North Central Regional Aquaculture Industry: Business Models

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Summary

This report is designed for aquaculture entrepreneurs seeking business model examples in the North Central region of the U.S. The North Central region (NCR) aquaculture industry is diverse. Varied topography, climate and groundwater availability have guided existing operation locations. Mild winters in the more southern states provided certain aquaculture pioneers with a more favorable production season than other states. Cold-water species find better growth conditions in the northern NCR states.

Nationwide, aquaculture is a growing industry with clusters of highly developed and specialized businesses. Examples of successful regional clusters include trout farms along the rivers of Idaho and catfish operations in the southeastern Mississippi River Delta states. Other areas of the U.S. are home to operations serving exclusively local demand or specific niches and market segments. California has several examples of niche fresh fish operations. Fish market segments could 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 consumer markets.

Business models for 10 different species–market combinations grown in ponds and another six species–market combinations grown in recirculating aquaculture systems (RAS) were developed in this study. Departing from a common farm size and RAS structure, the 16 business models detailed in this report were designed to take advantage of emerging aquaculture opportunities, build upon NCR's current industry strengths, avoid apparent weaknesses and steer around threats posed by competitive aquaculture businesses. These models are identified in Exhibit S1 and shown with various business characteristics. They were developed as entry-level firms and chosen to be large enough to fully employ a family's labor and yet small enough to focus on niche markets rather than compete with large firms.

Whenever available, all technical parameters and specifications were grounded in past technical publications. Price values were gathered from websites and fish suppliers in the North Central region. Fish prices showed large variation depending on the quantity purchased and the location of the fish farm, so we used prices closer to the median and gave preference to sources that represented prices for sales in larger quantities (and thus closer to wholesale prices). Two accompanying tools were developed alongside this report to allow producers to customize technical parameters and price values, enabling them to generate budgets that reflect their specific plans or operational realities.

When combining climate and market factors, it is clear there is no one-size-fits-all operation suitable for North Central region aquaculture. The region has a range of climate conditions and/or water resource availability, which also impacts the viability of each of the species analyzed in this study. Many times, the conditions present for a startup business

are not comparable to those in areas outside the North Central region where large-scale aquaculture markets exist, such as parts of Idaho and the southeast. For these reasons, opportunities for startup aquaculture operations in the North Central region are mostly focused on specialty or value-added products at a scale that supports a single family.

Exhibit S1. North Central aquaculture business model: pond culture.

Pond model	Unit of sale	Capital investment[1] ($)	Cycle[2] (months)	Stocking density[3] (fingerlings/ acre)	Annual production[4] (lb. of unprocessed fish)	Break-even price[5] ($)
Catfish (food)	lb. (1.8 lb./fish, whole fish)	423,964	12	3,750	56,700	3.40
Hybrid striped bass (food)						
Nursery	fish (6"/0.22 lb.)	423,964	6	13,400		1.48
Grow-out	lb. (2.5 lb./fish, whole fish)	423,964	12	3,200	57,600	5.48
Integrated (nursery + grow-out)	lb. (2.5 lb./fish, whole fish)	423,964	18	-	57,600	5.26
Yellow perch (food)	lb. (whole fish, size 0.33 lb./ fish)	423,964	12	10,000	33,660	7.91
Blue gill (stocking)	fish (4"–5"/0.1 lb.)	399,151	8	15,000	27,000	1.65
Catfish (stocking)	fish (11"+/0.5 lb.)	399,151	8	15,000	63,000	1.85
Golden shiner (bait/stocking)	lb. (live fish)	399,151	18	100,000	5,647	21.14
Grass carp (stocking)	fish (8"–11")	399,151	9	3,750	20,250	5.42
Hybrid striped bass (stocking)						
Nursery	fish (6"/0.22 lb.)	399,151	6	13,400		1.47
Grow-out	fish (12"+/0.8 lb.)	399,151	5	4,000	20,480	5.44
Integrated (nursery + grow-out)	fish (12"+/0.8 lb.)	399,151	11	-	20,480	4.75
Largemouth bass (stocking)						
Nursery	fish (6"/0.22 lb.)	399,151	6	30,000		2.69
Grow-out	fish (12"+/0.8 lb.)	399,151	5	8,000	38,400	7.19
Integrated (nursery + grow-out)	fish (12"+/0.8 lb.)	399,151	11	-	38,400	5.97
Yellow perch (stocking)	fish (7.5"–8.5")	399,151	6	10,000	21,600	3.48

1. Capital investment measures the cost of purchasing all items needed to start the operation.
2. Cycle refers to the assumed duration of a production cycle or stage, in the case of operations that include a nursery phase.
3. Stocking density refers to the number of fingerlings placed per acre.
4. Annual production refers to the pounds of unprocessed fish produced per year, based on the assumed stocking density and technical performance.
5. Break-even price refers to the minimum price required to cover the total production cost for the enterprise, based on the performance and input cost assumptions used in this report.

Exhibit S2. North Central aquaculture business model: recirculating aquaculture systems (RAS).

RAS model	Unit of sale	Capital investment[1] ($)	Cycle[2] (months)	Carrying capacity[3] (lb./gallon/cycle)	Annual production[4] (tons of unprocessed fish)	Break-even price[5] ($)
Salmon (food)	lb. (8.8 lb./fish, whole fish)	451,351	24	0.67	18.103	6.30
Trout (food)	lb. (3.3 lb./fish, whole fish)	447,623	10	0.54	34.679	5.10
Trout (stocking)	fish (6"–10")	451,351	7	0.38	34.523	2.47
Walleye (stocking)	fish (6"–10")	447,623	5	0.42	54.344	3.73
Yellow perch (food)	lb. (0.5 lb./fish, whole fish)	447,623	24	0.57	15.297	10.55
Yellow perch (stocking)	fish (3"–5")	447,623	12	0.59	31.622	2.31

1. Capital investment measures the cost of purchasing all items needed to start the operation.
2. Cycle refers to the assumed duration of a production cycle.
3. Carrying capacity refers to the maximum pounds of fish supported per gallon of water in the system.
4. Annual production refers to the tons of unprocessed fish produced per year, based on the assumed stocking density and technical performance.
5. Break-even price refers to the minimum price required to cover the total production cost for the enterprise, based on the performance and input cost assumptions used in this report.

1. Freshwater pond culture models

1.1 Background

Commodity pond aquaculture is a growing activity in the U.S., and its viability depends on aspects such as the availability of inputs, temperature, species and market conditions. Pond aquaculture in the North Central region might be a viable business depending on the right choice of species and suitability for each location. Cold-water species might perform well in northern NCR states, whereas warm-water species present longer cycles and are less viable. Resilient warm-water species might be grown in southern NCR states if market opportunities and cheaper inputs are available. Producing fish for recreational or pond stocking is an alternative that addresses climate limitations imposed by shorter production cycles for warm-water species; therefore, fish stockers have no minimum marketable size.

Considering these aspects, this report presents enterprise budgets developed for aquaculture in pond cultures in the North Central region for 10 combinations of species and markets. We include both warm- and cold-water species to provide a broad range of analysis that might benefit producers from the region and beyond. A sensitivity analysis of break-even prices in respect to survival is also presented for each budget.

1.2 Capital investments and operating inputs

Overall, the capital investment necessary to purchase and construct a 20-acre pond culture aquaculture farm is estimated at $438,050 (Exhibit 1.2.1). A typical pond culture operation in the North Central region may include ponds of 1 to 2 acres in size. 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. Equipment and structures comprise 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.

For pond systems that include a nursery, the model assumes that part of the acreage will be allocated to nursery and the rest to grow out, with the grow-out acreage being enough to raise all fish from one cycle of the nursery pond. For example, the model implies that the farm would have a nursery that raises catfish (food) to juvenile size for six months, and enough acreage for another pond to grow all juveniles from the nursery pond to market size (1.8 pounds) for an additional 12 months.

Exhibit 1.2.1. Capital investments in a 20-acre pond aquaculture system with 12-acre water area.

Item	Unit	Quantity	Price per unit ($)	Total cost ($)	Useful life (years)	Salvage value (%)	Annual cost ($)
18" low head PTO pump	each	1	6,000	6,000	15	30%	599
3" pump	each	1	2,500	2,500	8	30%	350
6" pump, 20 kW electric	each	1	15,000	15,000	20	30%	1,337
Aeration kit (regulator, hose, nozzle)	each	1	210	210	10	25%	26
Conex reefer*	each	1	25,000	25,000	15	40%	2,398
Electric aerators	each	6	3,000	18,000	10	0%	2,592
Electrical installation and equipment	each	1	6,000	6,000	30	5%	493
Emergency PTO aerator	each	1	4,000	4,000	25	5%	348
Feed bin	each	1	6,250	6,250	15	10%	673
Finish mower	each	1	7,000	7,000	10	25%	883
Fish baskets*	pack (5)	2	207	414	5	0%	51
Fish feeder	each	1	5,500	5,500	10	20%	713
Fish transport trailer	each	1	35,000	35,000	12	25%	3,983
Flat deck trailer	each	1	6,000	6,000	15	40%	576
Fuel tank	each	1	1,500	1,500	20	40%	130
Hand tools	each	1	1,000	1,000	10	40%	115
Handheld power tools	each	1	1,200	1,200	10	25%	151
Jon boat	each	1	1,200	1,200	15	40%	115
Office equipment	each	1	2,500	2,500	7	20%	411
Oxygen cylinder (125 cubic feet)	each	2	196	392	10	50%	42
Pickup	each	1	35,000	35,000	10	25%	4,415
Pond construction	acre	15	4,000	60,000	30	50%	4,654
Seine nets	each	2	750	1,500	10	10%	205
Shed (¼ office space)	each	1	40,000	40,000	30	20%	3,224
Shop tools and equipment	each	1	5,000	5,000	20	40%	434
Storage container	each	2	4,000	8,000	30	10%	653
Trolling motor	each	1	400	400	10	0%	58
Undeveloped land	acre	20	5,000	100,000	30	100%	7,250
Used 75 hp tractor	each	1	15,000	15,000	15	25%	1,527
Water well and line installation	each	1	15,000	15,000	30	0%	1,239
Total – stocking market models			**399,151**				**29,947**
Total – food market models			**423,964**				**32,327**

* Only used in food market models.

1.3 Channel catfish model (food market)

Channel catfish (*Ictalurus punctatus*) is the most popular warm-water species grown in the U.S. and is present in most rivers, ponds and lakes across the country. Optimal growth occurs under temperatures between 80°F and 85°F — but the fish tolerates temperatures between 45°F and 95°F — and low oxygen levels.

This model assumes that advanced fingerlings (4 to 5 inches) are stocked in ponds between April and May, and they reach market size of 1.8 pounds 12 months later. The marketing goal is to supply fresh whole fish across the Midwest. Key inputs and values used in this production system are shown in Exhibit 1.3.1.

Exhibit 1.3.1. Inputs used for channel catfish production budget (food market).

Item	Unit	Value
Stocking density	fingerlings/acre	3,750
Months to stocker harvest	months	12
Feed (catfish 32% floating, 5/32" pellet)	$/ton	688
Feed conversion ratio	lb. feed/lb. fish produced	2.2
Total fertilizer	lb./acre	0
Total hours electric aeration/ac/cycle	hours	1,000
Hired labor	hours/year	1,250
Survival (fry, commercial)	%	70%
Pond depth	feet	8
Fingerlings (3"–5")	$/fish	0.5
Fingerlings (3"–5")	lb./fish	0.1
Market price	$/lb.	6
Sale weight	lb./fish	1.8
Average delivery weight	lb.	750
Average miles driven per delivery	miles	150
Oxygen cylinders	refills/acre	0
Marketing expenses	% of sales	10%

Exhibit 1.3.2 presents an NCR catfish production budget with revenue and cost expectations. Net annual revenue is estimated at $314,685, after deducting the costs of delivering fish to markets. Variable costs include feed, fingerlings, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance, depreciation, interest, marketing and legal/accounting expenses. After deducting total costs of $192,548, the net return to the operation would be $122,137, or $2.15 per fish sold.

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as bird depredation and natural mortality. A sensitivity analysis of the break-even price as a function of survival is presented in Exhibit 1.3.3. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 35% survival is needed to achieve a break-even price of $5.73 per pound.

Exhibit 1.3.2. Channel catfish production budget in 12-acre pond culture (food market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/acre	$/lb.
Revenue						
Fish sales	$/lb.	6	56,700	340,200	28,350	6.00
Delivery to buyers/market	$/mile	1.50	17,010	25,515	2,126	0.45
Net revenue				**314,685**	**26,224**	**5.55**
Variable costs						
Feed	tons	688	64.85	44,616	3,718	0.79
Fry	fish		45,000	22,500	1,875	0.40
Aquatic organism control				1,800	150	0.03
Veterinary and medicine				6,804	567	0.12
Water treatments				1,154	96	0.02
Repair and maintenance				7,401	617	0.13
Fuel and electricity				12,288	1,024	0.22
Aeration	kWh	0.15	26,845.2	4,026.78	335.57	0.07
Water pumping	kWh	0.15	26,304	3,945.60	328.80	0.07
Truck and machinery fuel	gallons	3.50	600	2,100	175	0.04
Other electricity consumption				2,216	184.67	0.04
Hired labor				23,125	1,927	0.41
Supplies				2,400	200	0.04
Marketing	% of sales	10%	340,200	34,020	2,835	0.60
Interest on operating capital	annual % rate	7.3%		2,829	236	0.05
Total variable costs				**158,937**	**13,245**	**3.02**
Fixed costs						
Farm insurance	total			2,165	180	0.04
Legal/accounting	total			1,500	125	0.03
Capital recovery on real estate and equipment		7.3%		29,947	2,496	0.53
Total fixed costs				**33,612**	**2,801**	**0.59**
Total cost				**192,548**	**16,046**	**3.40**
Return to operator labor and management				**122,137**	**10,178**	**2.15**

Exhibit 1.3.3. Sensitivity analysis for channel catfish production (food market).

Survival (%)	Break-even price ($/lb.)	Survival (%)	Break-even price ($/lb.)	Survival (%)	Break-even price ($/lb.)
10.0%	17.39	37.5%	5.42	65.0%	3.58
12.5%	14.13	40.0%	5.15	67.5%	3.48
15.0%	11.95	42.5%	4.91	70.0%	3.40
17.5%	10.39	45.0%	4.69	72.5%	3.32
20.0%	9.23	47.5%	4.50	75.0%	3.24
22.5%	8.32	50.0%	4.33	77.5%	3.17
25.0%	7.60	52.5%	4.17	80.0%	3.10
27.5%	7.00	55.0%	4.03	82.5%	3.04
30.0%	6.51	57.5%	3.90	85.0%	2.98
32.5%	6.09	60.0%	3.78	87.5%	2.93
35.0%	5.73	62.5%	3.68	90.0%	2.88

1.4 Hybrid striped bass model (food market)

Hybrid striped bass is a cross between white bass (*Morone chrysops*) and striped bass (*Morone saxatilis*). It is a popular sportfish found in many large reservoirs in the U.S. Its optimal growth occurs within a temperature range of 77°F to 80.6°F, but it can survive in a wide range of environmental conditions and temperatures ranging from 39.2°F to 91.4°F.

Exhibit 1.4.1. Inputs used for hybrid striped bass production budget for a 12-acre farm serving the food market.

Item	Unit	Nursery	Grow-out
Stocking rate	fish/acre	13,400	3,200
Months stocked	months	6	12
Feed conversion rate	lb. feed/lb. fish produced	2.40	2.40
Feed cost	$/ton	2,000	1,800
Total fertilizer	lb./acre	0	0
Total hours electric aeration/ac/cycle	hours	1,000	1,500
Hired labor	hours/year	1,000	1,500
Survival	%	85%	80%
Final weight	lb.	0.22	2.50
Pond depth	feet	10	10
Fingerling prices	$/fish	0.385	1.75
Sale price	nursery ($/fish), grow-out ($/lb.)	1.75	9
Oxygen	refills/acre	3	0
Refrigeration operating costs	$/year		500
Average delivery weight	lb.	250	2,000
Average miles driven per delivery	miles	150	500
Marketing expenses	% of sales	5%	10%

This model assumes that 2-inch fingerlings are stocked in 2.31 acres of nursery pond between June and August for six months, until they reach 6 inches. They are then transferred to 9.69 acres of grow-out ponds where they grow for 12 more months until reaching the market size of 2.5 pounds. The marketing goal is to supply fresh whole fish to food markets across the Midwest during late fall. Nursery ponds will remain empty for six months between late fall and the next spring. Exhibit 1.4.1 shows key inputs and values used in this production system.

Exhibits 1.4.2 and 1.4.3 present an NCR hybrid striped bass production budget with revenue and cost expectations per acre for nursery ponds and grow-out ponds, and for the whole operation (2.31 acres of nursery + 9.69 acres of grow-out ponds). Estimates per acre for nursery and grow-out ponds (Exhibit 1.4.2) assume that fingerlings would be bought for stocking at the market price and sold at the market price. For nursery ponds, net annual revenue is estimated at $17,673 per acre. After deducting total costs of $16,805, the net return to the operation would be $868 per acre, or $0.08 per fish sold. For grow-out ponds, net annual revenue is estimated at $55,200 per acre. After deducting total costs of $35,102, the net return to the operation would be $20,098 per acre, or $3.13 per pound sold.

The estimates for the entire operation include 2.31 acres of nursery and 9.69 acres of grow-out ponds (Exhibit 1.4.3). Economies result from the operation raising its own fingerlings — from 2 inches to 6 inches — for stocking the grow-out ponds at a cost lower than the market price. The total net revenue is $534,708 for 12 acres, after deducting fish delivery costs. Variable costs include 2-inch fingerlings to be stocked in the nursery ponds, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance,

Exhibit 1.4.2. Hybrid striped bass production budget in 12-acre pond culture (food market), by stage.

		Nursery (per acre)				Grow-out (per acre)			
Item	**Unit**	**$/unit**	**Quantity**	**Total ($)**	**$/fish**	**$/unit**	**Quantity**	**Total ($)**	**$/lb.**
Revenue									
Fish sales	fish (nursery), lb. (grow-out and integrated op.)	1.75	11,390	19,933	1.75	9	6,400	57,600	9.00
Delivery to buyers/market	$/mile	1.50	1,507	2,260	0.20	1.50	1,600	2,400	0.38
Net revenue				**17,673**	**1.55**			**55,200**	**8.63**
Variable costs									
Feed	tons	2,000	2.97	5,950	0.52	1,800	7.15	12,864	2.01
Stocked fish (fingerlings, juveniles)	fish	0.385	13,400	5,159	0.45	1.75	3,200	5,600	0.88
Aquatic organism control				150	0.01			150	0.02
Fertilizer	lb.	0.40	0	0	0.00	0.40	0	0.00	0.00
Veterinary and medicine				399	0.04			1,152	0.18
Water treatments				96	0.01			96.13	0.02
Repair and maintenance				272	0.02			1,757.66	0.27
Fuel and electricity				953	0.10			1,275	0.11
Aeration (electric consumption)	kWh	0.15	2,242.5	336.38	0.03	0.15	3,363.75	504.56	0.08
Water pumping	kWh	0.15	2,740	411	0.04	0.15	2,740	411	0.06
Truck and machinery fuel	gallons	3.50	25	87.50	0.01	3.50	50	175	0.03
Non-aeration and fee (electricity consumption)				118	0.01			184.67	0.03
Oxygen refill		50	3	150	0.01	50	0	0.00	0.00
Refrigeration operating costs		0	0	0	0.00			51.62	0.01
Hired labor	hours/year/acre			771	0.07			2,312.50	0.36
Supplies				100	0.01			200	0.02
Marketing		5%	17,673	884	0.08	10%	55,200	5,520	0.86
Interest on operating capital	% annual rate	7.3%		270	0.03	7.3%		1,123	0.18
Total variable costs				**15,152**	**1.33**			**32,103**	**5.02**
Fixed costs									
Farm insurance	total			180	0.02			180	0.03
Legal/accounting	total			125	0.01			125	0.02
Capital recovery on real estate and equipment		7.3%		1,347	0.12	7.3%		2,694	0.42
Total fixed costs				**1,652**	**0.15**			**2,999**	**0.47**
Total cost				**16,805**	**1.48**			**35,102**	**5.48**
Return to operator labor and management				**868**	**0.08**			**20,098**	**3.14**

depreciation, interest and legal/accounting expenses. After deducting total costs of $326,233, the net return to the operation would be $208,842, or $3.37 per pound sold.

Exhibit 1.4.3. Hybrid striped bass production budget in 12-acre pond culture (food market), whole operation.

Item	Unit	Nursery (2.31 acres) ($)	Grow-out (9.69 acres) ($)	Integrated operation (12 acres) ($)
Revenue				
Fish value	fish (nursery), lb. (grow-out and integrated op.)		557,957	557,957
Delivery to buyers/market	$/mile		23,248	23,248
Net revenue			**534,708**	**534,708**
Variable costs				
Feed	tons	13,763	124,614	138,377
Stocked fish (fingerlings, juveniles)	fish	11,934		11,934
Aquatic organism control		347	1,453	1,800
Veterinary and medicine		922	11,159	12,081
Water treatments		222	931	1,154
Repair and maintenance		629	17,026	17,655
Fuel and electricity		2,551	12,353	14,557
Aeration (electric consumption)	kWh	778	4,888	5,666
Water pumping	kWh	951	3,981	4,932
Truck and machinery fuel	gallons	202	1,695	1,898
Non-aeration and fee (electricity consumption)		273	1,789	2,062
Oxygen refill			0	
Refrigeration operating costs		0	500	500
Hired labor	hours/year/acre	1,783	22,401	24,184
Supplies		231	1,937	2,169
Marketing		0	53,471	53,471
Interest on operating capital	% annual rate			15,110
Total variable costs		**32,036**	**245,845**	**292,991**
Fixed costs				
Farm insurance	total	417	1,748	2,165
Legal/accounting	total	289	1,211	1,500
Capital recovery on real estate and equipment		3,116	26,095	29,211
Total fixed costs		**3,822**	**29,053**	**32,876**
Total cost		**38,874**	**340,023**	**325,867**
Return to operator labor and management				**208,842**

Observation: The Nursery and Grow-out columns present cost estimates for each stage of an integrated operation, where fish are raised from fingerlings to market size. These figures do not include interest on operating costs. The Integrated Operation column presents cost and revenue estimates for a full production cycle, including all expenses associated with utilizing the 12 acres to develop both stages.

The aquaculture business must be financially resilient in the short term, particularly to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival for the nursery and grow-out stages is presented in Exhibit 1.4.4. It demonstrates that proper pond management is essential for reaching competitive

break-even prices. For instance, at least 70% survival is needed to achieve a break-even price of $1.71 per 6-inch fish and 52.5% to reach a break-even price of $7.31 per pound of market-sized fish produced.

Exhibit 1.4.4. Sensitivity analysis for hybrid striped bass (food market).

Survival over the phase (nursery or grow-out) (%)	Break-even price: Nursery ($/fish)	Break-even price: Grow-out ($/lb.)	Survival over the phase (nursery or grow-out) (%)	Break-even price: Nursery ($/fish)	Break-even price: Grow-out ($/lb.)
10.0%	9.86	29.83	52.5%	2.17	7.31
12.5%	7.96	24.26	55.0%	2.09	7.06
15.0%	6.70	20.55	57.5%	2.01	6.84
17.5%	5.79	17.90	60.0%	1.94	6.64
20.0%	5.11	15.92	62.5%	1.88	6.46
22.5%	4.58	14.37	65.0%	1.82	6.29
25.0%	4.16	13.13	67.5%	1.77	6.13
27.5%	3.82	12.12	70.0%	1.72	5.98
30.0%	3.53	11.28	72.5%	1.67	5.84
32.5%	3.28	10.57	75.0%	1.63	5.72
35.0%	3.07	9.96	77.5%	1.59	5.60
40.0%	2.74	8.96	80.0%	1.55	5.48
42.5%	2.60	8.55	82.5%	1.51	5.38
45.0%	2.47	8.19	85.0%	1.48	5.28
47.5%	2.36	7.86	87.5%	1.45	5.19
50.0%	2.26	7.57	90.0%	1.42	5.10

1.5 Yellow perch model (food market)

Yellow perch (*Perca flavescens*) is a cold-water fish popular in the Great Lakes of the North Central region of the U.S. Conditions for yellow perch production in the North Central region vary across states. It is a species sensitive to higher temperatures, and lethal upper temperatures have been reported to range from 79°F to 86°F. Consequently, states in the northern part of the NCR are more suitable for this species.

This model assumes that fingerlings (2 to 4 inches) are stocked in ponds between April and June, and they reach market size of 0.33 pounds 10 to 12 months later. The marketing

Exhibit 1.5.1. Inputs used for yellow perch production budget (food market).

Item	Unit	Value
Stocking density	fish/acre	10,000
Months to food fish harvest	months	12
Feed conversion ratio	lb. feed/lb. fish produced	1.85
Feed (catfish 32 floating, 5/32" pellet)	$/ton	1,058
Total fertilizer	lb./acre	140
Total hours electric aeration/ac/cycle	hours	1,000
Hired labor	hours/year	700
Refrigeration operating costs	$/year	500
Survival (fry, commercial)	%	85%
Pond depth	feet	7
Fingerlings (2"–4")	lb./fish	0.02
Fingerling price	$/fish	1
Average delivery weight	lb.	2,000
Average miles driven per delivery	miles	250
Weight at sale size	lb./fish	0.33
Price of fish at sale (whole fish)	$/lb.	9

goal is to supply fresh whole fish during early spring. Key inputs and values used in this production system are shown in Exhibit 1.5.1.

Exhibit 1.5.2 presents an NCR yellow perch production budget with revenue and cost expectations. Net annual revenue is estimated at $293,473, after deducting the costs of delivering fish to markets. Variable costs include feed, fingerlings, fuel or electricity, marketing, refrigeration, hired labor and other expenses. Fixed costs include insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $266,105, the net return to the operation would be $27,368, or $0.81 per fish sold.

Exhibit 1.5.2. Yellow perch production budget in 12-acre pond culture (food market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/acre	$/lb.
Revenue						
Fish sales	$/lb.	9	33,660	302,940	25,245	9.00
Delivery to buyers/market	$/mile	1.50	6,311	9,467	789	0.28
Net revenue				**293,473**	**24,456**	**8.72**
Variable costs						
Feed	tons	1,058.21	29.17	30,865	2,572	0.92
Fry	fish		120,000	120,000	10,000	3.57
Aquatic organism control				1,800	150	0.05
Fertilizer	lb.	0.40	1,680	672	56	0.35
Veterinary and medicine				6,059	505	0.18
Water treatments				1,154	96	0.03
Repair and maintenance				7,401	617	0.22
Fuel and electricity				11,795	983	
Aeration	kWh	0.15	26,845.2	4,026.78	335.57	0.12
Water pumping	kWh	0.15	23016	3,452.40	287.70	0.10
Truck and machinery fuel	gallons	3.50	600	2,100	175	0.06
Other electricity consumption				2,216	184.67	0.07
Refrigeration operating costs				500	41.67	0.01
Hired labor			700	12,950	1,079	0.38
Supplies				2,400	200	0.07
Marketing	% of sales	10%	302,940	30,294	2,525	0.90
Interest on operating capital	% annual rate	7.3%		4,094	341	0.12
Total variable costs				**229,984**	**19,165**	**6.83**
Fixed costs						
Farm insurance	total			2,295	191	0.07
Legal/accounting	total			1,500	125	0.04
Capital recovery on real estate and equipment		7.3%		32,327	2,694	0.96
Total fixed costs				**36,121**	**3,010**	**1.07**
Total cost				**266,105**	**22,175**	**7.91**
Return to operator labor and management				**27,368**	**2,281**	**0.81**

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A

sensitivity analysis of the break-even price as a function of survival is presented in Exhibit 1.5.3. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 77.5% survival is needed to achieve a break-even price of $8.93 per pound.

Exhibit 1.5.3. Sensitivity analysis for yellow perch production (food market).

Survival (%)	Break-even price ($/lb.)	Survival (%)	Break-even price ($/lb.)	Survival (%)	Break-even price ($/lb.)
10.0%	55.73	37.5%	15.98	65.0%	9.87
12.5%	44.89	40.0%	15.08	67.5%	9.56
15.0%	37.67	42.5%	14.28	70.0%	9.27
17.5%	32.50	45.0%	13.57	72.5%	9.01
20.0%	28.63	47.5%	12.94	75.0%	8.76
22.5%	25.62	50.0%	12.37	77.5%	8.52
25.0%	23.21	52.5%	11.85	80.0%	8.30
27.5%	21.24	55.0%	11.38	82.5%	8.10
30.0%	19.60	57.5%	10.96	85.0%	7.91
32.5%	18.21	60.0%	10.56	87.5%	7.72
35.0%	17.02	62.5%	10.20	90.0%	7.55

1.6 Bluegill model (stocking market)

Bluegills (*Lepomis macrochirus*) are small-bodied fish popular for stocking ponds in the North Central region. The production system for pond stocker bluegill begins with filling ponds in March. This stocking begins a six-month cycle, ending in mid-September, as bluegills grow from 2-inch fingerlings to 4.5-inch stocker fish weighing about one-fifth of a pound. The marketing goal is to supply fall pond stocking fish across the Midwest. The ponds then remain empty until the next March production cycle. Key inputs and values used in this production system are shown in Exhibit 1.6.1.

Exhibit 1.6.1. Inputs used for bluegill production budget (recreational stocking market).

Item	Unit	Value
Stocking density	fingerlings/acre	15,000
Months to stocker harvest	months	8
Feed conversion ratio	lb. feed/lb. fish produced	2
Feed (40/10 g, 3 mm floating pellet)	$/ton	2,254.70
Total fertilizer	lb./acre	140
Total hours electric aeration/ac/cycle	hours	1,200
Hired labor	hours/year	700
Survival (fry, commercial)	%	75%
Pond depth (feet)	feet	7
Fry (1"–3") price	$/fish	0.55
Fry (1"–3") weight	lb./fish	0.003
Market fish (4"–5") price	$/fish	1.95
Market fish (4"–5") weight	lb./fish	0.1
Average delivery weight	lb.	750
Average miles driven per delivery	miles	250
Oxygen cylinders	refills/year	4.5

Exhibit 1.6.2 presents an NCR bluegill production budget with revenue and cost expectations. Net annual revenue is estimated at $253,125, after deducting the costs of delivering fish to markets. Variable costs include feed, fingerlings, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance, depreciation, interest and legal/accounting

expenses. After total costs of $222.951, the net return to the operation would be $30,174, or $0.22 per fish sold.

Exhibit 1.6.2. Bluegill production budget in 12-acre pond culture (recreational stocking market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/acre	$/fish
Revenue						
Fish sales	$/fish	1.95	135,000	263,250	21,938	1.95
Delivery to buyers/market	$/mile	1.50	6,750	10,125	844	0.08
Net revenue				**253,125**	**21,094**	**1.88**
Variable costs						
Feed	tons	2,254.70	13.86	31,249	2,604	0.23
Fingerlings	fish	0.55	180,000	99,000	8,250	0.73
Aquatic organism control				1,800	150	0.01
Fertilizer	lb.	0.40	1,680	672	56	
Veterinary and medicine				5,265	439	0.04
Water treatments				1,154	96	0.01
Repair and maintenance				7,401	617	0.05
Fuel and electricity				12,601	1,050	0.09
Aeration	kWh	0.15	32,214.24	4,832.14	402.68	0.04
Water pumping	kWh	0.15	23016	3,452.40	287.70	0.03
Truck and machinery fuel	gallons	3.50	600	2,100	175	0.02
Other electricity consumption				2,216	184.67	0.02
Oxygen refill		50	4.5	225	18.75	0.00
Hired labor				12,950	1,079	0.10
Supplies				1,600	133	0.01
Marketing	% of sales	10%	263,250	13,163	1,097	0.10
Interest on operating capital	% annual rate	7.3%		2,261	188	0.02
Total variable costs				**189,340**	**15,778**	**1.40**
Fixed costs						
Farm insurance	total			2,165	180	0.02
Legal/accounting	total			1,500	125	0.01
Capital recovery on real estate and equipment		7.3%		29,947	2,496	0.22
Total fixed costs				**33,612**	**2,801**	**0.25**
Total cost				**222,951**	**18,579**	**1.65**
Return to operator labor and management				**30,174**	**2,514**	**0.22**

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival is presented in Exhibit 1.6.3. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 62.5% survival is needed to achieve a break-even price of $1.93 per fish.

Exhibit 1.6.3. Sensitivity analysis for bluegill production (recreational stocking market).

Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)
10.0%	10.84	37.5%	3.06	65.0%	1.87
12.5%	8.72	40.0%	2.89	67.5%	1.81
15.0%	7.30	42.5%	2.73	70.0%	1.75
17.5%	6.29	45.0%	2.59	72.5%	1.70
20.0%	5.54	47.5%	2.47	75.0%	1.65
22.5%	4.95	50.0%	2.36	77.5%	1.61
25.0%	4.48	52.5%	2.26	80.0%	1.56
27.5%	4.09	55.0%	2.17	82.5%	1.52
30.0%	3.77	57.5%	2.08	85.0%	1.49
32.5%	3.50	60.0%	2.00	87.5%	1.45
35.0%	3.27	62.5%	1.93	90.0%	1.42

1.7 Channel catfish model (stocking market)

States in the northern part of the North Central region present a disadvantage for growing food-sized catfish because it takes three to six months longer to produce a market-sized catfish in these states than in the southern NCR states. Still, there are market opportunities for recreational stocking, which does not require large fish sizes and can be completed in a shorter cycle.

This model assumes that advanced fingerlings (4 to 5 inches) are stocked in ponds early in the spring, and they reach market size of 7.5 to 8.5 inches eight months later. The marketing goal is to supply the fall pond stocking market in the Midwest. Ponds are assumed empty until the next production cycle. Key inputs and values used in this production system are shown in Exhibit 1.7.1.

Exhibit 1.7.1. Inputs used for channel catfish production budget (recreational stocking market).

Item	Unit	Value
Stocking density	fingerlings/acre	15,000
Months to stocker harvest	months	8
Feed (catfish 32 floating, 5/32" pellet)	$/ton	688
Feed conversion ratio	lb. feed/lb. fish produced	2.50
Total fertilizer	lb./acre	0
Total hours electric aeration/ac/cycle	hours	1,000
Hired labor	hours/year	700
Survival (fry, commercial)	%	70%
Pond depth (feet)	feet	8
Advanced fingerlings (3"–5") price	$/fish	0.5
Advanced fingerlings (4"–5") weight	lb./fish	0.10
Market fish (7.5"–8.5") price	$/fish	3
Market fish (7.5"–8.5") weight	lb./fish	0.5
Average delivery weight	lb.	500
Average miles driven per delivery	miles	150
Oxygen cylinders	refills/acre	3
Marketing expenses	% of sales	5%

Exhibit 1.7.2 presents a NCR catfish production budget with revenue and cost expectations. Net annual revenue is estimated at $335,475, after deducting the costs of delivering fish to markets. Variable costs include feed, fingerlings, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance, depreciation,

interest, marketing and legal/accounting expenses. After deducting total costs of $233,198, the net return to the operation would be $102,277, or $0.81 per fish sold.

Exhibit 1.7.2. Channel catfish production budget in 12-acre pond culture (recreational stocking market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/acre	$/lb.
Revenue						
Fish sales	$/fish	3	126,000	378,000	31,500	3.00
Delivery to buyers/market	$/mile	1.50	28,350	42,525	3,544	0.34
Net revenue				**335,475**	**27,956**	**2.66**
Variable costs						
Feed	tons	688	69.36	47,717	3,976	0.38
Fry	fish		180,000	90,000	7,500	0.71
Aquatic organism control				1,800	150	0.01
Veterinary and medicine				7,560	630	0.06
Water treatments				1,154	96	0.01
Repair and maintenance				7,401	617	0.06
Fuel and electricity				12,288	1,024	0.10
Aeration	kWh	0.15	2,6845.2	4,026.78	335.57	0.03
Water pumping	kWh	0.15	26,304	3,945.60	328.80	0.03
Truck and machinery fuel	gallons	3.50	600	2,100	175	0.02
Other electricity consumption				2,216	184.67	0.02
Oxygen refill		50	3	150	12.5	0.00
Hired labor				8,633	719	0.07
Supplies				1,600	133	0.01
Marketing	% of sales	5%	378,000	18,900	1,575	0.15
Interest on operating capital	% annual rate	7.3%		2,383	199	0.02
Total variable costs				**199,586**	**16,632**	**1.58**
Fixed costs						
Farm insurance	total			2,165	180	0.02
Legal/accounting	total			1,500	125	0.01
Capital recovery on real estate and equipment		7.3%		29,947	2,496	0.24
Total fixed costs				**33,612**	**2,801**	**0.27**
Total cost				**233,198**	**19,433**	**1.85**
Return to operator labor and management				**102,277**	**8,523**	**0.81**

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival is presented in Exhibit 1.7.3. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 42.5% survival is needed to achieve a break-even price of $3 per fish.

Exhibit 1.7.3. Sensitivity analysis for channel catfish production (recreational stocking market).

Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)
10.0%	10.73	37.5%	3.13	65.0%	1.96
12.5%	8.66	40.0%	2.96	67.5%	1.91
15.0%	7.28	42.5%	2.81	70.0%	1.85
17.5%	6.29	45.0%	2.67	72.5%	1.80
20.0%	5.55	47.5%	2.55	75.0%	1.75
22.5%	4.98	50.0%	2.44	77.5%	1.71
25.0%	4.52	52.5%	2.34	80.0%	1.67
27.5%	4.14	55.0%	2.25	82.5%	1.63
30.0%	3.82	57.5%	2.17	85.0%	1.59
32.5%	3.56	60.0%	2.10	87.5%	1.55
35.0%	3.33	62.5%	2.03	90.0%	1.52

1.8 Golden shiner (baitfish market)

Golden shiner, goldfish and fathead minnows are the three most-raised species for the bait market in the U.S. This baitfish model analyzes the production of golden shiner (*Notemigonus crysoleucas*), leveraging from publications available on this species. Note that the spreadsheet tool created for this model can be easily customized to provide economic analysis of other species.

Exhibit 1.8.1. Inputs used for golden shiner production budget (baitfish).

Item	Unit	Value
Fingerling prices	$/250,000	295
Baitfish sale price	$/lb.	25
Feed (catfish 32 floating, 5/32" pellet)	$/ton	1,058.21
Fish at sale size%	$/lb.	85
Stocking rate	fry/acre	100,000
Survival (fry, commercial)	%	40%
Feed conversion ratio	lb. feed/lb. fish produced	2.75
Pond depth	feet	4
Aeration rate	hp/acre	0.50
Total hours electric aeration/ac/cycle	hours	980
Total fertilizer	lb./acre	140
Hired labor	hours/year	400
Average delivery weight	lb.	500
Average miles driven per delivery	miles	250
Oxygen cylinders	refills/cycle	4.5
Months to stocker harvest	months	18

Golden shiners are native to the eastern U.S., but they currently have a wide range distribution in North America and are also found in Mexico and Canada. The production system assumed in this model starts with stocking golden shiner fries between late April and early May at a density of 250,000 fish per acre. The growth season in the North Central region is shorter than in southern states, so this model assumes an 18-month production cycle with harvest happening between their second summer and fall, and harvest size around 2.5 to 3.5 inches. Key inputs and values used in this production system are shown in Exhibit 1.8.1.

Exhibit 1.8.2 presents a production budget with revenue and cost expectations for this NCR golden shiner budget. Net annual revenue is estimated at $134,824, after deducting costs for delivering fish to buyers. Variable costs include feed, fries, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include farm insurance, depreciation, interest and legal/accounting expenses. After total costs of $119,401, the operation would have a net return of $1,285, or $2.73 per pound sold.

Exhibit 1.8.2. Golden shiner production budget in 12-acre pond culture for an 18-month cycle (baitfish).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/acre	$/lb.
Revenue						
Fish sales	lb.	25	5647.06	141,176	11,765	25.00
Delivery to buyers/market	$/mile	1.50	4,235	6,353	529	1.13
Net revenue				**134,824**	**11,235**	**23.88**
Variable costs						
Feed	tons	1,058.21	7	7,454	621	1.32
Fry	fish		1,200,000	1,416	118	0.25
Aquatic organism control				3,600	300	0.67
Fertilizer	lb.	0.40	1,680	672	56	0.12
Veterinary and medicine				2,824	235	0.50
Water treatments				1,154	96	0.20
Repair and maintenance				13,052	1,088	2.31
Fuel and electricity				9,269	772	1.64
Aeration	kWh	0.15	4,385	658	54.81	0.12
Water pumping	kWh	0.15	7,234	1,085	90.42	0.19
Truck and machinery fuel	gallons	3.50	900	3,150	262.50	0.56
Other electricity consumption				4,376	364.67	0.77
Oxygen refill		50	5	225	18.75	0.04
Hired labor		18.50	600	11,100	925	1.97
Supplies				3,600	300	0.64
Interest on operating capital	% annual rate	7.3%		1,736	145	0.31
Total variable costs				**55,843**	**4,654**	**9.89**
Fixed costs						
Farm insurance	total			2,165	180	0.38
Legal/accounting	total			1,500	125	0.27
Capital recovery on real estate and equipment		7.3%		59,893	4,991	10.61
Total fixed costs				**63,558**	**5,297**	**11.26**
Total cost				**119,401**	**9,950**	**21.14**
Return to operator labor and management				**15,422**	**1,285**	**2.73**

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival is presented in Exhibit 1.8.3. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 38% survival is needed to achieve a break-even price of $25 per pound.

Exhibit 1.8.3. Sensitivity analysis for golden shiner production (baitfish).

Survival (%)	Break-even price ($/lb.)	Survival (%)	Break-even price ($/lb.)	Survival (%)	Break-even price ($/lb.)
10.0%	78.97	37.5%	22.43	65.0%	13.73
12.5%	63.55	40.0%	21.14	67.5%	13.29
15.0%	53.27	42.5%	20.01	70.0%	12.88
17.5%	45.93	45.0%	19.00	72.5%	12.50
20.0%	40.42	47.5%	18.10	75.0%	12.15
22.5%	36.14	50.0%	17.29	77.5%	11.82
25.0%	32.71	52.5%	16.55	80.0%	11.51
27.5%	29.91	55.0%	15.89	82.5%	11.21
30.0%	27.57	57.5%	15.28	85.0%	10.94
32.5%	25.59	60.0%	14.72	87.5%	10.68
35.0%	23.90	62.5%	14.21	90.0%	10.44

1.9 Grass carp model (stocking market)

Grass carps (*Ctenopharyngodon Idella*) are popular herbivorous fish commonly added to ponds for aquatic vegetation control. The production system for grass carp begins with filling ponds in March with fingerlings. Fish will be grown from 3-inch fingerlings to 10-inch stocker fish weighing about six-tenths of a pound, in an eight-month cycle ending in mid-October. The marketing goal is to supply fall pond stocking fish across the Midwest. The ponds will remain empty until the next March production cycle. Exhibit 1.9.1 shows key inputs and values used in this production system.

Exhibit 1.9.1. Inputs used for grass carp production budget (recreational stocking market).

Item	Unit	Value
Stocking density	fingerlings/acre	3,750
Months to stocker harvest	months	9
Total organic fertilizer	tons/acre	12
Organic fertilizer price	$/ton	100
Total hours electric aeration/ac/cycle	hours	1,500
Hired labor	hours/year	750
Survival (fry, commercial)	%	90%
Pond depth	feet	7
Fry price/fish	$/fish	2
Fry weight/fish	lb./fish	0.06
Market fish (8"–11") price/fish	$/fish	8
Market fish (8"–11") weight/fish	lb./fish	0.6
Average delivery weight	lb.	750
Average miles driven per delivery	miles	250
Oxygen cylinders	refills/cycle	4.50

Exhibit 1.9.2 presents a Missouri grass carp production budget with revenue and cost expectations. Net annual revenue is estimated at $305,591, after deducting the costs of delivering fish to markets. Variable costs include pond fertilizer, fingerlings, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $219,447, the net return to the operation would be $86,144, or $2.13 per fish sold.

Exhibit 1.9.2. Grass carp production budget in 12-acre pond culture (recreational stocking market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/acre	$/fish
Revenue						
Fish sales	$/fish	8	40,500	324,000	27,000	8.00
Delivery to buyers/market	$/mile	1.50	12,273	18,409	1,534	0.45
Net revenue				**305,591**	**25,466**	**7.55**
Variable costs						
Fry	fish		45,000	90,000	7,500	2.22
Aquatic organism control				1,800	150	0.04
Organic pond fertilizer	tons	100	144	14,400	1,200	0.36
Veterinary and medicine				6,480	540	0.16
Water treatments				1,154	96	0.03
Repair and maintenance				7,401	617	0.18
Fuel and electricity				13,809	1,151	0.34
Aeration	kWh	0.15	40,267.8	6,040.17	503.35	0.15
Water pumping	kWh	0.15	23,016	3,452.40	287.70	0.09
Truck and machinery fuel	gallons	3.50	600	2,100	175	0.05
Other electricity consumption				2,216	184.67	0.05
Oxygen refill		50	4.50	225	18.75	0.01
Hired labor			750	13,875	1,156	0.34
Supplies				1,800	150	0.04
Marketing	% of sales	10%	324,000	32,400	2,700	0.80
Interest on operating capital	% annual rate	7.3%		2,492	208	0.06
Total variable costs				**185,835**	**15,486**	**4.59**
Fixed costs						
Farm insurance	total			2,165	180	0.05
Legal/accounting	total			1,500	125	0.04
Capital recovery on real estate and equipment		7.3%		29,947	2,496	0.74
Total fixed costs				**33,612**	**2,801**	**0.83**
Total cost				**219,447**	**18,287**	**5.42**
Return to operator labor and management				**86,144**	**7,179**	**2.13**

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival is presented in Exhibit 1.9.3. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 62.5% survival is needed to achieve a break-even price of $7.88 per fish.

Exhibit 1.9.3. Sensitivity analysis for grass carp production (recreational stocking market).

Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)
10.0%	40.98	37.5%	11.64	65.0%	7.13
12.5%	32.98	40.0%	10.98	67.5%	6.90
15.0%	27.65	42.5%	10.39	70.0%	6.69
17.5%	23.84	45.0%	9.86	72.5%	6.49
20.0%	20.98	47.5%	9.40	75.0%	6.31
22.5%	18.75	50.0%	8.97	77.5%	6.14
25.0%	16.98	52.5%	8.59	80.0%	5.97
27.5%	15.52	55.0%	8.25	82.5%	5.82
30.0%	14.31	57.5%	7.93	85.0%	5.68
32.5%	13.28	60.0%	7.64	87.5%	5.55
35.0%	12.40	62.5%	7.37	90.0%	5.42

1.10 Hybrid striped bass model (stocking market)

This model assumes that 2-inch hybrid striped bass fingerlings are stocked in 2.76 acres of nursery ponds between June and August and grown for six months, until they reach 6 inches. They are then transferred to 9.24 acres of grow-out ponds where they grow for five more months until reaching the market size of 11 inches. The marketing goal is to supply pond stocking fish across the Midwest during summer. Exhibit 1.10.1 shows key inputs and values used in this production system.

Exhibit 1.10.1. Inputs used for hybrid striped bass production budget (recreational stocking market).

Item	Unit	Value	Grow-out
Stocking rate	fish/acre	13,400	4,000
Months stocked	months	6	5
Feed conversion ratio	lb. feed/lb. fish produced	2.40	2.40
Feed cost	$/ton	2,000	1,800
Total hours electric aeration/ac/cycle	hours	1,000	500
Hired labor	hours/year	1,000	1,000
Survival	%	85%	80%
Final weight	lb.	0.22	0.80
Pond depth	feet	10	10
Fingerling prices	$/fish	0.385	1.75
Sale price	$/fish	1.75	14
Oxygen	refills/acre	3	3
Average delivery weight	lb.	250	500
Average miles driven per delivery	miles	150	150
Marketing expenses	% of sales	5%	5%

Exhibits 1.10.2 and 1.10.3 present an NCR hybrid striped bass production budget with revenue and cost expectations per acre for nursery ponds and grow-out ponds, and for the whole operation (2.76 acres of nursery + 9.24 acres of grow-out ponds). Estimates per acre for nursery and grow-out ponds (Exhibit 1.10.2) assume that fingerlings would be bought for stocking and later sold at market prices. For nursery ponds, net annual revenue is estimated at $17,673 per acre. After deducting total costs of $16,706, the net return to the operation would be $967 per acre, or $0.08 per fish sold. For grow-out ponds, net annual revenue is estimated at $24,448 per acre. After deducting total costs of $17,405, the net return to the operation would be $7,043 per acre, or $2.20 per fish sold.

Exhibit 1.10.2. Hybrid striped bass production budget in 12-acre pond culture (recreational stocking market), by stage.

		Nursery, per acre				Grow-out, per acre			
Item	**Unit**	**$/unit**	**Quantity**	**Total ($)**	**$/fish**	**$/unit**	**Quantity**	**Total ($)**	**$/fish**
Revenue									
Fish sales	fish	1.75	11,390	19,933	1.75	8	3,200	25,600	8.00
Delivery to buyers/market	$/mile	1.50	1,507	2,260	0.20	1.50	768	1,152	0.36
Net revenue				**17,673**	**1.55**			**24,448**	**7.64**
Variable costs									
Feed	tons	2000	2.97	5,950	0.52	1,800	2.27	4,088	1.28
Stocked fish (fingerlings, juveniles)	fish	0.385	13,400	5,159	0.45	1.75	4,000	7,000	2.19
Aquatic organism control				150	0.01			150	0.05
Fertilizer	lb.	0.40	0	-		0.40	-	-	-
Veterinary and medicine				399	0.04			512	0.16
Water treatments				96	0.01			96.13	0.03
Repair and maintenance				272	0.02			226.60	0.07
Fuel and electricity				953	0.08			750	0.23
Aeration (electric consumption)	kWh	0.15	2242.5	336.38	0.03	0.15	1,121.25	168.19	0.05
Water pumping	kWh	0.15	2740.0	411	0.04	0.15	2,740	411	0.13
Truck and machinery fuel	gallons	3.50	25	87.50	0.01	3.50	20.83	72.92	0.02
Non-aeration and fee (electricity consumption)				118	0.01			98.33	0.02
Oxygen refill		50	3	150	0.01	50	3	150	0.05
Hired labor	hours/year/acre		83	771	0.07		83	1,541.67	0.48
Supplies				100	0.01			83.33	0.01
Marketing		0.05	17,673	884	0.08	0.05	24,448	1,222.40	0.38
Interest on operating capital	% annual rate	7.3%		270	0.02	7.3%		239	0.08
Total variable costs				**15,152**	**1.33**			**16,060**	**5.02**
Fixed costs									
Farm insurance	total			180	0.02			180	0.06
Legal/accounting	total			125	0.01			125	0.04
Capital recovery on real estate and equipment		7.3%		1,248	0.11	7.3%		1,040	0.32
Total fixed costs				**1,553**	**0.14**			**1,345**	**0.42**
Total cost				**16,706**	**1.47**			**17,405**	**5.44**
Return to operator labor and management				**967**	**0.08**			**7,043**	**2.20**

Exhibit 1.10.3. Hybrid striped bass production budget in 12-acre pond culture (recreational stocking market), whole operation.

Item	Unit	Nursery (2.76 acres) ($)	Grow-out (9.24 acres) ($)	Integrated operation (12 acres) ($)
Revenue				
Fish sales	fish	54,986	236,579	236,579
Delivery to buyers/market	$/mile		10,646	10,646
Net revenue		**48,752**	**225,933**	**225,933**
Variable costs				
Feed	tons	16,413	37,781	54,193
Stocked fish (fingerlings, juveniles)	fish	14,232	0	14,232
Aquatic organism control		414	1,386	1,800
Veterinary and medicine		1,100	4,732	5,831
Water treatments		265	888	1,154
Repair and maintenance		750	2,094	2,844
Fuel and electricity		2,629	6,935	9,564
Aeration (electric consumption)	kWh	928	1,554	2,482
Water pumping	kWh	1,134	3,798	4,932
Truck and machinery fuel	gallons	241	674	915
Non aeration and fee (electricity consumption)		326	909	1,234
Oxygen refill			1,386	1,386
Hired labor	hours/year/acre	2,126	14,247	16,374
Supplies		276	770	1,046
Marketing			11,297	11,297
Interest on operating capital	% annual rate			3,978
Total variable costs		**38,204**	**81,516**	**123,699**
Fixed costs				
Farm insurance	total	498	1,667	2,165
Legal/accounting	total	345	1,155	1,500
Capital recovery on real estate and equipment		3,442	9,609	13,051
Total fixed costs		**4,285**	**12,432**	**16,716**
Total cost		**42,489**	**93,948**	**140,415**
Return to operator labor and management				**85,518**

Observation: The Nursery and Grow-out columns present cost estimates for each stage of an integrated operation, where fish are raised from fingerlings to market size. These figures do not include interest on operating costs. The Integrated Operation column presents cost and revenue estimates for a full production cycle, including all expenses associated with utilizing the 12 acres to develop both stages.

The estimates for the entire operation — comprising 2.76 acres of nursery and 9.24 acres of grow-out ponds (Exhibit 1.10.3) — account for the economies achieved by raising fingerlings in-house. By growing fingerlings from 2 to 6 inches before stocking them in grow-out ponds, the operation reduces input costs compared to purchasing fingerlings at market price. As a result, the operation generates a total net revenue of $225,933 per 12 acres, after deducting fish delivery costs to market. Variable costs include 2-inch fingerlings to be stocked in the nursery ponds, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance, depreciation, interest and legal/

accounting expenses. After deducting total costs of $140,415, the net return to the operation would be $85,518, or $2.89 per fish sold.

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival for the nursery and grow-out stages is presented in Exhibit 1.10.4. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 70% survival is needed to achieve a break-even price of $1.70 per 6-inch fish and 52.5% to reach a break-even price of $7.70 per 11-inch fish.

Exhibit 1.10.5. Sensitivity analysis for hybrid striped bass (recreational stocking market).

Survival over the phase (nursery or grow-out)	Break-even price: Nursery ($/fish)	Break-even price: Grow-out ($/fish)
10.0%	9.77	35.63
12.5%	7.89	28.73
15.0%	6.64	24.13
17.5%	5.74	20.84
20.0%	5.07	18.38
22.5%	4.54	16.46
25.0%	4.13	14.93
27.5%	3.78	13.67
30.0%	3.50	12.63
32.5%	3.26	11.74
35.0%	3.05	10.98
37.5%	2.87	10.33
40.0%	2.71	9.75
42.5%	2.57	9.24
45.0%	2.45	8.79
47.5%	2.34	8.39
50.0%	2.24	8.03
52.5%	2.15	7.70
55.0%	2.07	7.41
57.5%	2.00	7.13
60.0%	1.93	6.88
62.5%	1.87	6.65
65.0%	1.81	6.44
67.5%	1.76	6.24
70.0%	1.71	6.06
72.5%	1.66	5.89
75.0%	1.62	5.73
77.5%	1.58	5.58
80.0%	1.54	5.44
82.5%	1.50	5.31
85.0%	1.47	5.19
87.5%	1.44	5.07
90.0%	1.41	4.96

1.11 Largemouth bass model (stocking market)

Largemouth bass (*Micropterus salmoides*) is the most popular sportfish in the U.S., being stocked in most ponds and lakes across the country. Originally, this species was naturally found from northern Mexico up to the Great Lakes, extending along the Gulf Coast and southeastern Atlantic, and reaching inland as far as eastern West Virginia and western Pennsylvania to the St. Lawrence River.

Largemouth bass can tolerate a wide range of temperatures if acclimated, but mortality increases significantly below 60°F and they become significantly stressed at under 40°F. This model assumes that 2-inch fingerlings are stocked in 2.53 acres of nursery ponds

between late May and early July for six months, until they reach 6 inches. They are then transferred to 9.47 acres of grow-out ponds where they grow for five more months until reaching the market size of 11 inches. The marketing goal is to supply pond stocking fish across the Midwest during spring. Ponds are assumed to be 10 feet deep, offering thermal refuge in winter in the lower density grow-out ponds. Exhibit 1.11.1 shows key inputs and values used in this production system.

Exhibit 1.11.1. Inputs used for largemouth bass production budget (recreational stocking market).

Item	Unit	Nursery	Grow-out
Stocking rate	fish/acre	30,000	8,000
Months stocked	months	6	5
Feed conversion ratio	lb. feed/lb. fish produced	2.50	2.50
Feed cost ($/ton)	$/ton	2,000	1,800
Total fertilizer	lb./acre	0	0
Total hours electric aeration/ac/cycle	hours	1,000	500
Hired labor	hours/year	1,000	1,000
Survival	%	80%	75%
Final weight	lb./fish	0.22	0.80
Pond depth	feet	10	10
Fingerling prices	$/fish	1.3	3
Sale price	$/fish	3	8
Oxygen	refills/acre	3	3
Average delivery weight	lb.	250	500
Average miles driven per delivery	miles	150	150
Marketing expenses	% of sales	5%	5%

Exhibits 1.11.2 and 1.11.3 present an NCR largemouth bass production budget with revenue and cost expectations per acre for nursery ponds and grow-out ponds, and for the whole operation (2.53 acres of nursery + 9.47 acres of grow-out ponds). Estimates per acre for nursery and grow-out ponds (Exhibit 1.11.2) assume that fingerlings would be bought for stocking at the market price and sold at the market price. For nursery ponds, net annual revenue is estimated at $67,238 per acre. After deducting total costs of $64,616, the net return to the operation would be $2,622 per acre, or $0.11 per fish sold. For grow-out ponds, net annual revenue is estimated at $45,840 per acre. After deducting total costs of $43,167, the net return to the operation would be $2,673 per acre, or $0.45 per fish sold.

The estimates for the entire operation — comprising 2.53 acres of nursery and 9.47 acres of grow-out ponds (Exhibit 1.11.3) — account for cost savings from raising fingerlings in-house, from 2 inches to 6 inches, for stocking the grow-out ponds at a lower cost than market price. After deducting delivery costs, the total net revenue amounts to $434,274 for the 12-acre operation. Variable costs include 2-inch fingerlings to be stocked in the nursery ponds, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $347,891, the net return to the operation would be $69,714, or $1.22 per fish sold.

Exhibit 1.11.2. Largemouth bass production budget per cycle in 12-acre pond culture (recreational stocking market), by stage.

		Nursery, per acre				Grow-out, per acre			
Item	**Unit**	**$/unit**	**Quantity**	**Total ($)**	**$/fish**	**$/unit**	**Quantity**	**Total ($)**	**$/fish**
Revenue									
Fish sales	fish	3	24,000	72,000	3.00	8	6,000	48,000	8.00
Delivery to buyers/market	$/mile	1.50	3,175	4,762	0.20	1.50	1,440	2,160	0.36
Net revenue				**67,238**	**2.80**			**45,840**	**7.64**
Variable costs									
Feed	tons	2,000	7	14,881	0.62	1,800	5	9,128	1.52
Stocked fish (fingerlings, juveniles)	fish	1.30	30000	39,000	1.63	3	8,000	24,000	4.00
Aquatic organism control				150	0.01			150	0.03
Veterinary and medicine				1,440	0.06			960	0.16
Water treatments				96	0.00			96	0.02
Repair and maintenance				438	0.02			365	0.06
Fuel and electricity				930	0.04			2,582	0.46
Aeration (electric consumption)	kWh	0.15	2243	336	0.01	0.15	13,455	2,018	0.34
Water pumping	kWh	0.15	2740	411	0.02	0.15	2,740	411	0.07
Truck and machinery fuel	gallons	3.50	25	88	0.00	3.50	21	73	0.01
Non-aeration and fee (electricity consumption)				95	0.00			80	0.01
Oxygen refill		50	3	150	0.01	50	3	150	0.03
Hired labor	hours/year/acre			1,542	0.06			1,542	0.26
Supplies				100	0.00			83	0.01
Marketing		0.05	67,238	3,362	0.14	0.05	45,840	2,292	0.38
Interest on operating capital	% annual rate	7.3%		1,125	0.05	7.3%		625	0.10
Total variable costs				**63,063**	**2.63**			**41,822**	**6.97**
Fixed costs									
Farm insurance	total			180	0.01			180	0.03
Legal/accounting	total			125	0.01			125	0.02
Capital recovery on real estate and equipment		7.3%		1,248	0.05	7.3%		1,040	0.17
Total fixed costs				**1,553**	**0.06**			**1,345**	**0.22**
Total cost				**64,616**	**2.69**			**43,167**	**7.19**
Return to operator labor and management				**2,622**	**0.11**			**2,673**	**0.45**

Exhibit 1.11.3. Largemouth bass production budget per cycle in pond culture (recreational stocking market), whole operation.

Item	Unit	Nursery (2.53 acres) ($)	Grow-out (9.47 acres) ($)	Integrated operation (12 acres) ($)
Revenue				
Fish sales	fish		454,737	454,737
Delivery to buyers/market	$/mile		20,463	20,463
Net revenue			**434,274**	**434,274**
Variable costs				
Feed	tons	37,595	86,473	124,068
Stocked fish (fingerlings, juveniles)	fish	98,526		98,526
Aquatic organism control		379	1,421	1,800
Veterinary and medicine		3,638	9,095	12,733
Water treatments		243	911	1,154
Repair and maintenance		1,105	3,454	4,559
Fuel and electricity		2,348	24,459	26,808
Aeration (electric consumption)	kWh	850	19,120	19,970
Water pumping	kWh	1,038	3,894	4,932
Truck and machinery fuel	gallons	221	691	912
Non-aeration and fee (electricity consumption)		239	755	994
Oxygen refill			1,421	1,421
Hired labor	hours/year/acre	3,895	14,605	18,500
Supplies		253	789	1,042
Marketing			21,714	21,714
Interest on operating capital	% annual rate			10,378
Total variable costs		**147,982**	**162,921**	**322,702**
Fixed costs				
Farm insurance	total	456	1,709	2,165
Legal/accounting	total	316	1,184	1,500
Capital recovery on real estate and equipment		3,152	9,851	13,003
Total fixed costs		**3,924**	**12,744**	**16,668**
Total cost		**151,905**	**175,666**	**339,370**
Return to operator labor and management				**94,903**

Observation: The Nursery and Grow-out columns present cost estimates for each stage of an integrated operation, where fish are raised from fingerlings to market size. These figures do not include interest on operating costs. The Integrated Operation column presents cost and revenue estimates for a full production cycle, including all expenses associated with utilizing the 12 acres to develop both stages.

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival for the nursery and grow-out stages is presented in Exhibit 1.11.4. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 72.5% survival is needed to achieve a break-even price of $2.93 per 6-inch fish and 67.5% to reach a break-even price of $7.89 per 11-inch fish.

Exhibit 1.11.4. Sensitivity analysis for largemouth bass (recreational stocking market).

Survival over the phase (nursery or grow-out)	Break-even price: Nursery ($/fish)	Break-even price: Grow-out ($/fish)
10.0%	18.15	46.08
12.5%	14.62	37.11
15.0%	12.26	31.12
17.5%	10.58	26.85
20.0%	9.32	23.65
22.5%	8.34	21.15
25.0%	7.55	19.16
27.5%	6.91	17.53
30.0%	6.37	16.17
32.5%	5.92	15.02
35.0%	5.53	14.03
37.5%	5.19	13.18
40.0%	4.90	12.43
42.5%	4.64	11.77
45.0%	4.41	11.18
47.5%	4.20	10.66
50.0%	4.02	10.19
52.5%	3.85	9.76
55.0%	3.70	9.37
57.5%	3.56	9.02
60.0%	3.43	8.69
62.5%	3.31	8.39
65.0%	3.20	8.11
67.5%	3.10	7.86
70.0%	3.01	7.62
72.5%	2.92	7.40
75.0%	2.84	7.19
77.5%	2.76	7.00
80.0%	2.69	6.82
82.5%	2.63	6.65
85.0%	2.56	6.49
87.5%	2.50	6.34
90.0%	2.45	6.20

1.12 Yellow perch model (stocking market)

Conditions for yellow perch production in the North Central region vary across states. The species is sensitive to higher temperatures, and lethal upper temperatures have been reported to range from 79°F to 86°F. Due to this temperature sensitivity, states in the Northern part of the NCR are more suitable for this species.

This model assumes that late fingerlings (4 to 5 inches) are stocked in ponds between April and May, and they reach market size of 7.5 to 8.5 inches six months later. The marketing goal is to supply fall pond stocking fish across the Midwest. Ponds are assumed empty until the next production cycle. Key inputs and values used in this production system are shown in Exhibit 1.12.1.

Exhibit 1.12.1. Inputs used for yellow perch production budget (recreational stocking market).

Item	Unit	Value
Stocking density (fingerlings/acre)	fingerlings/acre	10,000
Months to stocker harvest	months	6
Fish weight at sale size	lb.	5
Feed conversion ratio	lb. feed/lb. fish produced	1.85
Total fertilizer	lb./acre	140
Total hours electric aeration/ac/cycle	hours	800
Hired labor	hours/year	700
Survival (fry, commercial)	%	90%
Pond depth	feet	7
Advanced fingerlings (4"–5") price	$/fish	1.9
Advanced fingerlings (4"–5") weight	lb./fish	0.1
Market fish (7.5"–8.5") price	$/fish	4.25
Market fish (7.5"–8.5") weight	lb./fish	0.2
Average delivery weight	lb.	750
Average miles driven per delivery	miles	250
Oxygen cylinders	refills/year	4.50
Feed (catfish 32 floating, 5/32" pellet)	$/ton	1,058.21

Exhibit 1.12.2 presents an NCR yellow perch production budget with revenue and cost expectations. Net annual revenue is estimated at $442,800, after deducting costs for delivering fish to recreational markets. Variable costs include feed, fingerlings, fuel or electricity, marketing, hired labor and other expenses. Fixed costs include insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $375,732, the net return to the operation would be $31,311, or $0.62 per fish sold.

Exhibit 1.12.2. Yellow perch production budget per cycle in 12-acre pond culture (recreational stocking market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/acre	$/fish
Revenue						
Fish sales	$/fish	4.25	108,000	459,000	38,250	4.25
Delivery to buyers/market	$/mile	1.50	10,800	16,200	1,350	0.15
Net revenue				**442,800**	**36,900**	**4.10**
Variable costs						
Feed	tons	1058.21	18.50	19,577	1,631	0.18
Fry	fish		120,000	228,000	19,000	2.11
Aquatic organism control				1,800	150	0.02
Fertilizer	lb.	0.40	1,680	672	56	
Veterinary and medicine				9,180	765	0.09
Water treatments				1,154	96	0.01
Repair and maintenance				7,401	617	0.07
Fuel and electricity				10,990	916	0.10
Aeration	kWh	0.15	21,476.16	3,221.42	268.45	0.03
Water pumping	kWh	0.15	23,016	3,452.40	287.70	0.03
Truck and machinery fuel	gallons	3.50	600	2,100	175	0.02
Other electricity consumption				2,216	184.67	0.02
Oxygen refill		50	4.50	225	18.75	0.00
Hired labor				12,950	1,079	0.12
Supplies				1,200	100	0.01
Marketing	% of sales	10%	459,000	45,900	3,825	0.43
Interest on operating capital	% annual rate	7.3%		3,073	256	0.03
Total variable costs				**342,121**	**28,510**	**3.17**
Fixed costs						
Farm insurance	total			2,165	180	0.02
Legal/accounting	total			1,500	125	0.01
Capital recovery on real estate and equipment		7.3%		29,947	2,496	0.28
Total fixed costs				**33,612**	**2,801**	**0.31**
Total cost				**375,732**	**31,311**	**3.48**
Return to operator labor and management				**67,068**	**5,589**	**0.62**

The aquaculture business must be able to financially survive short-term changes in production, which might happen due to events such as mortality and bird depredation. A sensitivity analysis of the break-even price as a function of survival is presented in Exhibit 1.12.3. It demonstrates that proper pond management is essential for reaching competitive break-even prices. For instance, at least 72.5% survival is needed to achieve a break-even price of $4.19 per fish.

Exhibit 1.12.3. Sensitivity analysis for yellow perch production (recreational stocking market).

Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)	Survival (%)	Break-even price ($/fish)
10.0%	27.19	37.5%	7.63	65.0%	4.62
12.5%	21.86	40.0%	7.18	67.5%	4.47
15.0%	18.30	42.5%	6.79	70.0%	4.33
17.5%	15.76	45.0%	6.44	72.5%	4.19
20.0%	13.85	47.5%	6.13	75.0%	4.07
22.5%	12.37	50.0%	5.85	77.5%	3.96
25.0%	11.19	52.5%	5.60	80.0%	3.85
27.5%	10.22	55.0%	5.37	82.5%	3.75
30.0%	9.41	57.5%	5.15	85.0%	3.65
32.5%	8.72	60.0%	4.96	87.5%	3.56
35.0%	8.14	62.5%	4.78	90.0%	3.48

2. Recirculating aquaculture system (RAS) models

2.1 Background

A recirculating aquaculture system (RAS) is a method of raising animals that are born in water using indoor tanks to produce at a high density. The tanks in a RAS vary in size to accommodate different sizes of fish or crustaceans. Water is pumped through various filters that remove fecal matter and uneaten food. Water is also aerated and treated to maintain the proper oxygen and pH levels and other important water quality characteristics.

Producing in RAS requires proactive fish sorting because high fish densities can lead to cannibalism. Therefore, sorting and moving fish is one of the primary labor needs in RAS. Oxygenation and filtration equipment maintenance are essential because the high stocking densities found in RAS will quickly consume the available oxygen in the tank if water circulation stops, which makes power outages or equipment failures major production risk factors.

RAS systems can be developed in many areas or locations. A good strategy is to place them close to major urban population centers and fish markets, which decreases delivery costs and provides market opportunities to restaurants, retailers and Asian markets.

RAS systems must be maintained at temperatures that are optimal for fish or crustacean growth. In the temperate climate of most of the North Central region states, RAS systems will likely require supplemental heating for about eight months a year.

Fingerlings represent the major cost for most of the systems analyzed in this study. Hired labor, feed and energy, in that order, represent the highest production costs. Buying fertilized eggs and installing a hatchery in the operation is an option for a few species cultivated in RAS. A hatchery occupies a small area, represents little additional cost in building or purchasing incubator tanks, and provides a significant amount of larvae to be grown to fingerling size. The challenges are that it requires more specialized labor and there is limited availability of fertilized eggs in some parts of the North Central region for most of the species.

2.2 Capital investments

Because RAS is a relative newcomer to aquaculture, no standard model has been identified for the U.S. industry. RAS systems are also challenged with higher production costs than other U.S. and international aquaculture production systems. For this reason, our project team developed a theoretical RAS system based on research and our evaluation of working, successful RAS systems.

Exhibit 2.2.1 illustrates the layout and Exhibit 2.2.2 details the capital investment expenses for a RAS operation. The system has about 5,600 square feet of water space in a 7,500-square-foot building. In operations whose production cycle starts from fertilized eggs, which is the case for trout and salmon, 50 square feet are designated for the hatchery area. In other operations, the whole area is used for grow-out purposes. This scale is roughly the minimum size recommended for a full-time operation and is of a size that the owner and one full-time helper would be able to fulfill the labor needs.

Exhibit 2.2.1. RAS operation layout example.

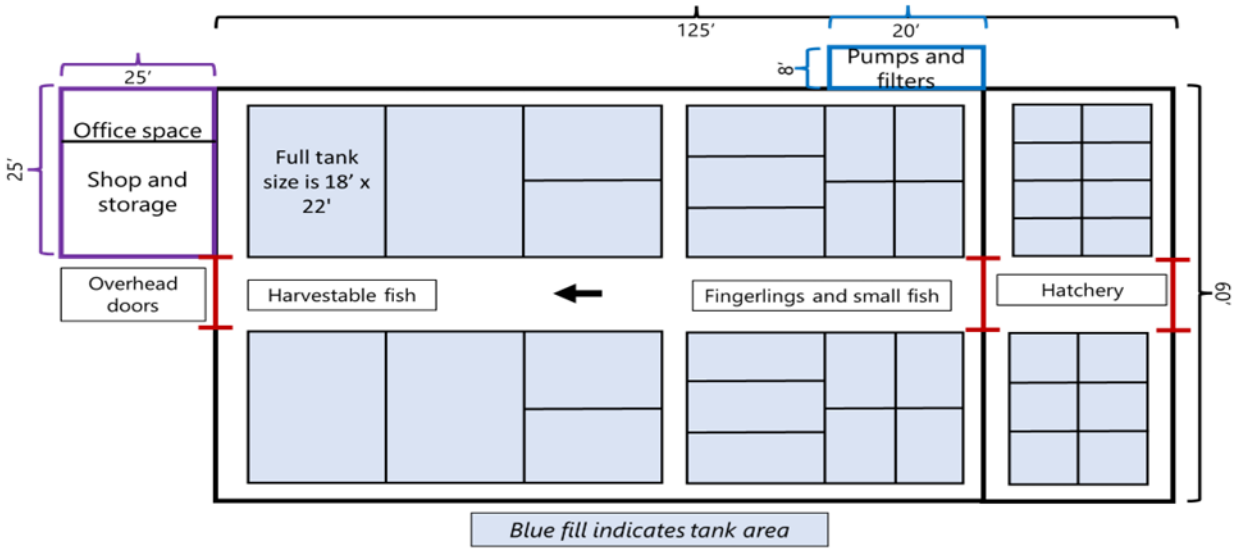

Exhibit 2.2.2. Capital investments for the RAS operation.

Item	Unit	Price per unit ($)	Quantity	Total cost ($)	Useful life (years)	Salvage value (%)	Depreciation (linear)
Aeration compressor	each	9,650	1	9,650	5	20%	1,544
Aeration compressor (hatchery)	each	1,433	1	1,433	5	20%	229
Climate control system	each	20,000	1	20,000	20	10%	900
Computer	total	1,100	1	1,100	7	10%	141
Concrete pad (installed)	square feet	5.75	8,200	47,150	40	5%	1,120
Digital scales	each	250	2	500	5	10%	90
Dipnets	each	30	5	150	2	0%	75
DO meter	each	900	2	1,800	5	10%	324
Electric panel	each	10,000	1	10,000	20	10%	450
Feed system/bins	each	20,000	1	20,000	10	10%	1,800
Filtration pump	each	2,700	1	2,700	5	10%	486
Filtration pump (hatchery)	each	740	1	740	5	10%	133
Filtration system (grow-out)	each	13,395	1	13,395	10	10%	1,206
Filtration system (hatchery)	each	1,555	1	1,555	10	10%	140
Fish hauling tank	each	8,000	1	8,000	10	25%	600
Forklift	each	15,000	1	15,000	15	25%	750
Hanging scale	each	500	2	1,000	5	10%	180
Insulation, electrical, plumbing	square feet	3	8,200	24,600	20	5%	1,169
Land	acre	6,000	0.5	3,000		100%	-
Office furnishings	total	1,000	1	1,000	10	10%	90
Office, shop, storage, and machinery space	square feet	20	700	14,000	20	10%	630
Pressure washer	each	1,500	1	1,500	5	10%	270
Regulator, flow meters, diffusers	total	1,500	1	1,500	5	10%	270
Septic/wastewater system	each	7,500	1	7,500	20	0%	375
Shipping/storage container	each	3,000	1	3,000	20	20%	120
Shop tools	total	5,000	1	5,000	10	25%	375
Standby generator	each	12,000	1	12,000	20	25%	450
Steel frame building materials	square feet	15	8,200	123,000	20	10%	5,535
Tank materials	cubic feet	1.25	15,903	19,878	10	20%	1,590
Truck	each	45,000	1	45,000	10	25%	3,375
Waders	each	200	1	200	3	0%	67
Water test kit	each	3,000	2	6,000	2	0%	3,000
Well installation	each	30,000	1	30,000	40	0%	750
Operation with hatchery	**Total investment ($):**		**451,351**		**Total cost ($):**	**28,234**	
Operation without hatchery	**Total investment ($):**		**447,623**		**Total cost ($):**	**27,731**	

2.3 Salmon model (food market)

Atlantic salmon in RAS systems are raised from egg to market size in a continuous 24-month production cycle. An example system for producing salmon may start with fertilized eggs in the hatchery area. For every two fertilized eggs, it is expected that one will hatch and generate a viable fry, which is then transferred to grow-out tanks and fed to a harvest weight of 8.8 pounds with a projected survival rate of 90%. Feed conversion ratio, estimated as pounds of feed per pound of fish weight gain, is estimated around 1.15-to-1. The estimated capacity is 0.67 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 salmon RAS budget (food fish market).

Input	Unit	Value
Fish sale price (whole fish)	$/lb.	6
Ration: 42-16 slow sinking	$/ton	2,050.22
Ration: transportation cost	$/ton	150
Feed conversion ratio	lb. feed/lb. fish produced	1.15
Eggs placed	eggs/1,000 gallon	170
Salmon fertilized eggs	$/1,000 eggs	300
Survival: eggs in per eggs out	eggs in/egg out	2
Survival rate: fry to grown fish	%	90%
Target weight: grown fish	lb.	8.8
Weight: fingerling	lb.	0.45
Carrying capacity (at commercial weight)	lb./gallon	0.67
Veterinary health	% of sales	2%
Hired labor	hours/year	2,920
Months to complete a cycle	months	24
Average miles driven per delivery	miles	400
Average delivery weight	lb.	2,000
Turns per year	turns	0.50

Exhibit 2.3.2 presents an NCR salmon RAS production budget with revenue and cost expectations. Net annual revenue is estimated at $227,491, after deducting costs for delivering fish to food fish markets. Variable costs include feed, fingerlings, hired labor, utilities, repairs and other expenses. Fixed costs include owner management or labor ($45,000), insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $251,421, the operation would have a net loss of $23,930, equivalent to $0.60 per pound of fish produced.

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 the financial feasibility of a business. Exhibit 2.3.3 demonstrates how survival impacts the break-even prices. Under the parameters assumed for this analysis, break-even prices vary between $7.59 per pound at 70% survival and $6.07 per pound at 95% survival.

Exhibit 2.3.2. Annualized salmon RAS budget (food fish market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/lb. sold	% of sales
Revenue						
Salmon sales	lb. unprocessed fish	6	39,911	239,464	6.00	100%
Delivery to buyers/market	miles	1.50	7,982	11,973	0.30	5%
Net revenue				**227,491**	**5.70**	**95%**
Variable costs						
Feed	tons	2,050.22	19.778	40,549.2	1.02	17%
Feed transportation	tons	150	19.778	2,967	0.07	1%
Fertilized eggs	1,000 eggs	300	10	3,017	0.08	1%
Hired labor				56,940	1.43	24%
Utilities				14,282	0.36	6%
Water treatments				8,400	0.21	4%
Repairs and maintenance				14,414	0.36	6%
Veterinary and medicine				4,789	0.12	2%
Supplies				3,000	0.08	1%
Interest on operating capital	% annual rate	7.8%		11,498	0.29	5%
Total variable costs				**159,856**	**4.01**	**67%**
Fixed costs						
Farm insurance	$/year			3,000	0.18	2%
Legal/accounting	$/year			1,000	0.06	1%
Owner labor and management	$/year			45,000	2.70	27%
Interest on real estate and equipment		7.3%		14,331	0.36	6%
Depreciation on real estate and equipment				28,234	0.71	12%
Total fixed costs				**91,565**	**2.29**	**38%**
Total cost				**251,421**	**6.30**	**105%**
Net return to operation				**(23,930)**	**(0.60)**	**–10%**

Exhibit 2.3.3. Sensitivity analysis for salmon RAS budget (food fish market).

Survival (%)	Break-even price ($/lb.)
5%	90.01
10%	45.44
15%	30.61
20%	23.21
25%	18.78
30%	15.84
35%	13.75

Survival (%)	Break-even price ($/lb.)
40%	12.18
45%	10.98
50%	10.02
55%	9.24
60%	8.59
65%	8.05
70%	7.59

Survival (%)	Break-even price ($/lb.)
75%	7.20
80%	6.86
85%	6.56
90%	6.30
95%	6.07

2.4 Trout model (food market)

Trout for the food market in RAS systems can be grown in a continuous 10-month production cycle. A benchmark operation may begin with 3-inch fingerlings and feed them to a harvest weight of 3.31 pounds. Feed conversion is estimated at about 1.36-to-1 pounds of feed per pound of gain for bigger trout, and a survival rate of 81% is projected for the system. An estimated capacity of 0.54 pounds of fish per gallon of water is used. Other key inputs and values used in this production system are shown in Exhibit 2.4.1.

Exhibit 2.4.1. Inputs used for trout RAS budget (food fish market).

Input	Unit	Value
Fish sales price	$/lb.	7
Fingerlings (3") price	$/fish	2.50
Ration: 50-15 slow sinking (1"–5" fish)	$/ton	3,346.57
Ration: 42-16 slow sinking (5" to harvest)	$/ton	2,050.22
Ration: transportation cost	$/ton	150
Feed conversion ratio, up to 5"	lb. feed/lb. fish produced	1.10
Feed conversion ratio, greater than 5"	lb. feed/lb. fish produced	1.36
Fingerlings placed	fish/1,000 gallons	200
Survival rate: 3"–5"	%	90%
Survival rate: 5" to harvest	%	90%
Weight: fry (10 grams)	lb.	0.02
Commercial weight	lb.	3.31
Carrying capacity (at commercial weight)	lb./gallon	0.54
Veterinary health	% of sales	2%
Hired labor	hours/year	2,920
Months to complete a cycle	months	10
Average miles driven per delivery	miles	400
Average delivery weight	lb.	2,000
Turns per year	turns	1.20

Exhibit 2.4.2 presents an NCR trout RAS production budget with revenue and cost expectations. Net annual revenue is estimated at $512,236, after deducting costs for delivering live fish to food fish markets. Variable costs include feed, fingerlings, hired labor, utilities, repairs and other expenses. Fixed costs include owner management or labor ($45,000), insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $390,208, the net annual return to the operation would be $122,027, or $1.60 per pound sold.

Exhibit 2.4.2. Annualized trout RAS budget (food fish market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/lb. sold	% of sales
Revenue						
Trout sales	lb. of whole fish	7	76,453	535,172	7.00	100%
Delivery to buyers/market	miles	1.50	15,291	22,936	0.30	4%
Net revenue				**512,236**	**6.70**	**96%**
Variable costs						
Feed: larvae to 5" fish	tons	3,346.57	0.346	1,159	0.02	0.2%
Feed: 5" to harvest	tons	2,050.22	49.783	102,067	1.34	19.1%
Feed transportation	tons	150	50.130	7,519	0.10	1.4%
Fingerlings	fish	2.50	28,550	71,375	0.93	13.3%
Hired labor				56,940	0.74	10.6%
Utilities				14,192	0.19	2.7%
Water treatments				8,400	0.11	1.6%
Repairs and maintenance				14,414	0.19	2.7%
Veterinary and medicine				10,703	0.14	2.0%
Supplies				3,000	0.04	0.6%
Interest on operating capital	% annual rate	7.75%		9,357	0.12	1.7%
Total variable costs				**299,127**	**3.91**	**56%**
Fixed costs						
Farm insurance	$/year			3,000	0.04	1%
Legal/accounting	$/year			1,000	0.01	0%
Owner labor and management	$/year			45,000	0.59	8%
Interest on real estate and equipment		7.3%		14,350	0.19	3%
Depreciation on real estate and equipment				27,731	0.36	5%
Total fixed costs				**91,081**	**1.19**	**17%**
Total cost				**390,208**	**5.10**	**73%**
Net return to operation				**122,027**	**1.60**	**22.80%**

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 the financial feasibility of a business. Exhibit 2.4.3 demonstrates how survival impacts the break-even prices. Under the parameters assumed for this analysis, break-even prices vary between $7.46 per pound at 50% survival and $4.53 per pound at 95% survival.

Exhibit 2.4.3. Sensitivity analysis for trout RAS budget (food market).

Survival (%)	Break-even price ($/lb.)
5%	60.04
10%	31.10
15%	21.35
20%	16.44
25%	13.47
30%	11.48
35%	10.06

Survival (%)	Break-even price ($/lb.)
40%	8.98
45%	8.14
50%	7.46
55%	6.91
60%	6.44
65%	6.05
70%	5.71

Survival (%)	Break-even price ($/lb.)
75%	5.41
80%	5.15
85%	4.92
90%	4.72
95%	4.53

2.5 Trout model (stocking market)

Trout for the recreational stocking market can be grown in RAS systems in a continuous seven-month production cycle. A benchmark operation may begin with fertilized triploid rainbow trout eggs incubated to grow 6-to-10-inch fingerlings (0.45 pounds) for stocking purposes. Feed conversion is estimated at about 1.3-to-1 pounds of feed per pound of gain for bigger trout, a survival rate of 72.25% from incubation to the transferred larvae stage is projected, and a survival rate of 81% is projected for the larvae to grown fish stage. An estimated capacity of 0.38 pounds of fish per gallon of water is used. Other key inputs and values used in this production system are shown in Exhibit 2.5.1.

Exhibit 2.5.1. Inputs used for trout RAS budget (recreational stocking market).

Input	Unit	Value
Sale price: 6"–10" fish	$/fish	3
Ration: 50-15 slow sinking (1"–5" fish)	$/ton	3,346.57
Ration: 42-16 slow sinking (5"–10" fish)	$/ton	2,050.22
Ration: transportation costs	$/ton	150
Feed conversion ratio, up to 5" fish	lb. feed/lb. fish produced	1.10
Feed conversion ratio, 5"–10" fish	lb. feed/lb. fish produced	1.30
Rainbow trout eggs (triploid RBT eggs)	$/1,000 eggs	35
Eggs placed	eggs/1,000 gallon	1,200
Survival rate: incubation	%	85%
Survival rate: larvae transferred	%	85%
Survival rate: larvae to fry	%	90%
Survival rate: fry to grown fish	%	90%
Weight: fry (10 grams)	lb.	0.02
Weight: grown fish (6"–10") (206 grams)	lb.	0.45
Carrying capacity	lb./gallon	0.38
Veterinary health	% of sales	2%
Hired labor	hours/year	2,920
Months to complete a cycle	months	7
Average miles driven per delivery	miles	400
Average delivery quantity	fish/delivery	2,000
Turns/year	turns	1.71

Exhibit 2.5.2 presents an NCR trout RAS production budget with revenue and cost expectations. Net annual revenue is estimated at $384,609, after deducting costs for delivering live fish to food fish markets. Variable costs include feed, fingerlings, hired labor, utilities, repairs and other expenses. Fixed costs include owner management or labor ($45,000), insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $352,502, the net annual return to the operation would be $32,107, or $0.23 per fish sold.

Exhibit 2.5.2. Annualized trout RAS budget (recreational stocking market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/fish sold	% of sales
Revenue						
Trout sales	fish	3	142,448	427,343	3.00	100%
Delivery to buyers/market	miles	1.50	28,490	42,734	0.30	10%
Net revenue				**384,609**	**2.70**	**90%**
Variable costs						
Feed: larvae to 5" fish	tons	2,050.22	1.838	3,767.8	0.03	0.9%
Feed: 5"–10" fish	tons	3,346.57	40.267	134,757	0.95	31.5%
Feed transportation	tons	150	42.105	6,315.8	0.04	1.5%
Rainbow trout eggs (triploid RBT eggs)	1,000 eggs	35	243	8,519	0.06	2.0%
Hired labor				56,940	0.40	13.3%
Utilities				14,192	0.10	3.3%
Water treatments				8,400	0.06	2.0%
Repairs and maintenance				14,414	0.10	3.4%
Veterinary and medicine				8,547	0.06	2.0%
Supplies				3,000	0.02	0.7%
Interest on operating capital	% annual rate	7.75%		5,851	0.04	1.4%
Total variable costs				**260,937**	**1.83**	**61%**
Fixed costs						
Farm insurance	$/year			3,000	0.02	0.7%
Legal/accounting	$/year			1,000	0.01	0.2%
Owner labor and management	$/year			45,000	0.32	10.5%
Interest on real estate and equipment		7.3%		14,331	0.10	3.4%
Depreciation on real estate and equipment				28,234	0.20	6.6%
Total fixed costs				**91,565**	**0.64**	**21%**
Total cost				**352,502**	**2.47**	**82%**
Net return to operation				**32,107**	**0.23**	**8%**

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 the financial feasibility of a business. Exhibit 2.5.3 demonstrates how survival impacts the break-even prices. Under the parameters assumed for this analysis, break-even prices vary between $3.49 per pound at 50% survival and $2.23 per pound at 95% survival.

Exhibit 2.5.3. Sensitivity analysis for trout RAS budget (recreational stocking market).

Survival (%)	Break-even price ($/lb.)
5%	25.38
10%	13.40
15%	9.34
20%	7.29
25%	6.04
30%	5.20
35%	4.59

Survival (%)	Break-even price ($/lb.)
40%	4.14
45%	3.78
50%	3.49
55%	3.25
60%	3.05
65%	2.88
70%	2.73

Survival (%)	Break-even price ($/lb.)
75%	2.61
80%	2.49
85%	2.40
90%	2.31
95%	2.23

2.6 Walleye model (stocking market)

Walleye for the stocking market in RAS systems can be grown in a continuous five-month production cycle. A benchmark operation may begin with 4-to-6-inch fingerlings and feed them to a market size of 6 to 10 inches. Feed conversion is estimated at about 1.35-to-1 pounds of feed per pound of gain, and a survival rate of 84% is projected for the system. An estimated capacity of 0.42 pounds of fish per gallon of water is used. Other key inputs and values used in this production system are shown in Exhibit 2.6.1.

Exhibit 2.6.1. Inputs used for walleye RAS budget (recreational stocking market).

Input	Unit	Value
Sale price: 6"–10" fish	$/fish	4.50
Ration: 42-16 slow sinking (6"–10" fish)	$/ton	2,050.22
Ration: transportation cost	$/ton	150
Feed conversion ratio, 4"–10" fish	lb. feed/lb. fish produced	1.35
Fingerling (4"–6")	$/fish	1.85
Fingerlings placed	fish/1,000 gallon	1,100
Survival rate, fingerlings (4"–10" fish)	%	84%
Weight: finished (6"–10")	lb.	0.45
Carrying capacity (6"–10")	lb./gallon	0.42
Veterinary health	% of sales	2%
Hired labor	hours/year	2,920
Months to complete a cycle	months	5
Average delivery distance (round trip)	miles	400
Average delivery quantity	fish/delivery	2,000
Turns/year	turns	2.40

Exhibit 2.6.2 presents an NCR walleye RAS production budget with revenue and cost expectations. Net annual revenue is estimated at $1,107,971, after deducting costs for delivering live fish to food fish markets. Variable costs include feed, fingerlings, hired labor, utilities, repairs and other expenses. Fixed costs include owner management or labor ($45,000), insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $984,840, the net annual return to the operation would be $123,131, or $0.47 per fish sold.

Exhibit 2.6.2. Annualized walleye RAS budget (recreational stocking market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/fish sold	% of sales
Revenue						
Fish sales	fish	4.50	263,803	1,187,112	4.50	100%
Delivery to buyers/market	miles	1.50	52,761	79,141	0.30	7%
Net revenue				**1,107,971**	**4.20**	**93%**
Variable costs						
Feed: 4"–10" fish	tons	2,050.22	80.351	164,738	0.62	14%
Feed transportation	tons	150	80.351	12,053	0.05	1%
Fingerlings	fish	1.85	314,051	580,994	2.20	49%
Hired labor				56,940	0.22	5%
Utilities				15,277	0.06	1%
Water treatments				8,400	0.03	1%
Repairs and maintenance				14,414	0.05	1%
Veterinary and medicine				23,742	0.09	2%
Supplies				3,000	0.01	0%
Interest on operating capital	% annual rate	7.8%		14,201	0.05	1%
Total variable costs				**893,759**	**3.39**	**75%**
Fixed costs						
Farm insurance	$/year			3,000	0.01	0%
Legal/accounting	$/year			1,000	0.00	0%
Owner labor and management	$/year			45,000	0.17	4%
Interest on real estate and equipment		7.3%		14,350	0.05	1%
Depreciation on real estate and equipment				27,731	0.11	2%
Total fixed costs				**91,081**	**0.35**	**8%**
Total cost				**984,840**	**3.73**	**83%**
Net return to operation				**123,131**	**0.47**	**10%**

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 the financial feasibility of a business. Exhibit 2.6.3 demonstrates how survival impacts the break-even prices. Under the parameters assumed for this analysis, break-even prices vary between $5.99 per fish at 50% survival and $3.35 per fish at 95% survival.

Exhibit 2.6.3. Sensitivity analysis for walleye RAS budget (recreational stocking market).

Survival (%)	Break-even price ($/fish)
5%	56.21
10%	28.31
15%	19.01
20%	14.36
25%	11.57
30%	9.71
35%	8.38

Survival (%)	Break-even price ($/fish)
40%	7.39
45%	6.61
50%	5.99
55%	5.48
60%	5.06
65%	4.70
70%	4.40

Survival (%)	Break-even price ($/fish)
75%	4.13
80%	3.90
85%	3.69
90%	3.51
95%	3.35

2.7 Yellow perch model (food market)

Yellow perch for the food market in RAS systems can be grown in a continuous 24-month production cycle. A benchmark operation may begin with 2-inch fingerlings and feed them to a harvest weight of 0.5 pounds. Feed conversion is estimated at about 1.9-to-1 pounds of feed per pound of gain, and a survival rate of 81% is projected for the system. An estimated capacity of 0.57 pounds of fish per gallon of water is used. Other key inputs and values used in this production system are shown in Exhibit 2.7.1.

Exhibit 2.7.1. Inputs used for yellow perch RAS budget (food fish market).

Input	Unit	Value
Sale price (whole fish)	$/lb.	10
Ration: 50-15 slow sinking (2"–5" fish)	$/ton	3,346.57
Ration: 42-16 slow sinking (greater than 5" fish)	$/ton	2,050.22
Cost with feed transportation	$/ton	150
Feed conversion ratio	lb. feed/lb. fish produced	1.90
Fingerlings (2"/5 grams)	$/fish	0.75
Fingerlings placed	fish/1,000 gallons	1,400
Survival rate: 2"–5"	%	90%
Survival rate: 5" to grow-out	%	90%
Weight at placement (2"–3")	lb.	0.011
Weight at 5"	lb.	0.11
Weight at market size	lb.	0.50
Carrying capacity	lb./gallon	0.57
Veterinary health	% of sales	2%
Hired labor	hours/year	2,920
Months to complete a cycle	months	24
Average delivery distance (round trip)	miles	400
Average delivery weight	lb.	2,000
Turns per year	turns	0.50

Exhibit 2.7.2 presents an NCR yellow perch RAS production budget with revenue and cost expectations. Net annual revenue is estimated at $327,130, after deducting costs for delivering live fish to food fish markets. Variable costs include feed, fingerlings, hired labor, utilities, repairs and other expenses. Fixed costs include owner management or labor ($45,000), insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $355,731, the net annual return to the operation would be negative, leading to a loss of $28,601, or $0.85 per pound sold.

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 the financial feasibility of a business. Exhibit 2.7.3 demonstrates how survival impacts the break-even prices. Under the parameters assumed for this analysis, break-even prices vary between $16.02 per pound at 50% survival and $9.23 per pound at 95% survival.

Exhibit 2.7.2. Annualized yellow perch RAS budget (food fish market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/lb. sold	% of sales
Revenue						
Revenue: Fish sales	lb. whole fish	10	33,725	337,248	10.00	100%
Delivery cost	miles	1.50	6,745	10,117	0.30	3%
Net revenue				**327,130**	**9.70**	**97%**
Variable costs						
Feed: up to 5" fish	tons	3,346.57	7.666	25,654	0.76	8%
Feed: greater than 5" fish	tons	2,050.22	23.781	48,756	1.45	14%
Feed transportation	tons	150	31.446	4,717	0.14	1%
Fingerlings	fish	0.75	83,271	62,453	1.85	19%
Hired labor				56,940	1.69	17%
Utilities				14,536	0.43	4%
Water treatments				8,400	0.25	2%
Repairs and maintenance				14,414	0.43	4%
Veterinary and medicine				6,745	0.20	2%
Supplies				3,000	0.09	1%
Interest on operating capital	% annual rate	7.75%		19,035	0.56	6%
Total variable costs				**264,650**	**7.85**	**78%**
Fixed costs						
Farm insurance	$/year			3,000	0.09	1%
Legal/accounting	$/year			1,000	0.03	0%
Owner labor and management	$/year			45,000	1.33	13%
Interest on real estate and equipment		7.3%		14,350	0.43	4%
Depreciation on real estate and equipment				27,731	0.82	8%
Total fixed costs				**91,081**	**2.70**	**27%**
Total cost				**355,731**	**10.55**	**105%**
Net return to operation				**(28,601)**	**(0.85)**	**-8.48%**

Exhibit 2.7.3. Sensitivity analysis for yellow perch RAS budget (food market).

Survival (%)	Break-even price ($/lb.)
5%	139.92
10%	71.53
15%	48.57
20%	37.03
25%	30.07
30%	25.41
35%	22.07

Survival (%)	Break-even price ($/lb.)
40%	19.55
45%	17.59
50%	16.02
55%	14.73
60%	13.65
65%	12.73
70%	11.94

Survival (%)	Break-even price ($/lb.)
75%	11.26
80%	10.66
85%	10.13
90%	9.66
95%	9.23

2.8 Yellow perch model (stocking market)

Yellow perch for the recreational stocking market in RAS systems can be grown in a continuous 12-month production cycle. A benchmark operation may begin with 2-inch fingerlings and feed them to a market size of 8 inches. Feed conversion is estimated at about 1.9-to-1 pounds of feed per pound of gain, and a survival rate of 86% is projected for the system. An estimated capacity of 0.59 pounds of fish per gallon of water is used. Other key inputs and values used in this production system are shown in Exhibit 2.8.1.

Exhibit 2.8.1. Inputs used for yellow perch RAS budget (recreational stocking market).

Input	Unit	Value
8" fish sales price	$/fish	3
Ration: 50-15 slow sinking (1"–5" fish)	$/ton	3,346.57
Ration: 42-16 slow sinking (5" to harvest)	$/ton	2,050.22
Cost with feed transportation	$/ton	150
Feed conversion ratio	lb. feed/lb. fish produced	1.90
Fingerlings (2"/5 grams)	$/fish	0.75
Fingerlings placed	fish/1,000 gallon	2,700
Survival rate, 2" to market size	%	90%
Survival rate, 5"–8"	%	95%
Weight at placement (2"/5 grams)	lb.	0.011
Weight at 5"	lb.	0.11
Finish weight (8"/115 grams)	lb.	0.25
Carrying capacity	lb./gallon	0.59
Veterinary expenses	% of sales	2%
Hired labor	hours/year	2,920
Months to complete a cycle		12
Average miles driven per delivery	miles	400
Average delivery quantity	fish/delivery	2,000
Turns/year	turns	1

Exhibit 2.8.2 presents an NCR yellow perch RAS production budget with revenue and cost expectations. Net annual revenue is estimated at $741,463, after deducting costs for delivering live fish to food fish markets. Variable costs include feed, fingerlings, hired labor, utilities, repairs and other expenses. Fixed costs include owner management or labor ($45,000), insurance, depreciation, interest and legal/accounting expenses. After deducting total costs of $635,304, the net annual return to the operation would be $106,160, or $0.39 per fish sold.

Exhibit 2.8.2. Yellow perch RAS budget (recreational stocking market).

Item	Unit	Price per unit ($)	Quantity	Total ($)	$/fish sold	% of sales
Revenue						
Revenue: fish sales	fish	3	274,616	823,848	3.00	100%
Delivery cost: to buyers/market	miles	1.50	54,923	82,385	0.30	10%
Net revenue				**741,463**	**2.70**	**90%**
Variable costs						
Feed: up to 5" fish	tons	3,346.57	26.734	89,467	0.33	11%
Feed: greater than 5" fish	tons	2,050.22	34.444	70,618	0.26	9%
Feed transportation	tons	150	61.178	9,177	0.03	1.1%
Fingerlings	fish	0.75	321,188	240,891	0.88	29%
Hired labor				56,940	0.21	7%
Utilities				14,536	0.05	2%
Water treatments				8,400	0.03	1%
Repairs and maintenance				14,414	0.05	2%
Veterinary and medicine				16,477	0.06	2%
Supplies				3,000	0.01	0%
Interest on operating capital	% annual rate	7.75%		20,302	0.07	2%
Total variable costs				**544,222**	**1.98**	**66%**
Fixed costs						
Farm insurance	$/year			3,000	0.01	0%
Legal/accounting	$/year			1,000	0.00	0%
Owner labor and management	$/year			45,000	0.16	5%
Interest on real estate and equipment		7.3%		14,350	0.05	2%
Depreciation on real estate and equipment				27,731	0.10	3%
Total fixed costs				**91,081**	**0.33**	**11%**
Total cost				**635,304**	**2.31**	**77%**
Net return to operation				**106,160**	**0.39**	**12.89%**

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 the financial feasibility of a business. Exhibit 2.8.3 demonstrates how survival impacts the break-even prices. Under the parameters assumed for this analysis, break-even prices vary between $3.68 per fish at 50% survival and $2.12 per fish at 95% survival.

Exhibit 2.8.3. Sensitivity analysis for yellow perch RAS budget (food market).

Survival (%)	Break-even price ($/lb.)
5%	32.14
10%	16.44
15%	11.17
20%	8.52
25%	6.92
30%	5.85
35%	5.08

Survival (%)	Break-even price ($/lb.)
40%	4.50
45%	4.05
50%	3.68
55%	3.39
60%	3.14
65%	2.93
70%	2.74

Survival (%)	Break-even price ($/lb.)
75%	2.59
80%	2.45
85%	2.32
90%	2.22
95%	2.12

3. Summary of business models

The business models presented in this report are examples of new, entry-level North Central region aquaculture operations. Exhibits 3.1 and 3.2 provide a production and financial comparison of these business models. 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. Further business planning assistance can be found in MU Extension publication G9469, Planning for an Aquaculture Business in Missouri (extension.missouri.edu/publications/g9469). Actual aquaculture startups may encounter a multiyear period of negative cash flow as the production system increases productivity, management gains experience and markets develop.

Opportunities for contract production, like those used in the poultry and swine industries, are emerging in some world aquaculture sectors. These use standard technology packages, contractor-supplied feed, defined production protocols and captive marketing agreements. Larger scale growth in an industry brings supplier clustering, lower transportation costs, faster technological improvements and overall lower costs of production. These production opportunities in the Midwest region could accelerate aquaculture growth in North Central region.

Exhibit 3.1. Comparison of North Central aquaculture models: pond culture.

Pond model	Stocking size	Unit of sale	Capital investment[1] ($)	Cycle[2] (months)	Stocking density[3] (fingerlings/ acre)	Feed[4] (FCR/protein)	Break-even price[5] ($/lb.)	Payback period[6] (years)	Internal rate of return[7] (10 years) (%)
Food – Catfish	(3"–5", 45 grams)	lb. (1.8 lb./fish, whole fish)	423,964	12	3,750	2.2/32%	3.40	3	35.20%
Food – Hybrid striped bass									
Nursery	(2", 3 grams)	fish (6"/100 grams)	423,964	6	13,400	2.4/36%	6.69		
Grow-out	(6", 100 grams)	lb. (2.5 lb./fish, whole fish)	423,964	12	3,200	2.4/32%	5.48		
Integrated (nursery + grow-out)	(2", 3 grams)	lb. (2.5 lb./fish, whole fish)	423,964	18	-	2.4/32%	5.26	2	55.89%
Food – Yellow perch	(4"–5", 14 grams)	lb. (0.33 lb./fish, whole fish)	423,964	12	10,000	1.85/32%	7.91	8	12.04%
Stocking – Blue gill	(1"–3", 2 grams)	fish (4"–5", 45 grams)	399,151	8	15,000	2/40%	16.51	8	12.17%
Stocking – Catfish	(3"–5", 45 grams)	fish (11"/0.5lb.)	399,151	8	15,000	2.5/32%	3.70	4	30.35%
Stocking – Golden shiner (bait/stocking)	Fry	lb. (live fish, 85 fish/lb.)	399,151	18	100,000	2.75/32%	21.14	9	9.56%
Stocking– Grass carp	(3"–5", 25 grams)	fish (8"–11", 226 grams)	399,151	9	3,750	-	10.84	5	19.41%
Stocking – Hybrid striped bass									
Nursery	(2", 3 grams)	fish (6"/100 grams)	399,151	6	13,400	2.4/36%	6.65		
Grow-out	(6", 100 grams)	fish (12"+/0.8 lb.)	399,151	5	4,000	2.4/32%	6.80		
Integrated (nursery + grow-out)	(6", 100 grams)	fish (12"+/0.8 lb.)	399,151	11	-	2.4/32%	5.94	5	21.99%
Stocking – Largemouth bass									
Nursery	(2"–4", 3 grams)	fish (6"/0.22 lb.)	399,151	6	30,000	2.4/36%	12.21		
Grow-out	(6", 100 grams)	fish (12"+/0.8 lb.)	399,151	5	8,000	2.4/32%	8.99		
Integrated (nursery + grow-out)	(6", 100 grams)	fish (12"+/0.8 lb.)	399,151	11	-	2.4/32%	7.46	4	24.32%
Stocking – Yellow perch	(4"–5", 14 grams)	fish (7.5"–8.5", 90 grams)	399,151	6	10,000	1.85/32%	17.40	5	21.60%

* Enterprise does not pay back over 10-year period.

1. Capital investment measures the cost of purchasing all items needed to start the operation.
2. Cycle refers to the assumed duration of a production cycle or stage, in the case of operations that include a nursery phase.
3. Stocking density refers to the number of fingerlings placed per acre.
4. Feed (FCR/protein): FCR refers to the number of pounds of feed needed to produce 1 pound of fish. Protein refers to the assumed protein content (%) of the feed ration.
5. Break-even price refers to the minimum price required to cover the total production cost for the enterprise, based on the performance and input cost assumptions used in this report.
6. Payback period refers to the time required for the enterprise to achieve a positive cumulative cash flow. Enterprises that do not generate returns above total costs will not reach payback.
7. Internal rate of return refers to the average annual rate of return on the enterprise's investments, accounting for all costs and investments and the timing of cash flows. It is calculated as the discount rate that results in a net present value of zero over 10 years of operation.

Exhibit 3.2. Comparison of North Central aquaculture models: recirculating aquaculture systems (RAS).

RAS model	Stocking size	Unit of sale	Capital investment[1] ($)	Cycle[2] (months)	Carrying capacity[3] (lb./gallon/cycle)	Feed[4] (FCR/protein)	Break-even price[5] ($/lb.)	Payback period[6] (years)	Internal rate of return[7] (10 years) (%)
Salmon (food)	Eggs	lb. (whole fish, 8.8 lb./fish)	451,351	24	0.67	1.15/42%	6.30	*	High loss
Trout (food)	(3", 3 grams)	lb. (whole fish, 3.3 lb./fish)	447,623	10	0.54	1.36/50-42%	5.10	3	34.79%
Trout (stocking)	Eggs	fish (6"–10", 30-135 grams)	451,351	7	0.38	1.30/50-42%	5.45	7	13.35%
Walleye (stocking)	(4"-6",8.5 grams)	fish (6"–10", 30-135 grams)	447,623	5	0.42	1.35/42%	8.22	3	35.04%
Yellow Perch (food)	(2"/5 grams)	lb. (whole fish, 0.5 lb./fish)	447,623	24	0.57	1.9/50-42%	21.10	*	-3.39%
Yellow Perch (stocking)	(2"/5 grams)	fish (3"–5")	447,623	12	0.59	1.9/50-42%	9.11	4	31.08%

* Enterprise does not pay back over 10-year period.

1. Capital investment measures the cost of purchasing all items needed to start the operation.
2. Cycle refers to the assumed duration of a production cycle.
3. Carrying capacity refers to the maximum pounds of fish supported per gallon of water in the system.
4. Feed (FCR/protein): FCR refers to the number of pounds of feed needed to produce 1 pound of fish. Protein refers to the assumed protein content (%) of the feed ration.
5. Break-even price refers to the minimum price required to cover the total production cost for the enterprise, based on the performance and input cost assumptions used in this report.
6. Payback period refers to the time required for the enterprise to achieve a positive cumulative cash flow. Enterprises that do not generate returns above total costs will not reach payback.
7. Internal rate of return refers to the average annual rate of return on the enterprise's investments, accounting for all costs and investments and the timing of cash flows. It is calculated as the discount rate that results in a net present value of zero over 10 years of operation.

You can customize this budget using the Missouri Aquaculture Budget: Pond-Raised Recreational Stocking and Food Fish workbook, which can be downloaded from the publication webpage (extension.missouri.edu/publications/mx466).

Cover photos (clockwise from top): smoked trout filets from Freshwater Farms of Ohio, ornamental fish from Ozark Fisheries in Missouri, barramundi culture at Hanilu Farms in Indiana, in-pond raceway from Superior Aquaculture in Wisconsin, marine shrimp from RDM in Indiana, and ponds at Big House Fish Farm in Illinois.

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