

Expected Economic Impact of Cage Trout Aquaculture on Michigan's Great Lakes

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About 65% of major global fish stocks are annually harvested at or above capacity and about one out of ten of these are over-harvested such that it will take many years for the fish populations to recover. The result is that natural fisheries are unable to meet current global demand and now about half of all seafood that is consumed is farmed. Recently, the United Nations Food and Agriculture Organization reported that without aquaculture a global seafood shortage is expected in the range of 50-80 million tons by 2030. While this has presented an opportunity internationally for aquaculture, the US also has many resources, such as the Great Lakes, that can be used for aquaculture production.

Despite these resources, the US imports about three-quarters of the seafood it consumes, where the leading suppliers are China, Thailand, Canada, Indonesia, Vietnam and Ecuador, and much of this is farmed. While Idaho is the number one producer of farmed rainbow trout, many states are currently expanding aquaculture production. However, Michigan has not been quick to embrace Great Lakes aquaculture even though it has abundant water resources.

Some Michigan wholesalers and processors contend that there is pent up demand for locally-sourced finfish (Beverluis 2009) but that the state lacks the necessary inputs to make the industry viable, as noted in Weeks and Knudson (2014). Constraints include: 1) feed costs, where no Michigan feed mill exist and fisheries have to import feed over vast distances; 2), lack of financial resources for aquaculture for financing capital investment and operating funds; and 3), limited labor and veterinary services with expertise in aquaculture and; and 4) insufficient in-state processing capacity to support growth. While there appears to be latent interest in expanding Michigan's aquaculture industry, current aquaculture production may not be sufficient to make such resources viable in Michigan in the short- and medium-term. Additionally, there has been some push back in Michigan from environmental groups to increase regulatory pressure on the aquaculture industry.

US Aquaculture Production

Trout farming has historically been concentrated along the Snake River in Idaho. However, the practice has recently been adopted across the U.S. such as in southern states like Georgia and Arkansas, eastern states including Pennsylvania, New Jersey, Tennessee, and North Carolina, into the Midwest, such as South Dakota, and westward to Oregon and Washington. As the primary requirement for raising trout is clean and cool water, followed closely by sufficient sources of fish food, growth in trout farming is likely to continue expanding in other states and regions.

One such region is the Great Lakes as it accounts for 90 percent of the U.S. fresh water supply and 20 percent of the world's fresh water supply. Therefore, it is natural to consider Great Lakes states as key candidates for advancing fishery operations. Michigan, bordering on all but one of the Great Lakes, is also central to major population centers. While Michigan lags in consumption of seafood, fresh seafood from Michigan could find a market of tens of million customers within a day's drive. Other reasons make Michigan an attractive state for trout farming, including the passage of the Aquaculture Development Act (Act 199 of 1996), but Michigan's regulatory mandates are not well prepared for growth in intensive aquaculture production (Colyn and Boersen 2012).

While the appropriate environment for fish health is the primary consideration for intensive trout farming, substantial investment in monitoring and control is also a requirement. Two types of trout farms are common. The first is the flow through system which consists of a series of catchments built around a circulating water system for raising trout on land. While several fishery operations exist in Michigan, the largest systems are flow-through systems but they produce less than 200,000 pounds of fish annually and typically are not large enough to generate a living wage for the farmer. The second type is the open water cage systems that are highly scalable operations, where cages that are anchored to the bottom of a lake are used to house fish feeding operations. While most common in marine environments, some fresh water cage systems are currently in use for the production of rainbow trout in Canadian waters of Lake Huron.

Fish Consumption

North America per-capita consumption of fish is much lower than dietary recommendations. For example, Americans consume about 16 pounds of fish per year, compared to USDA Dietary Guidelines for Americans recommendation of 26 pounds per year, and Canadians consume about 12 pounds of compared to 17 pounds recommended by Health Canada (U.S. Bureau of the Census 2011, RIAS Inc. 2013). Fish is a key dietary component that is recognized by consumers who routinely pursue healthier eating habits. One potential concern is that consumers in the Midwestern states and south central Canada are less likely to consume fish up to dietary recommendations as they have less access to fresh fish and also have food cultures that largely minimize fish consumption. In effect, expanding consumer access to fresh fish could have a germinating effect on consumer demand. In other words, expansion of consumer access to fresh fish may be sufficient in increasing consumer interest in buying and consuming more fish.

Michigan demand for finfish will largely come from Michigan restaurants, as about 70 percent of fish consumption in the U.S. is through restaurants. Though this has not materialized in measurable change in fish consumption, U.S. consumers' interest in improving diets has spawned an increase interest in fish consumption (Dominy 2007). A few reasons may explain this, public mistrust in seafood labeling, safety issues with imported fish (Mintel 2011), the relative high price of fish compared to other protein sources. Furthermore, because the price of fish is relatively high and because it is dominantly purchased in restaurants, demand for fish was likely disproportionately impacted by the Great Recession .

Demand for fish is likely to continue to grow in the Midwest as well as nationally and globally. Both demand and supply is on the rise globally, with demand largely exceeding world supply (World Bank 2013). Globally, finfish aquaculture is the leading source of annual fish output, and is the primary means of meeting the 2.5 percent annual growth in world demand for fish (FAO 2013).

Economic Case for Caged Trout Farming on the Great Lakes

Several concerns are relevant to the development of open water cage systems on the Great Lakes. Most are beyond the scope of this report, where the primary objective is to measure the expected economic contribution, in terms of jobs, income and output, of new aquaculture production in Michigan. Land-based flow-through raceway systems are relevant alternative aquaculture systems to open lake cage

systems. While such systems currently operate in the state, they are generally smaller in scale. There may be reason for this, land-based systems, require significantly more fixed investment and may be less suitable to larger scale operations. Flow-through raceway systems, installed on land, tend to be less profitable from an operational net revenue perspective than cage trout systems when comparing systems of equal capacity. However this does not take into consideration land rents or charges to water rights, where the latter is largely not well established. Flow-through raceways are also less amenable to scaling up, requiring proportional fixed investment, where cage systems benefit from decreasing fixed investment with larger operational scale (Weeks and Knudson 2014). Siting options for open water cage systems are not limited to the Great Lakes, but can also be established in streams, rivers and inland lakes. However, the Great Lakes afford a level of volume and currents that are largely expected to benefit fish health and operational efficiency.

Scenario for Analysis

The Michigan Department of Natural Resources asked the Center for Economic Analysis to undertake a study to measure the expected economic contribution of establishing open water cage systems for rainbow trout aquaculture on the Great Lakes. The focus of this report is therefore limited to determining impact to the Michigan economy of such a change. Potential ecological impacts are beyond the scope of this study, and no consideration is taken as to how increased access to fresh finfish will impact the distribution and in-state consumption of fish.

Two proposed cage trout facilities are envisioned with operations on the Great Lakes. The facilities will raise rainbow trout for human consumption from eggs to 12 or more inches and all fish produced will be processed in state. Each of the facilities are expected to generate up to one million pounds of rainbow trout a year, but will likely start out producing less than half that amount before expanding.¹ While this scale of operations may afford joint products, including fertilizer and fishmeal as food for fish, the value of these co-products are not considered in this analysis. A national retail distributor has been identified and has indicated a willingness to receive this volume of fish for human consumption and we assume that post-harvest processing will take place in state.²

As discussed in the recent Michigan SeaGrant report, economies of scale exists in aquaculture, and joint production opportunities for other marketable outputs may be viable (Weeks and Knudson 2014). Furthermore, aquaculture production requires specialized inputs largely currently not available in Michigan. A substantial increase in Michigan production would, however, likely draw in these resources. More specifically, Michigan currently lacks a fish feed mill and feed must be brought in from outside the state. Hence, feed input expenditures, which occupies approximately a third of total operating costs are assumed to flow out of the state. Joint production opportunities exist in harvesting fish waste during feeding as fertilizer used in agriculture and in converting processed cuttings for fishmeal. While there is some evidence that markets for these co-products exist, this analysis does not attempt to value these co-products.

¹ Specifications provided by the Department of Natural Resources.

² At least one processor has indicated willingness to expand to meet this level of production.

Methods

Standard economic impact modeling approaches that trace transactions across industries, households and the rest of the world are used to estimate the expected economic impacts from these sites. Input-output models are fundamental in understanding the potential macroeconomic-level of impacts from a direct infusion into a local economy. For this analysis, the Impact Analysis for Planning (IMPLAN) Pro 3.1 was used with the most recent (2013) Michigan county-level data (MIG Inc. 2010). Two models are developed – one for the state, comprised of 83 counties, and one comprised of three representative counties. The two models are used to develop impact estimates representative of 1) impacts to the state and 2) impacts to the local community hosting the cage trout systems.

The IMPLAN economic impact modeling system is built on representative production functions of 511 industries. These production functions value the transactions an industry makes in the process of producing a given value of output. The transaction values are measured in share of total final value. The production functions are structured in a table format that recognizes that for every dollar purchased, there is an equal value of a sale. Hence, when a fishery purchases transportation services, the transportation services makes a sale. Subsequently, the transportation services sector must purchase inputs along their production function schedule of purchases in providing that transportation service. These transactions continue as industries transact with other industries in response to the change in output of the aquaculture sector. Such models are well established in the regional economics literature and have been applied to questions of economic impacts for over 50 years.

The IMPLAN model traces purchases along a representative industry production function. For aquaculture, a representative industry does not exist. We start with the industry “commercial fishing”, which for Michigan is heavily influenced by wild catch operations, and modify the expenditure profile using enterprise budgets of cage system operations developed for Michigan (Weeks and Knudson 2014). These budgets detail the expected, typical operating costs and expenditures a cage system engenders over a year of operation. The expected budgeted expenditures change from year to year, but we limit the analysis to fifth-year operations as representative of full ongoing expected expenditures. Furthermore, the cage system enterprise budget is set up to be representative of commercial-scale operations producing 500,000 pounds of output per year. Hence, the budgets are doubled to represent two operations generating 1 million pounds of output per year. This has a potential of biasing the resulting estimates upward due to economies of scale, but it is sufficient to suggest the bias is relatively small. Offsetting this bias is the failure to capture potential co-production if such co-production of fertilizer and fishmeal should take place.

State-level impacts measure the expected cumulative value of transactions up to the processor level of output, while local impacts measure the cumulative value of transactions up to the fishery operations. The reason processor-level impacts are not measured at the local level is that few large-scale fish processing operations exist in Michigan by which to measure an economic impact and because it is conceivable that new facilities, if any, may not locate in the same community as the cage trout operations.

For state-level impacts, we wish to measure the expected output at the processor level, but direct effects are specified at the fishery level. If the fish are to be processed in Michigan, a measure of processor-level sales (output) from these fish is required. We use wholesale industry margins based on USDA, Economic Research Services Food Dollar Series (ERS 2015) and vetted against U.S. Census Wholesale Trade Margins (U.S. Bureau of the Census 2015) to estimate the value of processor output in the state based on full absorption of the combined output of the two cage trout operations. Total production is expected to be 2 million pounds of rainbow trout per year. If we value production at \$2.75 per landed pound (Weeks and Knudson 2014), this implies aquaculture production of \$5.5 million dollars annually. Actual revenues may differ, depending on values realized. As the Economic Research Service estimates that value added and processing accounts for 15.5 percent of total consumer value, once accounting for energy usage and transportation shares (ERS 2015), and converting to processor margins, the expected processor output totals \$6.611 million.

The local model is to be representative of a mostly rural three-county region. Three non-contiguous counties are modeled as a representative region of where a cage trout operation will likely locate. The three counties are coastal counties comprised of Alpena and Mason Counties on the east and west coasts of the Lower Peninsula, and Menominee County, along the Lake Michigan Coast of the Upper Peninsula. Local impacts are limited to fishery operations and only represent one of two projected operations producing one million pounds per year. The representative impacts are for one cage trout operation with one million pounds of production per year. This assumes processing will not take place in the community of the fishery.

We make several modifications to the underlying commercial fish production functions. First, since fish food is not included in wild catch commercial fishing, no change is required in recognizing that no fish mill is operated in the state. Next we remove petrochemical purchases from the commercial fisheries which mostly capture boat operations in wild catch production. Then we add utility consumption for the hatchery and heating, and account for trout egg purchases by adding the share of these purchases, based on enterprise budgets. Finally we bring in charges for eggs. Since the model production function is based on expenditure shares of output, the values imputed into the IMPLAN model is based on the enterprise budget percent of total budget as reported in Weeks and Knudson (2014) for fifth-year operations.

We will take the expected sale price of finished trout as reported in Weeks and Knudson (2014) at \$2.75 per pound. This places total expected value of output at \$2.75 million for each of the cage systems. Direct effects for the state model are specified as \$6.611 million increase in “Seafood product preparation and packaging” industry, while that for the local model is \$2.75 million change in the modified “Commercial fishing” industry.

Findings

The IMPLAN model traces secondary transactions across transacting industries and households to arrive at macroeconomic impacts. Two models are developed and estimated for economic impacts. First, the state model is estimated from the perspective of fish processors in the state, who are expected to

receive and process the farmed rainbow trout. The second model is designed to be representative of the region in which a single farming operation occurs. It assumes processing does not occur in the local community, so the estimates are limited to the value of the cage trout operations.

Estimated State Impacts

Table 1 shows the estimated economic impact of expanding cage trout farming on Michigan’s Great Lakes shores as exemplified by the above scenario. Two aquaculture operations are modeled with a total output of two million pounds per year. This output is pushed through to Michigan fish processing centers, giving rise to additional value added activity that directly supports nearly 17 Michigan jobs. These are not necessarily full-time. The direct jobs are expected to give rise to some \$1.2 million in personal income that includes compensation to workers and proprietors’ incomes. Secondary transactions across industries and households, and includes that of the cage trout operations are expected to generate an additional \$3.7 million in sales (Output) that supports 27 additional jobs.³ In total, we anticipate an increase in overall state jobs of 44 with total incomes of \$2.5 million and \$4.3 million contribution to gross state product (Value Added). These findings rely on the assumption that all culled fish are processed by Michigan processors.

Impact Type	Employment	Income (\$000)	Value Added (\$000)	Output (\$000)
Direct Effect	17	\$1,223	\$2,223	\$6,611
Secondary Effects	27	\$1,245	\$2,123	\$3,666
Total Effect	44	\$2,468	\$4,345	\$10,277

Table 1: State Expected Economic Impact through Processing

May not sum due to rounding error

The secondary employment effects appear larger than we generally anticipate, suggesting a relatively large employment impact from the fish processing sector. We anticipate that the estimated total employment effect may be overstated, when compared to total output effects. In this, the implied employment multiplier is 2.58, compared to 1.55 for output. As these multipliers are related, this large disparity between the two implied multipliers leads us to suggest that 44 jobs is likely the upper limit of the expected jobs total effects.

Estimated Local Impacts

The local model is developed based on three representative counties in Michigan including Alpena, Mason and Menominee Counties, and represents the expected outcomes that accrue to the community that hosts the rainbow trout farming operations. Because the analysis stops at the production of raw material inputs before processing, the impacts are more modest. In total, the hosting community can expect about eight direct jobs employed by the farming operation with total personal income of about \$672 thousand. Secondary transactions contribute to another 7 jobs. Once accounting for both the direct and secondary effects, we anticipate the community may tack on 15 additional jobs with local personal income of \$922 thousand.

³ Secondary effects are comprised of both indirect (between industries) and induced (from income) effects.

Impact Type	Employment	Income (\$000)	Value Added (\$000)	Output (\$000)
Direct Effect	8	\$672	\$725	\$2,750
Secondary Effects	7	\$250	\$441	\$960
Total Effect	15	\$922	\$1,167	\$3,710

Table 2: Local Expected Economic Impact From farming

May not sum due to rounding error

As purchases from fisheries are a secondary transaction to fish processors, the direct effects in Table 2 are encompassed in the secondary effects of Table 1. When comparing outcomes, it suggests that anticipated statewide impacts are fairly conservative compared to local impacts of the cage trout system.

Conclusions

Interest in developing and expanding Michigan’s aquaculture industry exists, in part, from a potential economic opportunity from increased US and global demand for seafood. Idaho is the nation’s number one producer of farm-raised rainbow trout, producing about 70 percent of the nation’s farmed output. Michigan, despite its abundant supply of water, has lagged other states in expanding aquaculture output. While aquaculture production is found throughout Michigan, this report takes up the question of economic impacts of developing cage systems that are housed on the Great Lakes. Some are concerned that intensive aquaculture poses environmental risks. This concern is enhanced given the novelty of the lakes and the luster of the pristine waters should cage systems be installed on the lakes. However, caged fisheries are not new to the Great Lakes; as such systems have been operating off Ontario’s shores of Lake Huron since the early 1980s. The Canadian experiences with open water cage systems on Lake Huron should be considered when moving forward. However, this report does not address potential environmental issues, nor regulatory constraints that restrain Great Lakes cage aquaculture.

Holding environmental issues aside, this report details the expected economic impacts of two Great Lakes cage trout systems that produce about one million pounds each. The estimated impacts are generic impacts based on anticipated typical production systems reported by Weeks and Knudson (2014). Care should be exercised in interpreting the results as impact estimates are based on hypothetical, not actual, pro forma budgets. Furthermore, if such an industry does materialize in Michigan to this scale, it is very likely that industry structure will change to take advantage of new opportunities. Where Michigan currently has no fishmeal provider, profitable opportunities to co-locate fishmeal production to serve new aquaculture facilities will tempt new entrants. Additionally, Michigan has one commercial-scale fish processing center in a somewhat inopportune location to where current proposals place fish farming. Again profit incentives would likely lead to changes in industry expenditures and structures that would change the expected economic impacts of fishing operations.

Two models were developed. The first is a statewide model that tracks the economic impact through processing on the assumption that all raised trout are processed in state. These estimates assume that processor capacity essentially expands without cost to meet the new processing demand. The second

model tracks transactions directly from the anticipated farm activity as it transits through the local, community-level economy.

The results suggest that locating two, one million pound cage trout fisheries could lead to up to 44 Michigan jobs gain with annual incomes of just under \$2.5 million. This will also likely to contribute \$4.3 million in annual gross domestic product. These numbers should be considered in light of additional factors relevant to policy discussions around open water cage systems on the Great Lakes. Most of these considerations, entailing ecological, aesthetic and regulatory issues were beyond the scope of this study.

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