Small Scale Yellow Perch Design Guide

University of Wisconsin Whitewater

Introduction to Aquaponics

Aquaponics is the integration of hydroponics with aquaculture, and serves as a model for sustainable food production by following certain principles:

- The waste products of one biological system serve as nutrients for the second biological system
- The integration of fish and plants results in a polyculture that increases diversity and yields multiple products
- Water is re-used through biological filtration and recirculation
- Local food production provides access to healthy foods and enhances the local economy.

Food producing greenhouse growers view aquaponics as a way to introduce organic hydroponic produce into the marketplace as the only fertility input is fish food, and all of the nutrients pass through a biological process. Plants yielding fruit (tomatoes, bell peppers, and cucumbers) have a higher nutritional demand and perform better in a heavily stocked, well established aquaponic system *(Aquaponics – Integration of Hydroponics with Aquaculture; ATTRA; 2006)*. Furthermore, pesticide-free produce and fresh fish can bring premium prices, particularly during winter months in urban areas.

Aquaponics helps to cancel out negative effects from hydroponics and aquaculture by creating a hybrid of the two. By combining fish, bacteria, and plants, aquaponics creates a symbiotic relationship, subsequently increasing the level of production.

Contributions

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1: Aquaponic greenhouse at S & S Aqua Farms, West Plains, MO. Photos by Steve Diver, NCAT

Ammonia buildup from the process of fish breathing and eating is digested by bacteria and converted into nitrites. These nitrates are good for the fish and serve as food for the plants. After being freshly oxygenated by the plants, the water flows back into the fish tank for the cycle to repeat.

Various trials have been conducted to measure hydroponic efficiency against that of aquaponic systems. After 6 months of production, Dr. Nick Savidov found that aquaponic growth was slightly slower due to the time aquaponic ecosystems take to mature into peak complexity. After the first 12 months of production, aquaponic growth rates started to take the lead by almost twice as fast as hydro ponic growth to most of the plant species being examined. Even after the first 24 months the aquaponic system further matured with some plants growing at over double the growth rate of hydroponic plants. It's likely that at this point that the optimum production level was reached.

2: Aquaponic greenhouse at S & S Aqua Farms, West Plains, MO. Photos by Steve Diver, NCAT

Sustainable Future

Aquaponic systems are shaping the way communities feed themselves. There is ongoing work in drought-stricken areas to develop these systems in order to conserve water while developing new food supplies. Although this report focuses on freshwater systems, it is important to note the ongoing work regarding saltwater aquaponics and its effort to farm seaweed using seawater.

Nonprofit groups such as "The Urban Farming Guys" are setting up extremely cost-effective aquaculture systems in some of the poorest areas around the world. Scalable systems such as the pictured "barrel-ponics" are very adaptable to situations where conventional electric pumps may not be practical.

3: Travis Hughey's barrel-ponics system

Commercial Systems

To be profitable, aquaculturists must understand environmental and economic issues relating to the industry. Higher feed costs combined with reduced consumer spending have limited the ability of producers to pass on costs to consumers, placing a downward pressure on margins *(Fish & Seafood Aquaculture in the US; IBISWorld; June 2012)*.

• Fish food purchase costs have increased rapidly over the past five years, moving in line with rapid increases in prices for corn, soybeans, and oil.
• A significant amount of capital is invested in selling and transporting products to local processors, wholesalers, and fish markets.
• Access to the latest available and most efficient technology and techniques and an ability to adapt these to local conditions will improve output efficiency and higher-quality fish that will yield greater values when sold downstream.
• Access to the necessary amount of land/type of property with appropriate water conditions is crucial to farming fish and seafood.
• Environmental compliance as industry operators must abide by strict federal, state, and county laws about water use and disposal.

Bacteria and Enzymes: Essential Agents for a Healthy Ecosystem

Like a natural ecosystem, an aquaponic system is a delicate mix of many organisms that must be in balance in order to remain sustainable. One crucial part of this relationship that is often overlooked is the role that bacteria and enzymes play in both natural occurring ecosystems and that of an aquaponics system.

Invisible to the naked eye and often associated with disease, bacteria and enzymes are necessary building blocks of life. Without them, fruit wouldn't ripen, leaves wouldn't change color, and humans wouldn't be able to digest food. They work together to break down specific contaminants while releasing nutrients as a byproduct.

Bacteria are simple single-cell organisms that feed off of a specific food source. When bumped into a food source they can digest. Enzymes are released that break down the food source, allowing the bacteria to feed.

An example of this is the human digestive system. The human stomach contains different strands of enzymes that are able to break down the food we eat and allow the naturally occurring bacteria to absorb the organic matter. Next, they release the nutrients we need to survive as the byproduct. Food intolerances, such as lactose intolerance, result when a specific strand of enzyme is missing from the digestive system.

Similar to the human digestive system, bacteria and enzymes are key components in a healthy aquaponics system. If certain enzymes are not present in the water tanks that hold the fish, organic contaminates like slime and sludge that will degrade the water quality, begin to build up. Adding the enzymes that break down these contaminants and then the bacteria that feed of off the contaminants will increase the water quality and reduce the maintenance necessary to keep the ecosystem healthy.

More than 50% of the waste produced by fish is in the form of ammonia, secreted through the gills and in the urine. The remainder of the waste excreted as fecal matter, undergoes a process called mineralization which occurs when Heterotrophic bacteria consumes fish waste, decaying plant matter and uneaten food, converting all three to ammonia and other compounds. In sufficient quantities ammonia is toxic to plant and fish. Nitrifying bacteria, which naturally live in the soil, water and air convert ammonia first to nitrite (Nitrosomonas bacteria) and then to nitrate (Nitrobacter) which the plants consume. Nitrifying bacteria will thrive in the grow beds and in the water in the system. The plants readily take up the nitrates in the water and, in consuming it, help to keep the water clean and safe for the fish. *(Travis W. Hughey, AquaPlanetOnline.com)*

Farming Perch

Perch are a commonly raised fish in aquaponics systems as they are relatively easy to raise and highly marketable.

• Suitable Conditions: Yellow perch are a cool water fish, showing optimum growth at 72-75 degrees Fahrenheit.

• Diet: Yellow perch are bottom feeders, eating almost anything. They prefer minnows, insect larvae, plankton, and worms. When they are young, they are attracted to light and found in open water. Within a few days they begin feeding primarily on algae, protozoans, and zooplankton. As they grow they begin to eat insects or other small invertebrates while continuing to feed on zooplankton. Adult yellow perch mainly consume larger insects, and other fishes.

• Breeding: Spawning occurs once per year in the spring, when temperatures are 43-54 degrees Fahrenheit. This typically takes place at night or in the early morning. Females are able to spawn up to eight times during their life. Spawning occurs throughout a 2-3 week period.
(NCRAC Perch Guide)

Requirements for a System Setup

Sizable fish tanks are needed to house the fish. For every fish three gallons of water is necessary if the filtration system is adequate.

Filtration of solid waste is a crucial process in aquaculture. Drum filters are commonly used to serve this purpose in commercial fish farming. An outlet inside of the fish tank pulls waste from the tank, through the filter, and eventually into the plant's grow bed.

4: Backyard Aquaponics in Western Australia. Photo by Joel Malcolm, Backyard Aquaponics. www.backyardaquaponics.com

5: ProfiDrum Eco 65

Before reaching the plant's grow bed, this wastewater enters the inside of the drum while a screen traps the solid waste as the water flows through it. In order to get rid of the fish waste, there is a high pressure spray that washes the waste into a tray. This tray empties through a tube and into a settlement tank, which separates the fish waste from the water. The fish waste settles where a tap can drain it externally.

As the screens clear, the water level within the drum drops until the normal operating water level is obtained. Drum rotation stops and the backwash pump shuts off. This cycle repeats at intervals that are dependent on the type and amount of solids being filtered and the pore size of the screens.

Grow beds are used to store the growing media. The growing media supplies nutrients, air, and water to the roots while allowing for maximum growth. The grow beds hold the plant-based ecosystems that breaks down the fish waste. Additionally, the media in the bed helps to filter out solids, dissolved organic matter, and ammonia while serving as an alternative to soil.

6 ViagrowTM ViaStone Expanded Clay Grow Rocks

Clay grow rocks are recommended for use as a growing medium because they are pH neutral, porous, reusable, and ecologically friendly. The pH neutrality is critical given the highly sensitive ecosystem. The porous rocks are especially useful in our type of system as they succeed in providing high oxygen levels around the roots.

The media guard keeps grow media from entering the siphon, ensuring proper water filtration.

7: Greenlife Aquaponics Media Guard & Auto Siphon

Aeration pumps add oxygen into the water in order to compensate for the deficit created through fish consumption and waste breakdown. Keeping a healthy amount of oxygen is possibly the most critical aspect of aquaculture.

The Economic Model

The feasibility of indoor aquaculture has attracted the attention of entreprenuers and academic researchers. This interest is based on the ideal of a locally produced product that can shorten the supply chain, provide access to quality product and produce a profit. This report is based on earlier research *(Garling 1991; Williams and Starr 1991; Hushak, et al. 1992)* conducted over the past 20 years. It updates the budget considerations. While the primary focus is on Yellow Perch, this report also contains an analysis of the Tilapia industry. It has been argued that Yellow Perch is an appropriate product to be produced in Recirculating Aquaculture Tank Production Systems.

Much of the earlier research on aquaculture concentrated on the southern catfish industry. As a result, there has been a recent evolution of economic research on yellow perch. Some marketing and production studies were conducted at the University of Wisconsin during the 1970s (see Kayes 1991). Rather than repeat much of the information provided in this research, the goal of this report is to update and collect the data from the earlier studies. It is the hope that this information will offer potential aquaculture entrepreneurs an entry point to the economic feasibility of the process. In the end, while the social good offered by the ideal of a shortened supply chain is commendable, the sustainability of the industry is as critical as the sustainability contribution it makes to society.

Neoclassical Economics is predicated on the premise that, in a competitive economy, while economic profit is equal to zero in the long run, accounting profit can be positive. As a result, the production of a budget that projects a profit is not contrary to standard economic thought. In creating a budget, there needs to be consideration regarding both the fixed costs and the variable costs. As a result, all of these considerations are included in this analysis. In the end, we are looking at a toolbox for the development of the yellow perch industry. We are limited to the idea of cage and pond culture of yellow perch. This begins the discussion regarding the costs of production.

The costs include a myriad of inputs. The process of growing the yellow perch begins with the purchase of advanced fingerlings. The following is a list of assumptions included in the analysis.

1. **Land/Warehouse.** While one consideration for Yellow Perch Production in Wisconsin is to seek out urban real estate that is prime for alternative use. In some cases, this would be former industrial space or urban land that is currently underutilized. Determining the price of these unique properties is a challenge since these properties are not a homogeneous good. As a result, this analysis focuses on farm land where the opportunity cost of using this land would equal the opportunity costs of using urban land (the lower cost input would ultimately win out in a contest). Once again, the accounting for land cost is challenging due to a limited market. However, in this case, it is possible to find estimates. Earlier research estimated that flat, uncluttered land is needed, and therefore that low production corn land (100 bushels per acre yield) would be converted to the pond production of fish. The use of the land for fish production implies foregoing the return that could have been obtained from growing corn on that land. Therefore, the annual land charge reflects this foregone return. Once again, this cost would be in equilibrium with the urban land that may be repurposed.

2. **Size of operation.** This report focuses on entrepreneurs of aquaculture. As a result, we do not include small scale producers (5,000 pounds in the earlier literature) and concentrate on larger producers of 50,000 pounds of Yellow Perch

3. **Production.** This analysis is based on fingerlings of four to five inches that are stocked in the initial phase of the growing season. They are harvested when they reach ¼ to 1/3 of a pound. Smaller fingerlings will either produce smaller fish or require a longer growing season. While this may offer a lower cost of fingerling purchase, the variable cost of food (and time) will rise. As a result, our study is based on this standard size.

4. **Feed.** The feed necessary to produce 50,000 pounds of Yellow Perch is based on this production target and a death loss assumption. The budgets begin with feed conversion ratio, production target, and death loss assumptions, and use these to calculate

the quantity of feed needed. In some other studies, the budgets start out with feed quantities, known from either actual production experience or generated through a fish growth model, and then calculate feed conversion ratios. Given the current limitations on culture data, using expected feed conversion ratios and other production values to estimate feed usage is a reasonable method. There were two additional considerations in how feed usage is calculated. One is that the weight of the fingerlings at stocking is not taken into account. Second, death loss is assumed to be a random event, spread out over the entire production cycle

5. **Labor.** For this study, labor was seen as a variable cost of production that will depend on the level of production and type of system. The labor hours per day will increase with the size of production; a 5,000 pound capacity system needs 1.0 labor hour for a cage system and 1.5 hours for a pond system, a 50,000 pound capacity system need 4.0 labor hours for a cage system and 3.5 hours for a pond system. The labor hours are assumed to be 87.5% unskilled labor and 12.5% semiskilled labor, with different wages.

6. **Electrical use for aeration.** Aerators are assumed to be 1.0 horsepower, consume 1.0 kilowatts per hour, and to run for six hours a day during June and July with ten percent of the time total added on for special aeration needs.

7. **Interest rates.** The cost of borrowing capital is the interest rate paid and was set at 11%. The cost of owned capital was seen as the opportunity cost of forgone income from alternative investments and was set at a real interest rate of 9%.

8. **Market prices.** There is no well-defined market price available to use for analysis, so it is necessary for each individual aquaculturist to define their own price based on their breakeven point and the price their prospective buyers are willing to pay.

9. **Repairs, taxes, and insurance on investment items.** The annual cost for repairs, taxes, and insurance was set at 2%, 1%, and 0.5% respectively of the investment costs of the durable equipment used. These numbers are based on livestock budgets developed at Purdue University.

10. **Accounting procedure.** The budget cost structure uses the expected useful life time for an investment item rather than the allowable lifetime set by the IRS. It is recommended that each potential aquaculturists consult a professional to evaluate their unique budget and tax statements.

11. **Location.** The location costs used will reflect those of a company located in Wisconsin and will mostly consist of the cost of delivery for the fingerlings.

12. **Annual ownership costs.** The total annual ownership costs consists of the costs for repairs, taxes, and insurance, as well as a land charge that entails a depreciation cost and interest costs. The depreciation costs is simply the total amount invested divided by the lifetime of the investment. The interest cost is the interest rate multiplied by half of the investment amount.

13. **Annual operating costs.** Operating costs will consist only of the costs of the items used during the production period that vary with the level of production and have no significant value beyond the production period.

Results

5,000 lbs. production

Our initial examination of the costs associated with Wisconsin aquaculture will begin with an examination of a 5 acre plot used for production. A 5 acre plot would allow for a target production level of 5,000 pounds of perch. Such a level of production would require approximately 19,600 fingerlings, given a death loss rate of roughly 15%. At the time of harvest the remaining 16,667 fish, weighing approximately 0.3 lbs each, would allow for the target production level, of 5,000 lbs., to be met.

Table 1: Budget Assumptions for Food-Size Yellow Perch: 5,000 lbs. Production, Cage Culture, WI, 2014			
Farm pond size (acres)	5	Targeted production (lbs.)	5,000
Prodution/acre (lbs.)	1000	<pond size * (production/acre)>	
Cage: 5'x20'x4' (cubic f.)	400	Cubic feet space needed	2,000
Pounds per cu. f of cage	2.5	<production / lbs. per cubic ft.>	
Fingerling size (ins.)	4	Total number of cages	5
Harvest size (lbs.)	0.3	<cubic ft. needed / cubic ft. per cage>	
Production time (mos.)	8	Number of harvested fish	16,667
Death loss	15%	<production / harvest size>	
Feed conversion ratio	2	Number of fingerlings	19,608
(lbs. feed per 1.0 lb. gain)		<No. fish / (1-death loss)>	
Labor per day (hours)	1	Feed quantity (lbs.)	10,811
percent unskilled	87.50%	<(production * feed conversion) / 1 - (√$_2$(death loss))>	
percent semi-skilled Interest rates/ capital charge	12.50%		
operating capital (nominal)	11%		
investment capital (real = nominal minus infation)	9%		
Investment repairs (2%), taxes (1%), and insurance rate	3.50%		

These results rely on 3 major budget assumptions. First of all, the production assumption which stipulates that semi-mature fingerlings will be purchased to allow for harvest in one season. This allows the aquaculture operation to forego the costs associated with over-wintering a fish population. The second assumption, is the marketing assumption. This assumption states that the fish harvest will be sold in round lots on wholesale markets. Finally, we assume that the land used in this aquaculture venture is already owned, and the only costs associated with the land are opportunity costs and property taxes. However, opportunity cost is considered to be relatively low. This is because the ponds are already in existence and would allow for little else in the way of economic use.

Table 2: Investment and Annual Ownership Costs for Food-Size Yellow Perch: 5,000 lbs. Production, Cage Culture, WI, 2014						
Equipment	Units (no.)	Unit cost ($)	Investment ($)	Useful Life (yrs.)	Annual Deprac. ($)	Annual Intesrst ($)
Production Equipment						
Cages	20	769.01	15,380.20	10	1,538.20	692.11
Net Treatment	1	604.00	604.00	5	120.80	27.18
Boatwinches (hand)	2	19.99	39.98	5	8.00	1.80
Anchors	10	18.95	189.50	7	27.07	8.53
Polyethylene Rope	1	32.00	32.00	7	4.57	1.44
Cable	1	240.32	240.32	7	34.33	10.81
Dock	5	881.16	4,405.80	20	220.29	198.26
Chemical Test Kit	1	24.99	24.99	7	3.57	1.12
Thermometer	1	9.95	9.95	7	1.42	0.45
Electric Aerator	1	1,086.52	1,086.52	10	108.65	48.89
Electrical Service	1	961.27	961.27	10	96.13	43.26
Scale	1	84.99	84.99	7	12.14	3.82
Dipnet	1	34.99	34.99	5	7.00	1.57
Miscellaneous	1	80.11	80.11	5	16.02	3.60
Harvesting/Marketing Equip-ment						
Dividing Seine	1	59.99	59.99	5	12.00	2.70
Fish Baskets	2	16.99	33.98	5	6.80	1.53
Containers (for fish on ice)	27	19.20	518.40	5	103.68	23.33
Refrigerator Unit	1	4,806.34	4,806.34	5	961.27	216.29
Total Investment						$3,281.75
Total Annual Deepreciation (investment/useful life)						$3,281.75
Total Annual Interest (1/2 * Investment * Investment Capital Rate)						$1,286.70
Total Annual Repairs, Taxes, and Insurance (investment * investment R, T, I Rate)						$1000.77
Annual Land Charge (opportunity cost + property taxes)						$48.06
Total Annual Ownership Cost						$5,617.28

Table 2 shows the annual ownership costs for the 5,000 lb. harvest operation. The costs shown in Table 2 are costs associated with capital equipment. We begin by estimating the number of units required for a 5,000 lb aquaculture production target. Unit costs are then gathered from various supply sources to attempt to find the lowest prices for each good. Some of the larger items were given price estimations using price adjustments using CPI inflation. Since these capital goods can be used over several years, the useful life of each capital good is taken from previous work on aquaculture operations and depreciated over the useful life of the equipment. The total annual ownership cost of an aquaculture operation with 5,000 lbs. of targeted production would incur annual ownership costs of $5,617.28.

Table 3: Operating and Total Costs for Food-Size Yellow Perch: 5,000lbs. Production, Cage Culture, WI, 2014					
Item	Unit Cost ($)	Number of Units	Annual Cost ($)	Cost per lb.	Percent Total Cost
Production Costs					
Fingerlings	0.36	19,608.00	7,058.88	1.41	28.1%
Feed	0.72	10,811.00	7,832.57	1.57	31.2%
Oxygen Refill Kit	49.00	2.00	98.00	0.02	0.4%
Chemicals	41.65	5.00	208.25	0.04	0.8%
Electricity	0.14	402.00	57.33	0.01	0.2%
Labor (unskilled)	7.25	210.00	1,522.50	0.30	6.1%
Labor (semi-skilled)	12.00	30.00	360.00	0.07	1.4%
Harvesting/Marketing Costs					
Ice	0.15	3,333.00	499.95	0.10	2.0%
Labor	7.25	20.00	145.00	0.03	0.6%
Pickup Charge	0.40	600.00	240.00	0.05	1.0%
Overall Costs					
Miscellaneous	1.60	20.00	32.00	0.01	0.1%
Interest (operating capital)	0.08	18,000.00	1,440.00	0.29	5.7%
Total Operating Costs			19,494.47		77.6%
Breakeven price - operating costs				3.90	
Total Annual Depreciation			$ 3,281.75	$ 0.66	13.1%
Total Annual Interest			$ 1,286.70	$ 0.26	5.1%
Total Annual Repairs, Taxes, and Insurance			$ 1,000.77	$ 0.20	4.0%
Annual Land Charge			$ 48.06	$ 0.01	0.2%
Total Annual Ownership Cost			$ 5,617.28	$ 1.12	22.4%
Breakeven price - total costs				$ 5.02	

Table 3 shows the annual operating costs of an aquaculture operation with targeted production of 5,000 lbs. The majority of the cost of the aquaculture operation comes from two inputs, fingerlings and feed, which together make up just under 60% of the cost of the aquaculture operation. Other operating costs make up approximately 17% of the aquaculture operation. If fingerlings were grown from eggs by the aquaculture operation then costs could be reduced, however that would also result in some over-winter costs. The total operating costs at the 5,000 lb. production level are $19,494.47, which when combined with the annual ownership costs result in a breakeven price of $5.02 per lb. of production.

10,000 lbs. production

Next we examine the costs associated with Wisconsin aquaculture using 50 acres for production. A 50 acre plot would allow for a target production level of 50,000 pounds of perch. Such a level of production would require approximately 185,185 fingerlings, given a death loss rate of roughly 15%. At the time of harvest the remaining 166,667 fish, weighing approximately 0.3 lbs each, would allow for the target production level of 50,000 lbs. to be met.

Table 4: Budget Assumptions for Food-Size Yellow Perch: 50,000 lbs. Production, Cage Culture, WI, 2014			
Assume Values		Calculated Values	
Farm Pond Size (acres)	50	Targeted production (lbs.)	50,000
Production/acre (lbs.)	1,000	<pond size * production/acre>	
Cage: 10'x20'x5' (cubic ft.)	1,000	Cubic feet space needed	20,000
Pounds per cubic ft. of cage	2.5	<production/lbs. per cubic ft.>	
Fingerling size (ins.)	4	Total number of cages	20
Harvest size (lbs.)	0.3	<cubic ft. needed / cubic ft. per cage>	
Production time (mos.)	8	Number of harvested fish	166,667
Death loss	10%	<production / harvest size>	
Feed Conversion Ratio	2	Number of fingerlings	185,185
(lbs. feed per 1.0 lb. gain)		<No. fish / (1-death loss)>	
labor per day (hours)	4	Feed quantity (lbs.)	105,263
percent unskilled	87.50%	<(production * feed conversion) ――――――――― 1 - ($\sqrt{}_2$(death loss))>	
percent semi-skilled interest t rates / capital charge	12.50%		
Operating Cpaital	11%		
(nominal)			
investment capital	9%		
(real = nominal minus inflation)			
investment repairs (2%), taxes (1%), and insurance rate	3.50%		

Market Budget Assumptions:

Production Assumptions:

Stock advances fingerlings to growout in one season

Marketing Assumptions:

Sell in the round, on ice, in wholesale markets, hauling in a refrigerator unit in a pickup bed.

Land Assumptions:

Own the land, no other economic use, only lange charge for property taxes

Table 5: Investment and Annual Ownership Costs for Food-Size Yellow Perch: 50,000 lbs. Production, Cage Culture, WI, 2014						
Equipment	Units (no.)	Unit Cost ($)	Investment ($)	Useful Life (yrs.)	Annual Deprec. ($)	Annual Interest ($)
Production Equipement						
Cages	20	769.01	15,380.00	10.00	1,538.00	692.10
Net Treatment	1	604.00	604.00	5.00	120.80	27.18
Boatwinches (hand)	2	19.99	39.98	5.00	8.00	1.80
Anchors	10	18.95	189.50	7.00	27.07	8.53
Polyethylene Rope	1	32.00	32.00	7.00	4.57	1.44
Cable	1	240.32	240.32	7.00	34.33	10.81
Dock	5	881.16	4,405.80	20.00	220.29	198.26
Boat	1	801.06	801.06	10.00	80.11	36.05
Oxygen/Temp. Meter	1	541.51	541.51	10.00	54.15	24.37
Electric Aerator	5	1,086.52	5,432.60	10.00	543.26	244.47
Electrical Service	1	3,183.40	3,183.40	10.00	318.34	143.25
Feed Storage	1	1,281.69	1,281.69	5.00	256.34	57.68
Scale	1	84.99	85.99	7.00	12.28	3.87
Dipnets	2	34.99	35.99	5.00	7.20	1.62
Miscellaneous	1	240.32	240.32	5.00	48.06	10.81
Harvesting/Marketing Equipment						
Dividing Seine	2	59.99	119.98	7.00	17.14	5.40
Fish Baskets	10	16.99	169.60	7.00	24.27	7.65
Containers for fish on ice	60	19.20	1,152.00	5.00	240.40	51.84
Refrigerator Unit	1	11,214.78	11,214.78	5.00	2,242.96	504.67
Total Investment			**$ 45,150.82**			
Total Annual Depreciation						**$ 5,797.57**
Total Annual Interest						**$ 2,031.79**
Total Annual Repairs, Taxes, and Insurance						**$ 1,580.28**
Annual Land Charge						**$ 240.32**
Total Annual Ownership Cost						**$ 9,649.95**

Table 5 shows the annual ownership costs for the 50,000 lbs. harvest operation. The costs shown in Table 5 are costs associated with capital equipment. We estimate the number of units required for a 50,000 lb. aquaculture production target. Unit costs are then gathered from various supply sources to attempt to find the lowest prices for each good. Some of the larger items were given price estimations using price adjustments using CPI inflation. Since these capital goods can be used over several years, the useful life of each capital good is taken from previous work on aquaculture operations and depreciated over the useful life of the equipment. The total annual ownership cost of an aquaculture operation with 50,000 lbs. of targeted production would incur annual ownership costs of $9,649.95.

Table 6: Operating and Total Costs for Food-Size Yellow Perch: 50,000 lbs. Production, Cage Culture, WI, 2014					
Item	Unit Cost ($)	Number of Units	Annual Cost ($)	Cost per lb.	Percent Total Cost
Production Costs					
Fingerlings	0.36	185,185	66,666.60	1.33	44.42%
Feed	0.46	105,263	48,508.06	0.97	32.32%
Chemicals	62.39	20	1,247.90	0.02	0.83%
Electricity	0.14	2,010	286.63	0.01	0.19%
Labor (unskilled)	7.25	840	6,090.00	0.12	4.06%
Labor (semi-skilled)	12.00	120	1,440.00	0.03	0.96%
Harvesting/Marketing Costs					
Ice	0.15	33,333	4,999.95	0.10	3.33%
Labor	7.25	140	754.00	0.02	0.50%
Pickup Charge	0.40	1,800	720.00	0.01	0.48%
Overall Costs					
Miscellaneous	1.60	75	120.00	0.00	0.08%
Interest	8.00%	120,000	9,600.00	0.19	6.40%
Total Operating Costs			140,433.13	2.81	93.57%
Total Annual Depreciation			$ 5,797.57	$ 0.12	3.86%
Total Annual Interest			$ 2,031.79	$ 0.04	1.35%
Total Annual Repairs, Taxes, and Insurance			$ 1,580.28	$ 0.03	1.05%
Annual Land Charge			$ 240.32	$ 0.00	0.16%
Total Annual Ownership Costs			$ 9,649.95	$ 0.19	6.43%
Total Annual Costs			$ 150,083.09		100.00%
Breakeven price				3.00	

Table 6 shows the annual operating costs of an aquaculture operation with targeted production of 50,000 lbs. The majority of the cost of the aquaculture operation comes from two inputs, fingerlings and feed, which together make up over 75% of the cost of the aquaculture operation. Other operating costs make up approximately 17% of the aquaculture operation. If fingerlings were grown from eggs by the aquaculture operation then costs could be reduced, however that would also result in some over-winter costs. The total operating costs at the 50,000 lb. production level are $138,535.53, which when combined with the annual ownership costs result in a breakeven price of $3.00 per lb. of production.

Table 7: Sensitivity Analysis of Net Returns to Market Price, by Production System and Size of Operation

			Production System, Size, and Breakeven price (per lb.)			
	Wholesale Cage Culture Pond Culture Market Price for in the round (per lb.)		5,000lbs.		50,000lbs.	
			$ 5.02		$ 3.00	
	$ 1.75		$ (16,350.00)		$ (62,500.00)	
	$ 2.00		$ (15,100.00)		$ (50,000.00)	
	$ 2.25		$ (13,850.00)		$ (37,500.00)	
	$ 2.50		$ (12,600.00)		$ (25,000.00)	
	$ 2.75		$ (11,350.00)		$ (12,500.00)	
	$ 3.00		$ (10,100.00)		$ -	
	$ 3.25		$ (8,850.00)		$ 12,500.00	
	$ 3.50		$ (7,600.00)		$ 25,000.00	
	$ 3.75		$ (6,350.00)		$ 37,500.00	
	$ 4.00		$ (5,100.00)		$ 50,000.00	
	$ 4.25		$ (3,850.00)		$ 62,500.00	

Table 7 shows the sensitivity analysis of profits associated with various market prices. This table shows the prices at which small and large scale aquaculture operations could operate profitably. The 5 acre aquaculture operation is not profitable at any market price shown here. The 50 acre operation becomes profitable at a market price of $3.00 so in the table breakeven is seen at the $3.00 wholesale price level. Any wholesale price over that level results in higher profits for the aquaculture operation.

Conclusion

We have seen that, given the current wholesale price of yellow perch, which at the time of the writing of this report is roughly $3.20 per pound, aquaculture at targeted levels of production of 5,000 pounds would not be profitable. However, larger operations that are able to utilize economies of scale which allow for costs to be spread over a greater fish harvest become profitable. This is seen at the 50,000 lb. production level where profits of $0.20 per pound of fish are available to the aquaculturist. This would result in profits of $10,000.

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