Growing Missouri's Aquaculture Industry: Business Models

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Missouri Soybeans

MASBDA
Missouri Agricultural and Small Business Development Authority

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Summary

Designed for aquaculture entrepreneurs, this report provides business model examples to consider before building an aquaculture operation in Missouri. Today, Missouri has a diverse aquaculture industry composed of businesses serving many different customers and market channels. Varied topography and groundwater availability have guided existing operation locations. Mild winters in the southeast region of the state provided certain aquaculture pioneers with a more favorable production season than the season found in other Missouri areas. University of Missouri Extension publication MX461 Growing Missouri's Aquaculture Industry: Needs Assessment (extension.missouri.edu/publications/mx461) details current industry information and needs identified by Missouri aquaculture businesses.

Nationwide, the aquaculture industry has grown to feature clusters of highly developed and specialized businesses. Examples of successful regional clusters include trout farms along rivers in Idaho and operations raising catfish in the southeastern Mississippi River Delta states. Other areas of the country are home to operations satisfying local demand or those selling fresh fish into niche markets. For instance, California has several examples of niche fresh fish operations. Niche aquaculture markets include raising fish for pond stocking; rearing fish for conservation departments and municipalities to fill lakes and rivers; and producing tropical, premium or specialty fish for local food and ornamental markets.

Business models detailed in this report intend to take advantage of emerging aquaculture opportunities, build on Missouri aquaculture's strengths, avoid Missouri's apparent weaknesses and steer around threats posed by competitive aquaculture businesses. Exhibit S1 summarizes Missouri aquaculture's strengths, weaknesses, opportunities and threats.

Exhibit S1. Missouri's Competitive Position: Strengths, Weaknesses, Opportunities and Threats

Strengths	Weaknesses
Available water with good quality in many areas	Relatively high costs in Missouri to produce warm-water species
Experience and specialized production knowledge among existing operations	Lack of scale advantage to enable low-cost warm-water species production
Successful existing multigenerational operations with well-developed marketing channels	Lack of scale advantage for producing cold-water species in raceway systems
Centralized location and proximity to large U.S. consumer markets	Missouri aquaculture is heavily regulated to protect waters from invasive species and pests
Trout production possible in areas with high volume of natural spring water	Labor shortages in many areas
Nearby soybean, corn and insect feed production	RAS systems consume oxygen in the tank if water circulation stops, which makes rural power outages a risk
Opportunities	**Threats**
Grow existing ornamental or fish stocking markets via events, brokers, direct-to-consumer transactions and online sales	Developing aquaculture system expertise often requires trial and error (killed fish) over many years
Supply live and fresh food fish for ethnic consumer markets in nearby Midwest cities	Price competition for commodity fish imported from Asia or produced by existing U.S. businesses
Custom produce and process ultra fresh food fish for restaurants and institutions	Fish feed is expensive in Missouri because existing feed suppliers are not located near the state
Sell fresh or frozen food fish directly to consumers seeking quality through online sales and fulfillment	Capital availability is limited to those with strong track records or balance sheets due to lack of industry familiarity among traditional agricultural lenders
Develop large-scale integrated indoor recirculating systems to produce fish intended for selling as branded products and replacing wild catch and imports	Southern U.S. outdoor aquaculture has lower cost of production for warm-water species
Develop agritourism fishing venues to grow the market for stocking fish	Southeast Asia has climate, labor and scale advantage in producing low-cost warm-water species

Exhibit S2 summarizes eight business models for aquaculture entrepreneurs to consider. Developed for new entrants, these models reflect a scale large enough to return $45,000 in salary to an owner and yet small enough to focus on niche markets rather than compete with large firms. These models were designed assuming an entrepreneur is building a business from scratch and not using any pre-existing ponds, building or equipment. A 6.5% cost of capital is charged on average capital invested. Models assume the producer bears the cost of delivering fish or crustaceans. These and other assumptions are reflective of the current conditions at the time this report was written. Potential new entrants are encouraged to reexamine and update these assumptions over time and for their respective situation.

Exhibit S2. Missouri Aquaculture Business Models: Pond Culture and Recirculating Aquaculture Systems (RAS)

Model	**Culture System**	**Annual Production** (Pounds)	**Primary Market Channel**	**Capital Investment** (Dollars)	**Hired Labor** (Dollars)	**Cost of Production** (Percent of Total Sales)	**Feed Cost** (Percent of Total Sales)	**Labor Cost** (Percent of Total Sales)
Catfish	Pond	76,500	Recreational stocking	438,050	12,544	77%	12%	3%
Bluegill	Pond	54,600	Recreational stocking	438,050	10,752	85%	7%	1%
Bass	Pond	50,400	Recreational stocking	438,050	13,440	95%	16%	4%
Grass carp	Pond	25,650	Recreational stocking	438,050	13,440	135%	NA	9%
Catfish	RAS	68,384	Food fish (live)	360,353	40,320	77%	12%	15%
Bass	RAS	40,102	Food fish (live)	360,353	35,840	84%	10%	15%
Shrimp	RAS	15,513	Food fish (live)	360,353	31,360	76%	9%	10%
Tilapia	RAS	142,467	Food fish (live)	360,353	53,760	83%	23%	15%

Considering the state's climate and market variability, no one-size-fits-all operation will suit Missouri aquaculture. Missouri's climate and water resources do not compare to conditions in areas, such as Idaho and the southeastern Mississippi River Delta states, where developed, large-scale aquaculture has become more established. However, some large-scale commercial operations exist within Missouri. These existing operations leverage previously built infrastructure or unique aquaculture resources. Many operations were built when the competitive economic landscape and environmental regulation were different from today's. They have established markets channels that new businesses would have to create over time. For these reasons, opportunities for startup aquaculture operations detailed here are focused more on niche markets and selling live, fresh or small-scale specialty products.

1. Freshwater Pond Culture Models

1.1. Background

In most of Missouri, production of commodity food fish in pond aquaculture struggles to be cost competitive compared to the southeastern U.S. A center of catfish production, the southeastern U.S. has catfish farms covering hundreds or even thousands of acres. These producers take advantage of the warm climate to raise fish year-round, and the region's adequate water supply supports their operations. Outside the Bootheel, Missouri's cold winter months impede outdoor aquaculture production. Therefore, Missouri's warm-water food fish production cycle would be too long to be competitive with the commodity production cycles typical in other states. Missouri's climate may better suit producers raising fish for recreational or pond stocking. Stocker fish have no minimum marketable size. Missouri's shorter growing season can accommodate one full cycle of stocker fish production per year. Combining local production with shorter delivery distances to regional buyers leads to a more competitive enterprise.

1.2. Capital Investments

Overall, the capital investment necessary to purchase and construct a 20-acre pond culture aquaculture farm in Missouri is estimated at $438,050; see Exhibit 1.2.1. A typical pond culture operation in Missouri may include 1- to 2-acre ponds. The model assumes the new operation will have 12 acres of water on 20 acres of land. The cost of land is estimated at $5,000 per acre with pond construction at $4,000 per acre for 15 of the 20 total acres. Required equipment and structures include a small tractor, a pickup truck, aquaculture equipment, a medium-sized steel building, a 2-ton feed bin, shipping containers for storage, a deep well combined with water lines across the property and electrical service.

Exhibit 1.2.1. Capital Investments in a 20-Acre Pond Aquaculture System

Item	**Unit**	**Quantity**	**Cost Per Unit** ($)	**Total Cost** ($)	**Useful Life**	**Salvage Value** (Percent)
Undeveloped land	Acre	20	5,000	100,000	N/A	N/A
Pond construction	Acre	15	4,000	60,000	N/A	N/A
Shed (1/4 office space)	Each	1	40,000	40,000	25	10%
Feed bin	Each	1	6,250	6,250	15	10%
Storage container	Each	2	4,000	8,000	20	10%
Electrical installation/ equipment	Each	1	6,000	6,000	30	5%
Water well and line installation	Each	1	15,000	15,000	20	0%
Tractor (75-hp)	Each	1	30,000	30,000	15	25%
Pickup	Each	1	60,000	60,000	8	25%
Fish transport trailer	Each	1	35,000	35,000	12	25%
Flat deck trailer	Each	1	6,000	6,000	15	25%
Jon boat	Each	1	1,200	1,200	15	25%
Trolling motor	Each	1	400	400	10	0%
Finish mower	Each	1	7,000	7,000	10	25%
Electric aerators	Each	12	3,000	36,000	10	0%
Emergency PTO aerator	Each	1	4,000	4,000	25	5%
Fuel tank	Each	1	1,500	1,500	20	5%
Fish feeder	Each	1	5,500	5,500	10	20%
3-inch pump	Each	1	2,500	2,500	8	10%
6-inch PTO pump	Each	1	6,000	6,000	15	10%
Office equipment	Each	1	2,500	2,500	7	10%
Handheld power tools	Each	1	1,200	1,200	10	25%
Hand tools	Each	1	1,000	1,000	10	25%
Shop tools and equipment	Each	1	3,000	3,000	20	25%
			Total capital investment	**438,050**		

1.3. Catfish Model

Catfish are the most common food fish grown in the U.S. The Missouri production system for recreational stocker catfish begins with filling ponds in March with fingerlings. These fish grow — from 3-inch fingerlings to 10-inch stocker fish weighing 0.4 pounds — in an eight-month production cycle that ends in mid-October. To sell the 10-inch stocker fish, producers target the fall pond stocking market in the Midwest. The ponds remain empty until the following March when the next production cycle begins. Exhibit 1.3.1 shows key inputs and values used in this production system.

Exhibit 1.3.1. Inputs Used for Catfish Production Budget (Recreational Stocking Market)

Item	Unit	Value
Stocker price (10-inch)	Dollars per fish	$2
Floating feed (32% protein)	Dollars per ton	$600
Fingerling price (3-inch)	Dollars per fish	$0.15
Stocking capacity	Pounds per acre	7,500
Stocker final weight	Pounds	0.40
Fingerling weight	Pounds	0.01
Survival rate	Percent	70%
Feed conversion ratio	Feed per pound gained	2
Months to stocker harvest	Months	8
Hired labor	Hours	700
Average delivery distance	Miles	400
Average delivery weight	Fish pounds per delivery	2,000

For this Missouri catfish business model, Exhibit 1.3.2 presents a production budget with revenue and cost expectations. Net annual revenue is estimated at $325,125; this figure has had the costs of delivering fish to recreational markets deducted. Variable costs include feed, fingerlings, fuel and electricity, marketing and hired labor. The model includes the following fixed costs: value of owner’s management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. Assuming total costs of $296,178, the operation has a net return of $28,947 or $0.15 per fish sold.

Exhibit 1.3.2. Catfish Production Budget in Pond Culture (Recreational Stocking Market)

Item	**Unit**	**Quantity**	**Price or Cost Per Unit** ($)	**Total** ($)	**$ Per Fish Sold**	**Percent of Sales**
Revenue						
Catfish sales	Fish	191,250	2.00	382,500	2.00	100%
Delivery to buyers or markets	Annual miles	38,250	1.50	55,688	0.30	15%
			Net revenue	**325,125**	**1.70**	**85%**
Variable costs						
Feed	Tons	72	600.00	44,753	0.23	12%
Fingerlings	Fish	225,000	0.15	33,750	0.18	9%
Aquatic organism control				2,250	0.01	1%
Veterinary and medicine				7,650	0.04	2%
Water treatments				720	0.00	0%
Repair and maintenance				3,000	0.02	1%
Fuel and electricity				19,250	0.10	5%
Hired labor				12,544	0.07	3%
Supplies				2,400	0.01	1%
Marketing				76,500	0.40	20%
Other operating expenses				0	0.00	0%
Interest on operating capital	% APR		7.3%	4,579	0.02	1%
			Total variable costs	**207,396**	**1.08**	**54%**
Fixed costs						
Farm insurance	Total			5,000	0.03	1%
Legal/accounting	Total			1,000	0.01	0%
Owner labor and management	Total			45,000	0.24	12%
Interest on real estate and equipment	Total		6.5%	18,926	0.10	5%
Depreciation	Total			18,856	0.10	5%
			Total fixed costs	88,782	0.46	23%
			Total costs	296,178	1.55	77%
			Net return to operation	28,947	0.15	8%

	Breakeven Price ($)	**Breakeven Yield** (Quantity of Fish)	**Breakeven Stocking Density** (Pounds per Acre)
To cover variable costs	1.08	103,698	3,457
To cover total costs	1.55	148,089	4,936

The aquaculture business must be able to financially survive short-term changes in production. A sensitivity analysis measures how different production assumptions may impact a business' financial feasibility. Exhibit 1.3.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect various financial scorecard metrics. "Typical production" represents the input assumptions used in Exhibit 1.3.1.

Exhibit 1.3.3. Sensitivity Analysis for Catfish Production (Recreational Stocking Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	0%	36%	47%
Net return to operation	($52,870)	$28,947	$110,764
Cost of production per fish	$2.09	$1.55	$1.25

1.4. Bluegill Model

Bluegill are small-bodied fish popular for stocking ponds. To raise pond stocker bluegill, producers begin by filling production ponds in April. During the next six months — ending in mid-September — the bluegill grow from 2-inch fingerlings into 6-inch stocker fish weighing approximately one-tenth of a pound. Producers then target the fall pond stocking fish market across the Midwest, and the ponds remain empty until the following April when the next production cycle begins. Exhibit 1.4.1 shares key inputs and values used in this production system.

Exhibit 1.4.1. Inputs Used for Bluegill Production Budget (Recreational Stocking Market)

Item	Unit	Value
Stocker price (6-inch)	Dollars per fish	$1.50
Floating feed (46% protein)	Dollars per ton	$950
Fingerling price (2-inch)	Dollars per fish	$0.50
Stocking capacity	Pounds per acre	5,200
Fingerling weight	Pounds	0.003
Stocker final weight	Pounds	0.10
Survival rate	Percent	75%
Feed conversion ratio	Feed per pound gain	2.3
Months to stocker harvest	Months	6
Hired labor	Hours	600
Average delivery distance	Miles	400
Average delivery weight	Fish pounds per delivery	4,000

Exhibit 1.4.2 presents a Missouri bluegill production budget with revenue and cost expectations. Net annual revenue is estimated at $737,100, which has had fish delivery costs deducted. Variable costs include feed, fingerlings, fuel and electricity, marketing and hired labor. The model accounts for these fixed costs: value of owner's management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. After adjusting for total costs ($692,588), the net return to the operation is $44,512 or $0.08 per fish sold.

Exhibit 1.4.2. Bluegill Production Budget in Pond Culture (Recreational Stocking Market)

Item	**Unit**	**Quantity**	**Price or Cost Per Unit** ($)	**Total** ($)	**$ Per Fish Sold**	**Percent of Sales**
Revenue						
Bluegill sales	Fish	546,000	1.50	819,000	1.50	100%
Delivery to buyers or markets	Annual miles	54,600	1.50	81,900	0.15	10%
			Net revenue	**737,100**	**1.35**	**90%**
Variable costs						
Feed	Tons	61	950.00	57,861	0.11	7%
Fingerlings	Fish	624,000	0.50	312,000	0.57	38%
Aquatic organism control				2,250	0.00	0%
Veterinary and medicine				16,380	0.03	2%
Water treatments				720	0.00	0%
Repair and maintenance				3,000	0.01	0%
Fuel and electricity				19,250	0.04	2%
Hired labor				10,752	0.02	1%
Supplies				2,400	0.00	0%
Marketing				163,800	0.30	20%
Other operating expenses				0	0.00	0%
Interest on operating capital	% APR		7.3	15,392	0.03	2%
			Total variable costs	**603,806**	**1.11**	**74%**
Fixed costs						
Farm insurance	Total			5,000	0.01	1%
Legal/accounting	Total			1,000	0.00	0%
Owner labor and management	Total			45,000	0.08	5%
Interest on real estate and equipment	Total			18,926	0.03	2%
Depreciation	Total			18,856	0.03	2%
			Total fixed costs	**88,782**	**0.16**	**11%**
			Total costs	**692,588**	**1.27**	**85%**
			Net return to operation	**44,512**	**0.08**	**5%**

	Breakeven Price ($)	**Breakeven Yield** (Quantity of Fish)	**Breakeven Stocking Density** (Pounds per Acre)
To cover variable costs	1.11	402,537	3,354
To cover total costs	1.27	461,725	3,848

An aquaculture business must be able to financially survive short-term changes in production. A sensitivity analysis measures how different production assumptions may impact a business' financial feasibility. Exhibit 1.4.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect various financial scorecard metrics. "Typical production" represents the input assumptions used in Exhibit 1.4.1.

Exhibit 1.4.3. Sensitivity Analysis for Bluegill Production (Recreational Stocking Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	(13%)	18%	35%
Net return to operation	($154,346)	$44,512	$243,370
Cost of production per fish	$1.75	$1.27	$1.01

1.5. Largemouth Bass Model

A popular carnivorous fish, largemouth bass are stocked in ponds and lakes across Missouri and beyond. If raising largemouth bass for pond stocking purposes, then the production system starts by filling ponds in March with fingerlings. During the next eight months, fish will grow from 2-inch fingerlings into 8-inch stocker fish by mid-October. The 8-inch stockers will weigh approximately one-half pound and be sold for fall pond stocking across the Midwest. Ponds are assumed to stay empty until the following March when production resumes. Exhibit 1.5.1 shows key inputs and values used in this production system.

Exhibit 1.5.1. Inputs Used for Largemouth Bass Production Budget (Recreational Stocking Market)

Item	Unit	Value
Stocker price (8-inch)	Dollars per fish	$2.50
Floating feed (46% protein)	Dollars per ton	$950
Fingerling price (2-inch)	Dollars per fish	$0.30
Stocking capacity	Pounds per acre	4,800
Fingerling weight	Pounds	0.01
Stocker final weight	Pounds	0.40
Survival rate	Percent	75%
Feed conversion ratio	Feed per pound gain	2.20
Months to stocker harvest	Months	8
Hired labor	Hours	750
Average delivery distance	Miles	400
Average delivery weight	Fish pounds per delivery	2,000

For this business model, Exhibit 1.5.2 presents a Missouri largemouth bass production budget with revenue and cost expectations. Net annual revenue is estimated at $277,200; this net value has had delivery costs deducted for moving fish to recreational markets. Variable costs include feed, fingerlings, fuel and electricity, marketing and hired labor. Fixed costs are value of owner's management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. After subtracting total costs of $279,118, the net return to the operation arrived at ($22,184) or ($0.18) per fish sold. This is a net loss.

Exhibit 1.5.2. Largemouth Bass Production Budget in Pond Culture (Recreational Stocking Market)

Item	Unit	Quantity	Price or Cost Per Unit ($)	Total ($)	$ Per Fish Sold	Percent of Sales
Revenue						
Bass sales	Fish	126,000	2.50	315,000	2.50	100%
Delivery to buyers or markets	Annual miles	25,200	1.50	37,800	0.30	12%
			Net revenue	**277,200**	**2.20**	**88%**
Variable costs						
Feed	Tons	55	950.00	51,878	0.41	16%
Fingerlings	Fish	144,000	0.30	43,200	0.34	14%
Aquatic organism control				2,250	0.02	1%
Veterinary and medicine				6,300	0.05	2%
Water treatments				720	0.01	0%
Repair and maintenance				3,000	0.02	1%
Fuel and electricity				19,250	0.15	6%
Hired labor				13,440	0.11	4%
Supplies				2,400	0.02	1%
Marketing				63,000	0.50	20%
Other operating expenses				0	0.00	0%
Interest on operating capital	% APR		7.3%	5,163	0.04	2%
			Total variable costs	**210,602**	**1.67**	**67%**
Fixed costs						
Farm insurance	Total			5,000	0.04	2%
Legal/accounting	Total			1,000	0.01	0%
Owner labor and management	Total			45,000	0.36	14%
Interest on real estate and equipment	Total		6.5%	18,926	0.15	6%
Depreciation	Total			18,856	0.15	6%
			Total fixed costs	**88,782**	**0.70**	**28%**
			Total costs	**299,384**	**2.38**	**95%**
			Net return to operation	**(22,184)**	**(0.18)**	**(7%)**

	Breakeven Price ($)	**Breakeven Yield** (Quantity of Fish)	**Breakeven Stocking Density** (Pounds per Acre)
To cover variable costs	1.67	84,241	2,808
To cover total costs	2.38	119,754	3,992

The aquaculture business must be able to financially survive short-term changes in production. A sensitivity analysis measures how changing production assumptions may impact the financial feasibility of a business. Exhibit 1.5.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect various financial scorecard metrics. "Typical production" represents the input assumptions used in Exhibit 1.5.1.

Exhibit 1.5.3. Sensitivity Analysis for Largemouth Bass Production (Recreational Stocking Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	0%	24%	37%
Net return to operation	($87,891)	($22,184)	43,523
Cost of production per fish	$3.20	$2.38	$1.93

1.6. Grass Carp Model

Pond owners often add grass carp to their ponds to control aquatic vegetation. Producing grass carp begins by filling ponds in March with 3-inch fingerlings. By mid-October, the fish will grow to be 10-inch stocker fish weighing approximately six-tenths of a pound. In the fall, producers sell 10-inch fish to stock ponds across the Midwest. A producer's grass carp ponds will remain empty until production resumes the following March. Exhibit 1.6.1 shows key inputs and values used in this production system.

Exhibit 1.6.1. Inputs Used for Grass Carp Production Budget (Recreational Stocking Market)

Item	Unit	Value
Stocker price (10-inch)	Dollars per fish	$3.50
Liquid manure	Dollars per ton	$100
Fingerling price (3-inch)	Dollars per fish	$0.50
Stocking capacity	Pounds per acre	2,250
Fingerling weight	Pounds	0.03
Stocker final weight	Pounds	0.60
Survival rate	Percent	90%
Feed conversion ratio	Feed per pound gain	3
Months to stocker harvest	Months	9
Hired labor	Hours	750
Average delivery distance	Miles	400
Average delivery weight	Fish pounds per delivery	2,000

Exhibit 1.6.2 presents a Missouri grass carp production budget with revenue and cost expectations for this business model. Net annual revenue is estimated at $136,800; this has deducted delivery costs of moving fish to markets. Variable costs include pond fertilizer, fingerlings, fuel and electricity, marketing, hired labor and other expenses. Fixed costs include value of owner's management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. After factoring in total costs of $202,595, the net return to the operation represented ($65,795) or ($1.54) per fish sold. This is a net loss.

Exhibit 1.6.2. Grass Carp Production Budget in Pond Culture (Recreational Stocking Market)

Item	Unit	Quantity	Price or Cost Per Unit ($)	Total ($)	$ Per Fish Sold	Percent of Sales
Revenue						
Grass carp sales	Fish	42,750	3.50	149,625	3.50	100%
Delivery to buyers or markets	Annual miles	8,550	1.50	12,825	0.30	9%
			Net revenue	**136,800**	**3.20**	**91%**
Variable costs						
Pond fertilizer	Tons	144	100.00	14,400	0.34	10%
Fingerlings	Fish	45,000	0.50	22,500	0.53	15%
Aquatic organism control				2,250	0.05	2%
Veterinary and medicine				2,993	0.07	2%
Water treatments				720	0.02	0%
Repair and maintenance				3,000	0.07	2%
Fuel and electricity				19,250	0.45	13%
Hired labor				13,440	0.31	9%
Supplies				2,400	0.06	2%
Marketing				29,925	0.70	20%
Other operating expenses				0	0	0%
Interest on operating capital	% APR		7.3%	2,935	0.07	2%
			Total variable costs	**113,812**	**2.66**	**76%**
Fixed costs						
Farm insurance	Total			5,000	0.12	3%
Legal/accounting	Total			1,000	0.02	1%
Owner labor and management	Total			45,000	1.05	30%
Interest on real estate and equipment	Total		6.5%	18,926	0.44	13%
Depreciation	Total			18,856	0.44	13%
			Total fixed costs	**88,782**	**2.08**	**59%**
			Total costs	**202,595**	**4.74**	**135%**
			Net return to operation	**(65,795)**	**(1.54)**	**(44%)**

	Breakeven Price ($)	**Breakeven Yield** (Quantity of Fish)	**Breakeven Stocking Density** (Pounds per Acre)
To cover variable costs	2.66	32,518	1,626
To cover total costs	4.74	57,884	2,894

The aquaculture business must be able to financially survive short-term production changes. A sensitivity analysis measures how changing production assumptions may impact the financial feasibility of a business. Exhibit 1.6.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect key financial metrics. "Typical production" represents the input assumptions used in Exhibit 1.6.1.

Exhibit 1.6.3. Sensitivity Analysis for Grass Carp Production (Recreational Stocking Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	(13%)	17%	33%
Net return to operation	($101,617)	($65,795)	($29,973)
Cost of production per fish	$6.60	$4.74	$3.74

2. Recirculating Aquaculture System (RAS) Models

2.1. Background

Using a recirculating aquaculture system (RAS) allows producers to raise fish or crustaceans in indoor tanks at a high production density. The tanks in an RAS system vary in size to accommodate different sizes of fish or crustaceans. Water is pumped through filters to remove fecal matter and uneaten food. Water also undergoes aeration and treatment to maintain proper oxygen and pH levels and provide other desired water quality characteristics. RAS also requires proactive fish sorting because high fish densities can lead to cannibalism. Therefore, RAS operators must sort and move fish — one of the primary labor needs. Maintaining oxygenation and filtration equipment is essential when operating a RAS. Aquatic life stocked at high densities will quickly consume oxygen in the tank if water circulation stops, which makes power outages or equipment failures a major risk. Environmentally, RAS is a favorable method of producing fish or crustaceans. Water usage is low relative to production and there is less likelihood for ground or surface water contamination than in an outdoor pond or raceway system. Additionally, there is no chance for fish raised to escape and enter local waterways.

RAS systems can be developed in many areas or locations. They may be more financially feasible if placed near major urban centers and fish markets. Energy costs contribute significantly to RAS system costs because RAS systems must be maintained at temperatures optimal for fish or crustacean growth. In Missouri's temperate climate, RAS systems will likely require supplemental heating about eight months a year.

2.2. Capital Investments

As a relative newcomer to aquaculture, RAS configurations have no standard model for U.S. operations. RAS systems are also challenged with higher production costs than other aquaculture production systems used in the U.S. and internationally. For this reason, our project team developed a research-based theoretical RAS system based on our evaluation of successful RAS systems that are in operation.

For a typical RAS operation, Exhibit 2.2.1 illustrates the layout, and Exhibit 2.2.2 details the capital investment expenses. The system has about 3,750 square feet of water space in a 6,250-square-foot building. As roughly the minimum size recommended for a full-time operation, this scale enables the owner and part-time help to fulfill the labor needs. As in the pond culture models, these models are designed to allow an owner to withdraw a $45,000 salary from the business and operate at an initial scale small enough to target higher priced niche markets while gaining production experience.

Exhibit 2.2.1. RAS Operation Layout Example

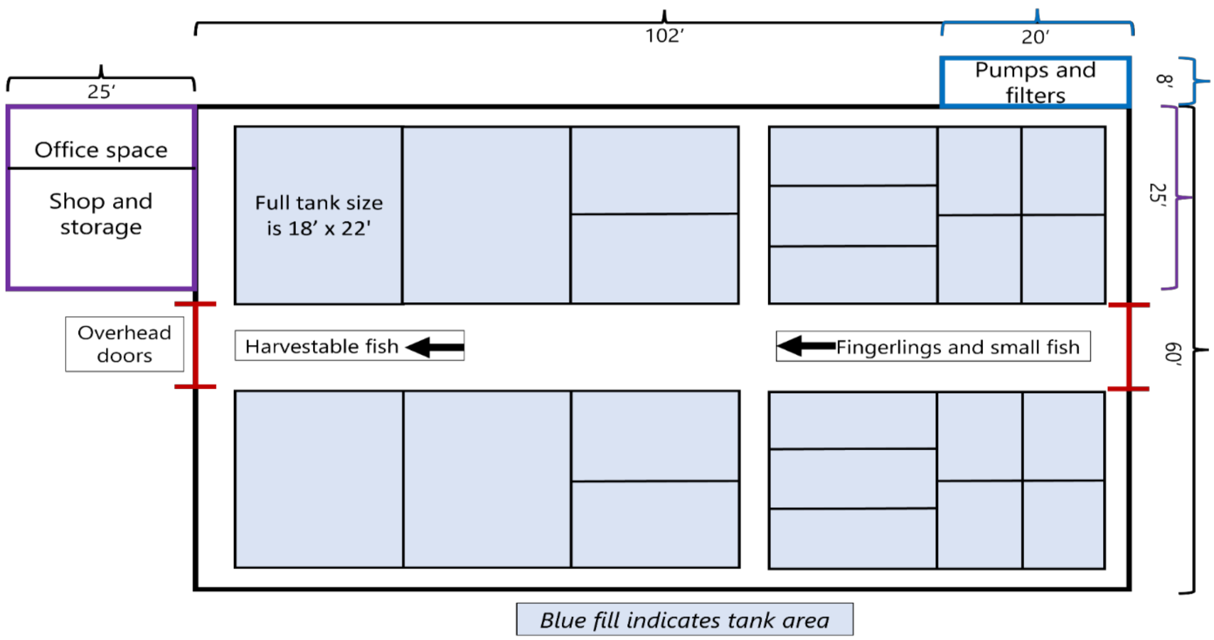

Exhibit 2.2.2. Capital Investments for RAS Operation

Item	**Unit**	**Quantity**	**Price or Cost Per Unit** ($)	**Total Cost** ($)	**Useful Life**	**Salvage Value** (%)
Land	Acre	0.5	6,000	3,000	N/A	N/A
Steel frame building materials	Square feet	6,240	12.00	74,880	20	10%
Concrete pad (installed)	Square feet	6,940	5.00	34,700	30	5%
Insulation, electrical, plumbing	Square feet	6,940	3.00	20,820	20	5%
Office, shop, storage and machinery space	Square feet	700	20.00	14,000	20	10%
Tank materials	Cubic feet	11,286	1.25	14,108	10	20%
Well installation	Each	1	25,000	25,000	15	0%
Filtration system	Each	1	13,395	13,395	10	10%
Aeration compressor	Each	1	9,650	9,650	5	20%
Filtration pump	Each	1	2,700	2,700	5	10%
Septic/wastewater system	Each	1	5,000	5,000	20	0%
Climate control	Each	1	15,000	15,000	20	10%
Truck	Each	1	45,000	45,000	10	25%
Fish hauling truck	Each	1	8,000	8,000	10	25%
Regulator, flow meters, diffusers	Total	1	750	750	5	10%
Feed systems/bins	Each	1	20,000	20,000	10	10%
Shop tools	Total	1	5,000	5,000	10	25%
Shipping/storage container	Each	1	3,000	3,000	20	20%
DO meter	Each	1	900	900	5	10%
Water test kit	Each	1	3,000	3,000	2	0%
Office furnishings	Total	1	1,000	1,000	10	10%
Computer	Total	1	1,100	1,100	5	10%
Standby generator	Each	1	12,000	12,000	20	25%
Electric panel	Each	1	10,000	10,000	20	10%
Digital scales	Each	2	250	500	5	10%
Forklift	Each	1	15,000	15,000	15	25%
Waders	Each	1	200	200	3	0%
Pressure washer	Each	1	1,500	1,500	5	10%
Hanging scale	Each	2	500	1,000	5	10%
Dipnets	Each	5	30	150	2	0%
			Total capital investment	**360,353**		

2.3. Catfish Model

Catfish in RAS systems are raised in a continuous eight-month production cycle. An operation producing live catfish to sell at a premium may start with 3-inch fingerlings and feed them to a 2-pound harvest weight. Assume a 90% projected survival rate and a roughly 1.5:1 feed conversion ratio. The estimated capacity is 0.6 fish pounds per gallon of water. Exhibit 2.3.1 shows key inputs and values used in this production system.

Exhibit 2.3.1. Inputs Used for Catfish RAS Budget (Live Food Fish Market)

Item	Unit	Value
Catfish sales price	Dollars per pound	$4.00
Floating feed (32% protein)	Dollars per ton	$600
Fingerling price	Dollars per fish	$0.15
Veterinary health	Percent of sales	2%
Stocking capacity	Pounds per gallon	0.60
Catfish finish weight	Pounds	2.00
Survival rate	Percent	90%
Feed conversion ratio	Feed per pound gain	1.50
Fingerling weight	Pounds	0.05
Turns per year	Turns	1.50
Hired labor	Hours	2,250
Average delivery distance	Miles (round trip)	400
Average delivery weight	Fish pounds per delivery	2,000

Exhibit 2.3.2 shows the estimated budget for catfish RAS production, including revenue and cost expectations, and Exhibit 2.3.3 provides a sensitivity analysis for key financial indicators.

The budget estimates net annual revenue at $242,764 after deducting delivery costs incurred to move live fish to food markets. Variable costs include feed, fingerlings, hired labor, utilities and repairs. The model includes these fixed costs: value of owner's management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. After subtracting total costs of $211,277 from net revenue, the operation has a net annual return of $31,487 or $0.46 per pound sold.

Exhibit 2.3.2. Catfish RAS Budget (Live Food Fish Market)

Item	Unit	Quantity	Price or Cost Per Unit ($)	Total ($)	$ Per Pound Sold	Percent of Sales
Revenue						
Catfish sales	Pound	68,384	4.00	273,537	4.00	100%
Delivery to buyers or markets	Miles	13,677	2.25	30,773	0.45	11%
			Net revenue	**242,764**	**3.55**	**89%**
Variable costs						
Feed	Tons	53	600.00	31,583	0.46	12%
Fingerlings	Fish	37,991	0.15	5,699	0.08	2%
Hired labor				40,320	0.59	15%
Utilities				13,622	0.20	5%
Water treatments				8,400	0.12	3%
Repair and maintenance				14,414	0.21	5%
Veterinary and medicine				5,471	0.08	2%
Supplies				3,000	0.04	1%
Other operating expenses				0	0.00	0%
Interest on operating capital	% APR		7.3%	2,961	0.04	1%
			Total variable costs	**125,469**	**1.83**	**46%**
Fixed costs						
Farm insurance	Total			3,000	0.04	1%
Legal/accounting	Total			1,000	0.01	0%
Owner labor and management	Total			45,000	0.66	16%
Interest on real estate and equipment	Total		6.5%	13,078	0.19	5%
Depreciation	Total			23,730	0.35	9%
			Total fixed costs	**85,808**	**1.25**	**31%**
			Total costs	**211,277**	**3.09**	**77%**
			Net return to operation	**31,487**	**0.46**	**12%**

	Breakeven Price ($)	Breakeven Yield (Fish Pounds)
To cover variable costs	1.83	31,367
To cover total costs	3.09	52,819

The aquaculture business must be able to financially survive short-term changes in production. A sensitivity analysis measures how changing production assumptions may impact the financial feasibility of a business. Exhibit 2.3.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect various financial scorecard metrics. “Typical production” represents input assumptions used in Exhibit 2.3.1.

Exhibit 2.3.3. Sensitivity Analysis for Catfish RAS Budget (Live Food Fish Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	33%	48%	57%
Net return to operation	($30,226)	$31,487	$93,200
Cost of production per pound	$4.18	$3.09	$2.50

2.4. Largemouth Bass Model

Raising largemouth bass in RAS systems involves a continuous nine- to 10-month production cycle. A benchmark operation may begin with 2-inch fingerlings and feed them to a 1.5-pound harvest weight. This model assumes an estimated 1.75:1 feed-to-gain conversion and 95% survival rate. This model estimates capacity at 0.5 pounds of fish per gallon of water. Key inputs and values used in this production system are shown in Exhibit 2.4.1.

Exhibit 2.4.1. Inputs Used for Largemouth Bass RAS Budget (Live Food Fish Market)

Item	Unit	Value
Bass sales price	Dollars per pound	$6
Floating feed (46% protein)	Dollars per ton	$725
Fingerling price	Dollars per fish	$0.30
Veterinary health	Percent of sales	2%
Stocking capacity	Pounds per gallon	0.50
Bass finish weight	Pounds	1.50
Survival rate	Percent	95%
Feed conversion ratio	Feed per pound gain	1.75
Fingerling weight	Pounds	0.05
Turns per year	Turns	1.00
Hired labor	Hours	2,000
Average delivery distance	Miles (round trip)	400
Average delivery weight	Fish pounds per delivery	2,000

Exhibit 2.4.2 presents a Missouri largemouth bass RAS production budget with estimated revenue and costs. Net annual revenue is estimated at $222,565 after deducting fish delivery costs to food markets. Variable costs include feed, fingerlings, hired labor, utilities and repairs. The model accounts for these fixed costs: value of owner's management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. Variable and fixed costs sum to $202,598, and the projected net annual return to the operation equals $19,967 or $0.50 per pound sold.

Exhibit 2.4.2. Largemouth Bass RAS Budget (Live Food Fish Market)

Item	Unit	Quantity	Price or Cost Per Unit ($)	Total ($)	$ Per Pound Sold	Percent of Sales
Revenue						
Bass sales	Pound	40,102	6.00	240,611	6.00	100%
Delivery to buyers or markets	Miles	8,020	2.25	18,046	0.45	8%
			Net revenue	**222,565**	**5.55**	**93%**
Variable costs						
Feed	Tons	35	725.00	25,222	0.63	10%
Fingerlings	Fish	28,142	0.30	8,442	0.21	4%
Hired labor				35,840	0.89	15%
Utilities				12,574	0.31	5%
Water treatments				8,400	0.21	3%
Repair and maintenance				14,414	0.36	6%
Veterinary and medicine				4,812	0.12	2%
Supplies				3,000	0.07	1%
Other operating expenses				0	0.00	0%
Interest on operating capital	% APR		7.3%	4,086	0.10	2%
			Total variable costs	**116,790**	**2.91**	**49%**
Fixed costs						
Farm insurance	Total			3,000	0.07	1%
Legal/accounting	Total			1,000	0.02	0%
Owner labor and management	Total			45,000	1.12	19%
Interest on real estate and equipment	Total		6.5%	13,078	0.33	5%
Depreciation	Total			23,730	0.59	10%
			Total fixed costs	**85,808**	**2.14**	**36%**
			Total costs	**202,598**	**5.05**	**84%**
			Net return to operation	**19,967**	**0.50**	**8%**

	Breakeven Price ($)	**Breakeven Yield** (Fish Pounds)
To cover variable costs	2.91	19,465
To cover total costs	5.05	33,766

The aquaculture business must be able to financially survive short-term changes in production. A sensitivity analysis can measure how changing production assumptions may impact a business' financial feasibility. Exhibit 2.4.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect various financial scorecard metrics. "Typical production" represents the input assumptions used in Exhibit 2.4.1.

Exhibit 2.4.3. Sensitivity Analysis for Largemouth Bass RAS Budget (Live Food Fish Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	31%	48%	57%
Net return to operation	($37,792)	$19,967	$77,726
Cost of production per pound	$6.90	$5.05	$4.06

2.5. Shrimp Model

Shrimp in RAS systems are raised in continuous three-month production cycles. The benchmark operation begins by introducing larvae to tanks and feeding them to a harvest weight of 22 grams per shrimp. Feed conversion is estimated at 1.4:1 pounds of feed per pound of gain. A survival rate of 75% is projected for the system; this assumes an estimated capacity of 0.07 shrimp pounds per gallon of water. Exhibit 2.5.1 shows key inputs and values used in this production system.

Exhibit 2.5.1. Inputs Used for Shrimp RAS Budget (Live Food Fish Market)

Item	Unit	Value
Shrimp sales price	Dollars per pound	$20
Floating feed (46% protein)	Dollars per ton	$2,400
Shrimp larvae	Dollars per larvae	$0.10
Veterinary health	Percent of sales	2%
Stocking capacity	Pounds per gallon	0.07
Shrimp finish weight	Grams	22.00
Survival rate	Percent	75%
Feed conversion ratio	Feed per pound gain	1.40
Larvae weight	Pounds	1.30
Turns per year	Turns	3.50
Hired labor	Hours	1,750
Average delivery distance	Miles (round trip)	400
Average delivery weight	Pounds per delivery	500

Exhibit 2.5.2 presents a Missouri shrimp RAS production budget with revenue and cost expectations for this business model. Net annual revenue is estimated at $282,338; this deducts the costs of delivering shrimp to food markets. Variable costs include feed, larvae, hired labor, utilities, repairs and other expenses. Fixed costs include value of owner's management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. After factoring in total costs of $234,972, the net annual return to the operation reached $47,366 or $3.05 per pound sold.

Exhibit 2.5.2. Shrimp RAS Budget (Live Food Fish Market)

Item	Unit	Quantity	Price or Cost Per Unit ($)	Total ($)	$ Per Pound Sold	Percent of Sales
Revenue						
Shrimp sales	Pound	15,513	20.00	310,262	20.00	100%
Delivery to buyers or markets	Miles	12,410	2.25	27,924	1.80	9%
			Net revenue	**282,338**	**18.20**	**91%**
Variable costs						
Feed	Tons	12	2,400.00	28,025	1.81	9%
Larvae	Number	426,469	0.10	42,647	2.75	14%
Hired labor				31,360	2.02	10%
Utilities				13,584	0.88	4%
Water treatments				8,400	0.54	3%
Repair and maintenance				14,414	0.93	5%
Veterinary and medicine				6,205	0.40	2%
Supplies				3,000	0.19	1%
Other operating expenses				0	0.00	0%
Interest on operating capital	% APR		7.3%	1,529	0.10	0%
			Total variable costs	**149,164**	**9.62**	**48%**
Fixed costs						
Farm insurance	Total			3,000	0.19	1%
Legal/accounting	Total			1,000	0.06	0%
Owner labor and management	Total			45,000	2.90	15%
Interest on real estate and equipment	Total		6.5%	13,078	0.84	4%
Depreciation	Total			23,730	1.53	8%
			Total fixed costs	**85,808**	**5.53**	**28%**
			Total costs	**234,972**	**15.15**	**76%**
			Net return to operation	**47,366**	**3.05**	**15%**
			Breakeven Price ($)		**Breakeven Yield** (Shrimp Pounds)	
		To cover variable costs	9.62		7,458	
		To cover total costs	15.15		11,749	

The aquaculture business must be able to financially survive short-term changes in production. A sensitivity analysis measures how changing production assumptions may impact the financial feasibility of a business. Exhibit 2.5.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect various financial scorecard metrics. "Typical production" represents the input assumptions used in Exhibit 2.5.1.

Exhibit 2.5.3. Sensitivity Analysis for Shrimp RAS Budget (Live Food Fish Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	30%	47%	57%
Net return to operation	($27,066)	$47,366	$121,798
Cost of production per pound	$20.69	$15.15	$12.16

2.6. Tilapia Model

In RAS systems, tilapia are raised in continuous eight-month production cycles. This model assumes an operator procures 3-inch fingerlings and feeds them to a harvest weight of 1.4 pounds. Feed conversion is an estimated 1.5:1 pounds of feed per pound of gain, and this analysis assumes a 90% survival rate. The estimated capacity is 1.25 pounds of fish per gallon of water. Exhibit 2.6.1 shows other key inputs and values used in this production system.

Exhibit 2.6.1. Inputs used for Tilapia RAS Budget (Live Food Fish Market)

Item	Unit	Value
Tilapia sales price	Dollars per pound	$2.50
Floating feed (45% protein)	Dollars per ton	$725
Tilapia fingerlings	Dollars per fish	$0.20
Veterinary health	Percent of sales	2%
Stocking capacity	Pounds per gallon	1.25
Tilapia finish weight	Grams	1.40
Survival rate	Percent	90%
Feed conversion ratio	Feed per pound gain	1.50
Fingerling weight	Pounds	0.01
Turns per year	Turns	1.50
Hired labor	Hours	3,000
Average delivery distance	Miles (round trip)	400
Average delivery weight	Pounds per delivery	2,000

Exhibit 2.6.2 presents a Missouri tilapia RAS production budget with revenue and cost expectations. Net annual revenue is estimated at $292,057, which has had delivery costs deducted. Variable costs include feed, fingerlings, hired labor, utilities and repairs. Fixed costs are value of owner's management and labor ($45,000), insurance, depreciation, interest and legal and accounting expenses. Given these assumptions, net annual return to the operation is ($4,236) or ($0.03) per pound sold — a net loss.

Exhibit 2.6.2. Tilapia RAS Budget (Live Food Fish Market)

Item	Unit	Quantity	Price or Cost Per Unit ($)	Total ($)	$ Per Pound Sold	Percent of Sales
Revenue						
Tilapia sales	Pound	142,467	2.50	356,168	2.50	100%
Delivery to buyers or markets	Miles	28,493	2.25	64,110	0.45	18%
			Net revenue	**292,057**	**2.05**	**82%**
Variable costs						
Feed	Tons	112	725.00	80,961	0.57	23%
Fingerlings	Number	113,069	0.20	22,614	0.16	6%
Hired labor				53,760	0.38	15%
Utilities				15,247	0.11	4%
Water treatments				8,400	0.06	2%
Repair and maintenance				14,414	0.10	4%
Veterinary and medicine				7,123	0.05	2%
Supplies				3,000	0.02	1%
Other operating expenses				0	0.00	0%
Interest on operating capital	% APR		7.3%	4,967	0.03	1%
			Total variable costs	**210,486**	**1.48**	**59%**
Fixed costs						
Farm insurance	Total			3,000	0.02	1%
Legal/accounting	Total			1,000	0.01	0%
Owner labor and management	Total			45,000	0.32	13%
Interest on real estate and equipment	Total		6.5%	13,078	0.09	4%
Depreciation	Total			23,730	0.17	7%
			Total fixed costs	**90,297**	**0.60**	**24%**
			Total costs	**296,294**	**2.08**	**83%**
			Net return to operation	**(4,236)**	**(0.03)**	**(1%)**

	Breakeven Price ($)	Breakeven Yield (Fish Pounds)
To cover variable costs	1.48	84,194
To cover total costs	2.08	118,517

From a financial perspective, the aquaculture business must be able to survive short-term changes in production. A sensitivity analysis measures how different production assumptions impact the financial feasibility of a business. Exhibit 2.6.3 demonstrates how a 30% decrease in production and a 30% increase in production would affect various financial scorecard metrics. "Typical production" represents the input assumptions used in Exhibit 2.6.1.

Exhibit 2.6.3. Sensitivity Analysis for Tilapia RAS Budget (Live Food Fish Market)

Metric	-30% Decrease in Production	Typical Production	30% Increase in Production
Operating profit margin	10%	28%	38%
Net return to operation	($65,428)	($4,236)	$56,956
Cost of production per pound	$2.71	$2.08	$1.74

3. Business Model Summary

These business models serve as possibilities for startup Missouri aquaculture operations. Exhibit 3.1 compares production and financial factors for the eight business models detailed in this report. Establishing a new aquaculture business requires evaluating the biological, economic, market, financial and management feasibility of raising a particular fish, group of fishes or other aquaculture products. For further business planning assistance, see MU Extension publication G9469 Planning for an Aquaculture Business in Missouri (extension.missouri.edu/publications/g9469). Note, when starting an aquaculture venture, many experienced entrepreneurs report a multiyear period of negative cash flows as the selected system is refined, productivity is improved, management gains experience and new markets develop.

Exhibit 3.1. Comparison of Missouri Aquaculture Models

Model	Culture System	Annual Production (Pounds)	Primary Market Channel	Capital Investment (Dollars)	Annual Sales (Dollars)	Operating Profit Margin[1] (Percent)
Catfish	Pond	76,500	Recreational stocking	438,050	382,500	36%
Bluegill	Pond	54,600	Recreational stocking	438,050	819,000	18%
Bass	Pond	50,400	Recreational stocking	438,050	315,000	24%
Grass Carp	Pond	25,650	Recreational stocking	438,050	149,625	17%
Catfish	RAS	63,384	Food fish (live)	360,353	273,537	48%
Bass	RAS	40,102	Food fish (live)	360,353	240,611	48%
Shrimp	RAS	15,513	Food fish (live)	360,353	310,262	47%
Tilapia	RAS	142,467	Food fish (live)	360,353	356,168	28%

[1] Operating profit is calculated by sales net of delivery costs minus operating costs minus ownership costs. Operating profit is then divided by net sales to arrive at the operating profit margin.

Opportunities for integrated contract production, like those currently used in the U.S. poultry and swine industries, are now emerging in some global aquaculture sectors. These models typically involve standard technology packages, contractor-supplied feed, defined production protocols and captive marketing agreements.

Larger scale growth in an industry often leads to a clustering of suppliers, lower transportation costs, faster technological improvements and overall lower costs of production. These production opportunities in the Midwest could accelerate aquaculture growth in Missouri.

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