are immediately transported and released into the previously approved public water (Figure 2). A NYSDEC specialist is often present to observe the harvest and release of fingerlings. Although many members of the sportsman's association eagerly assist with stoclung of fry and harvest of fingerlings, routine pond management is usually provided by a small core of dedicated individuals who can become quite knowledgeable and skilled in walleye culture over time. To a large degree, the success realized by a sportsman's group is dependent upon the dedication, stamina, and skills of a few members.

Each sportsman's group must submit an annual report to NYSDEC by late fall that identifies the number of fry received, number of fingerlings produced and released, and the water stocked. A winter meeting, coordinated by an extension specialist, is frequently used to bring together representatives of each sportsman's association involved in walleye production. The meeting facilitates exchange of information: what worked, what didn't work, and changes planned for

Figure 1. Members of the Niagara River Anglers Association seine harvest walleye fingerlings from a pond that they managed.

Figure 2. Walleye fingerlings raised by the Niagara River Anglers Association are released into the Niagara River.

next year. Representatives from NYSDEC and assisting academic institutions also participate in the meeting.

Since 1986, cooperative programs have produced and introduced to public waters of New York State over 750,000 fingerling walleye (Table 1). Between 1986 and 1993, production gradually increased and peaked at 120,000–150,000 walleye fingerlings (1.25–2 in, 30–50 mm TL) annually. Concurrently, participation expanded from one to 11–12 sportsman's groups. In 1994, production and participation decreased (Table 1), as the original goals and expectations of several sportsman's groups had been met. Walleye cultured and released as part of cooperative programs have contributed to the fishery and have helped to re-establish populations and spawning runs in several waters (Buttner et al. 1991; New York Sea Grant 1994,1995).

Ontario experience

Cooperative walleye culture programs in the Province of Ontario are coordinated by the Ontario Ministry of Natural Resources (OMNR) as part of their larger Community Fisheries Involvement Program (CFIP). CFIP originated in 1982 as a spin-off of the successful British Columbia Salmon Enhancement Program. During the first few years it was dominated by salmonid projects; cooperative walleye culture efforts did not begin until 1984. Walleye projects have gradually increased in number and importance. Walleye are now the most commonly targeted species by CFIP. Significantly, CFIP projects "must improve Ontario's fisheries resource" and priority is given to projects that increase natural reproduction (Anon. 1989; Community Fisheries Involvement Program Review Committee 1990). As such, CFIP projects have focused largely on rehabilitation and restoration of natural habitats. Cooperative walleye culture programs are increasingly coupled with some form of habitat improvement.

A cooperative project to culture walleye fingerlings usually involves the OMNR and a public organization. OMNR reviews and approves applications, provides technical support, and has a budget of C$500,000 (Canadian) to sponsor approved projects. Public organizations propose projects, provide labor and commit time to the project, and characteristically generate additional revenues to facilitate the project. Initially, public participation was limited to fish and game clubs, but other groups have become involved (e.g., cottage and camp associations, tourist outfitters-lodge owners, schools, First Nations people).

Considerable written information, as well as a Coordinator for CFIP, have been assembled by OMNR. Written materials include a detailed information packet, "Community Fisheries Involvement Program (CFIP): Goals, Project Eligibility, Application Forms," and technical manuals to assist cooperative members with their walleye culture effort (e.g., Anon. 1984; Anon. undated; Richards and Hynes, 1986). OMNR field personnel provide on-site advice and technical assistance to cooperative participants. Perhaps most significantly, OMNR can provide financial support up to C$8,000 for a project; the average financial support provided is approximately C$2,500. Typically, public organizations supplement these dollars through lotteries, donations, garage sales, and from the club or organization itself.

Walleye cooperative programs in Ontario, while widely recognized as being successful, are varied in composition and purpose. Perhaps the experiences and efforts of Bob and Wade Leonard (Hartington, ON) can provide a flavor for the nature and evolution of CFIP-sponsored walleye culture programs.

The Leonards became involved in CFIP in 1985 when they hatched eggs and stocked walleye fry into waters approved by the OMNR. Fingerling production began in 1986 with the construction of a drainable pond. Since 1986, several ponds have been added and culture efforts have been refined. Current efforts employ low-cost, low-technology methods to produce August fingerlings. Hatchling walleye, obtained by spawning walleye from the Napanee River and incubating fertilized eggs, are released into fertilized culture ponds. Throughout the approximate 45-day culture period, which begins in early May and concludes in late June/early July, Secchi disk visibility is maintained at approximately 16 in (40 cm) via applications of organic fertilizer. Walleye fingerlings that average approximately 0.05 oz (1.5 g) each are harvested and transferred to ponds stocked with a mixture of local minnows (e.g., unidentified stickleback, unidentified dace, and fathead minnows). The management goal is to produce and stock a minimum of 3,000 walleye fingerlings that are at least 4 in (100 mm) TL and 1.8 **oz** (50 g). Fingerlings are released into nearby waters approved by the OMNR at a target rate of one fish per two surface acres. OMNR personnel assist with spawning, are present at harvest, and supervise release of fingerlings. A detailed report is prepared and submitted to OMNR at the end of each culture effort. OMNR analyses of otoliths has determined that walleye fingerlings produced and released by the Leonards have contributed substantially to the population and fishery of several lakes.

The Leonards' success has stimulated interest and participation by others. Bob and Wade now serve **as** a resource for 15 other walleye culture groups. Over 100,000 walleye fingerlings were produced by the cooperative groups in 1994. Recently, Mohawks of the Bay of Quinte have sought advice and assistance from the Leonards as they pursue enhancement of walleye populations in the Salmon River as part of a Remedial Action Plan for the Bay of Quinte (T. Northardt, Environmental Coordmator, Mohawks of the Bay of Quinte, personal communication; Figure **3).** Facilitated by CFIP, and made possible through the efforts of people like the Leonards, walleye fingerling culture programs in the Province of Ontario now involve thousands of concerned citizens and stocked fingerlings have contributed significantly to the walleye fishery in several lakes.

Discussion

Though cooperative programs may differ in response to specific needs and situations, they recognize and utilize the enthusiasm that many sportsman's groups and other organizations, as well as individuals, have for the environment. Also acknowledged is the need for agency personnel to identify new and innovative methods to assist with management of natural resources, as financial and personnel resources become increasingly limited and inadequate to address all legitimate needs. As illustrated, New **York** State and the

Figure 3. In summer 1993, the Mohawks of the Bay of Quinte constructed ponds to culture fingerling walleye. The three ponds pictured were stocked with walleye in 1994.

Province of Ontario have used cooperative walleye culture programs to enhance the walleye fishery in targeted public waters. These programs have helped improve the relationships between the agencies and their clientele.

While developing a cooperative program, it is crucial that agency and lay people identify and agree upon a specific and realistic goal (e.g., enhancement of walleye populations in an appropriate water body). The project must have the sincere support of both agency personnel and lay participants. Trust between the coordinating agency and the collaborating group is essential; there must be a degree of freedom to explore, learn, and evolve. Finally, criteria to evaluate the cooperative effort must be developed. Cooperative walleye culture programs, like cooperative efforts in general, are dynamic efforts. They address and resolve a clearly identified problem; once the agreed upon goal has been achieved, they then cease to exist or can define a new goal.

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