A Strategic Plan

for a

Thriving & Sustainable Michigan Aquaculture

Michigan Sea Grant Integrated Assessment – Project Report

October, 2014

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Commercial aquaculture has been underdeveloped in Michigan and the Great Lakes Region at a time when global demand for seafood is on the rise and global capture fisheries have reached maximum yield. Michigan is situated centrally to the abundant freshwater resources of the Great Lakes basin containing 20% of the world's available freshwater. The strategic plan for the sector provides a roadmap to the creation of a thriving and sustainable aquaculture providing abundant healthy food while sharing and preserving vital water resources for other uses including tourism/recreation, industry, and other forms of agriculture.

Sea Grant Michigan

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food systems for a healthier world

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Executive Summary

The United Nations Conference on Trade and Development (UNCTAD) issued in September 2013 its Trade and Environment Review 2013 (TER13) that focused on a call to make agriculture truly sustainable. The TER13 contends that, "*We need to see a move from a linear to a holistic approach in agricultural management, which recognizes that a farmer is not only a producer of agricultural goods, but also a manager of an agro-ecological system that provides quite a number of public goods and services (e.g. water, soil, landscape, energy, biodiversity, and recreation)*" and "a higher regional focus of agriculture along the lines of '*as much regionalized/localized food production as possible; as much traded food as necessary*'"[1].

Through this reasoning, a thriving aquaculture sector is not only a great opportunity for Michigan, but an important step forward in support of a growing world population with increasing demand for safe and sustainable seafood. The balance in global demand has shifted and in 2012 China, the leading producer of seafood, has become a net seafood importer. Meanwhile, USA's seafood deficit surpassed the $12 billion mark, and appears to be increasing by approximately $1 billion annually at its current rate. With 20% of the world's usable fresh water along its borders, and freshwater aquaculture supplying over 60% of global production, many believe strongly that Michigan is capable of creating a billion dollar sustainable seafood sector by 2025.

And the timing is right. On December 3, 2013 the National Restaurant Association published its Top Ten Trends[2]. Two of the top ten included locally sourced and sustainable seafood, while a number of other top trends listed can be indirectly related to sustainable, branded and healthy seafood products (right).

The Sea Grant Integrated Assessment project that initiated the development of this Strategic Plan for a Thriving and Sustainable Michigan Aquaculture Sector is indeed an assessment – a look at options on how the sector might develop into the future. Since the sector currently is very small, with sales of less than $5 million annually, the project developed a plan that

[1] UCCTAD, Trade and Environment Review 2013, September 18, 2013, accessed on October 22, 2013 at http://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=666

[2] http://www.restaurant.org/News-Research/News/What-s-Hot-in-2014-culinary-forecast-confirms-sour

includes a set of scenarios outlining what that sector might look like in the year 2025. The various scenarios range from the less ambitious "***Hamburger Nation***" scenario - minimal internal, organic growth of the sector, contributing little if any to the global or local food demand, to a thriving sector portrayed in the "***Seafood: An Essential Animal Protein***" scenario with Michigan contributing $1 billion or more of farm gate product. And while the latter scenario seems like a stretch, others have suggested that in fact the sector could generate much more - up to $5 billion at the farm gate. Why? One driving factor is the projection that global seafood demand is expected to increase by 100-170 billion pounds and $330 billion dollars in value by 2030. For example, the October 2013 Transparency Market Research report projected that aquaculture will reach $195 billion by 2019 – a $60 billion increase from 2012[3]. That's an average of $10 billion in annual growth. Since the capture fisheries are at or above maximum sustainable yields, aquaculture will be relied upon to meet this seafood demand.

Given the current global annual value is over $100 billion, projections for increasing demands for fish protein both at home and abroad, and Michigan's abundant aquatic resources, a figure of $1 billion by 2025 does indeed seem possible. It is important to remember that this value should be considered as an all barrier removed figure, with expansion supported by research, minimal and acceptable environmental or water quality impact, a promotional regulatory environment, and social acceptance. The plan describes 3 other scenarios that could also occur. Realistically, the future has highest probability of falling somewhere between all scenarios.

The real question should be then: how can Michigan achieve a billion dollar sustainable seafood sector through aquaculture? The state has the water – fully 10% of the world's usable fresh water lies literally within the state borders. It possesses a talented workforce – engineers and biologists that can be engaged in adapting and inventing technology and systems for fish production. This Strategic Plan is rooted in a view that the earth is rich in resources and that mankind's innate creative capacity and desire to thrive can be leveraged to meet the increasing global demand for seafood, sustainably, in part from the Great Lakes State and the region, led by enterprising and stewardly Michiganders.

- ✓ **Aquaculture has surpassed wild-capture seafood market share.**
- ✓ **The capture fishery is at maximum yield or collapsing worldwide.**
- ✓ **Michigan is a global leader in water technology and sustainable water management.**
- ✓ **Sustainable aquaculture needs Michigan.**
- ✓ **Michigan can be the future of sustainable freshwater aquaculture.**

This Strategic Plan's target audience includes all stakeholders in a sustainable seafood production sector. First among those could be entrepreneurs including established, new, or interested commercial fish farmers that support this plan and have desire to drive the strategy forward. Secondly the report addresses government officials at all levels to provide sufficient information for their endorsement of

[3] Transparency Market Research—*Aquaculture (Marine Water, Freshwater and Brackish Water) Market for Carp, Mollusks, Crustaceans, Salmon, Trout and Other Fishes - Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2013 – 2019* accessed October 30,,2013 at http://www.prnewswire.com/news-releases/global-aquaculture-market-is-expected-to-reach-usd-19513-billion-in-2019-transparency-market-research-229075211.html

the strategy in support of messaging Michigan being "open for business". Thirdly the report provides context for non-governmental organizations (NGOs) to engage and ensure that the triple bottom line is considered in ensuring that both a thriving and sustainable aquaculture sector is developed, one that meets the **economic, social, and ecological** needs of our citizens, including members of the public and communities with high concern for local, sustainable and healthy food supplies, jobs, and cultural lifestyles.

Ideally this strategic plan will serve as a launching pad to a thriving and sustainable aquaculture sector in Michigan and the Great Lakes Region. More importantly it will stimulate further dialog and discovery on what exactly the sector can become. We have no pretense that the scenarios we propose will play out as we have proposed – either one specifically or any combination of the four. They serve primarily to advance ongoing thought processes and planning. Actions resulting from these discussions dictate whether Michigan will contribute to feeding the world safe, high quality protein produced in a well-managed, environmentally sustainable agro-ecological system. To that end we trust the leadership of the Michigan aquaculture sector to use this as living document, appending it with better information and insight over time, to guide the development of a thriving and sustainable sector.

Commercial aquaculture presents significant opportunities to the welfare of Michigan and its citizens. Among them include jobs, good food, improved health, and economic prosperity. The capacity of our resources and the capability of our residents can address the technical, policy, regulatory, business and stewardship challenges required to create the thriving and sustainable sector envisioned. As this plan points out, achieving success will be a significant challenge, yet it is achievable.

The Strategic Plan focuses on seven key objectives designed to help achieve a thriving and sustainable Michigan aquaculture sector (*below)*.

One priority links **Social Acceptance** (the broader society) with **Political Will (**within governments). These are clustered with **Achieving Trust**, through commercial, government, and third party practices. **Invest** and **Design** action areas are important because commercial aquaculture is still relatively early in its life cycle. **Research**, **education** and **extension** will be required to ensure that people and practices are in place to support sustainable growth, and will likely arise through some combination of private (feed, technology, genetic, suppliers and/or established seafood integrators and consultants) and public (universities, extension, government programs) effort. **Leadership** for the sector should come from the commercial sector, ideally through a refocused trade association committed to this plan. The Michigan Aquaculture Association adoption of this plan is an important first step. Staffing for an Executive Director is a critical following step. Achieving **Improved Business Plans** and **Financing** offers regional opportunity and leveraging of abundant water and people resources to attract entrepreneurs from other sectors of agriculture, other aquaculture enterprises globally, and investors new to the sector.

As a Sea Grant Integrated Assessment report, this strategic plan was peer reviewed (2014) by a number of stakeholders. Additional feedback offering insight, that provides additional science, points out challenges and options, and otherwise builds on this product are expected and welcome. A strategic plan should never be static. Indeed in a recent book "Strategy: A History"[4], Lawrence Freedman concludes that it may be better to look at strategy as a form of script…which is open ended. Unless prepared to adapt it (the strategy) as circumstances change it is unlikely to do much good. The Michigan Aquaculture Association has adopted this Strategic Plan and is beginning to act.

The Integrated Assessment Approach

The Sea Grant Integrated Assessment approach used in this report both reviews and analyzes existing information and provides possible solutions for the development of a sustainable and thriving aquaculture sector in Michigan. This project is somewhat unique in that it focuses on management and business aspects of aquaculture while addressing issues of policy and science. The policy question this project was designed to achieve is as stated:

Integrated Assessment Policy Question

What critical elements are restricting Michigan's current commercial aquaculture activities from developing into a major sustainable seafood production industry, what actions must be implemented to rectify the situation, and what are the associated benefits to the state of Michigan?

The business of aquaculture includes food production, planting and stocking to public and private water, and bait, however, in the context of feeding an increasing world population the aquaculture challenge of the next few decades will focus on sustainable food production. So how do we make well "informed decisions"? The Sea Grant Integrated Assessment framework helps to provide a basis for making informed decisions by considering social sciences, natural sciences, and policy along with economic/business factors and forces.

The project process used in the development of this strategic plan is outlined in Appendix 2.

[4] http://www.amazon.com/Strategy-A-History-Lawrence-Freedman/dp/0199325154

Initial Strategic Actions (2014)

Expand and Establish Aquaculture Enterprises Along the Supply Chain

– BASED ON PROVEN SPECIES, TECHNOLOGIES, AND MARKETS TO DEMONSTRATE SUSTAINABLE GROWTH

- By: 2014-2016
- Through: Commercial enterprise – achieve near-term targeted quadrupling to $3-8 million in farm-gate sales

"Open for Business"

(1 - Social Acceptance/Political Will)

– AQUACULTURE IS ENDORSED IN THE MICHIGAN GREAT LAKES WATER STRATEGY AS A NEEDED ECONOMIC ACTIVITY

- By: Q1, 2014
- Through: Office of the Great Lakes, with support from Quality of Life Departments, MEDC, Governor

Engage Tribal Leadership & State Regulators in Great Lakes Water Usage

(1 - Social Acceptance/Political Will)

– DEFINE WATER AREAS FOR SHIPPING, FISHING, PRESERVES, RECREATION, **and AQUACULTURE** AS PART OF A COMPREHENSIVE USE PLAN THAT CONSIDERS THE NEED FOR COMMERCIAL ACTIVITY FOR THE PUBLIC GOOD FROM PUBLIC RESOURCES.

- By: Initiate dialog in 2014, work towards definition ahead of expiration of current 1836 Consent Decree (by 2020)
- Through: Negotiations and/or legislation towards consensus that seeks the economic/social/environmental welfare of all stakeholders in society

Permitting and Regulation

(2 – Achieving Trust)

– Continue to DRIVE SIMPLIFICATION OF PERMITTING THROUGH STATE GOVERNMENT, building on the current QOL Working Group process, ACHIEVING WORLD-CLASS TURN-AROUND (< 60 days)

- By: Year End 2014
- Through: Continuous Improvement practices, while handling new incoming applications

Drive RAS Operations Cost Reduction

(3/4 – Research/Education/Extension)

- By: 2104 and ongoing - secure research grant for 2015 and implement research program
- Through: Research Program to Improve on Energy Usage and Capital Costs per unit of Production - secure first research grant funding through Michigan Sea Grant or other sources

Funding Sector Leadership

(5 – Leadership: a Sector Champion)

– HIRE A CHAMPION FOR A THRIVING AND SUSTAINABLE MICHIGAN AQUACULTURE, ENGAGING STAKEHOLDERS, ATTRACTING INVESTORS, LEADING PUBLIC-SECTOR PARTNERING

- By: year-end 2014
- Through: The trade association (MAA), with private and/or public funds (with matching "kick-start" funds for up to 5 years from an MEDC Aquaculture Development Program – negotiated or legislated)

Attracting Investors and Financing Growth

(6 Improved Business Plans & 7 Attraction)

– BEGIN MESSAGING IN SUPPORT OF "OPEN FOR BUSINESS"

- By: 2014 & 2015 aquaculture sector annual meetings and conferences – and ongoing
- Through: MAA Leadership, in partnership with AIM stakeholders including MEDC and MDARD-OAD

Thriving and Sustainable Michigan Aquaculture

I – Introduction:

Commercial aquaculture has been underdeveloped in Michigan and the Great Lakes Region at a time when global demand for seafood is on the rise and global capture fisheries have reached maximum yield. Michigan is situated centrally to the abundant freshwater resources of the Great Lakes basin containing 20% of the world's available freshwater. The strategic plan for the sector provides a roadmap to the creation of a thriving and sustainable aquaculture providing abundant healthy food while sharing and preserving vital water resources for other uses including tourism/recreation, industry, and other forms of agriculture.

The world faces an unprecedented challenge over the next 35-40 years. A population of 9 billion will necessitate doubling of global food production – and a quadrupling of protein production. Southeast Asia's 3 billion people presently consume about 20 grams of protein a day compared to a western country's diet of up to 200 grams per day. This population is in the process of improving the quantity of its protein consumption to more closely resemble the U.S. consumption thus necessitating even greater food production as protein. As incomes increase people eat more meat (including seafood), as illustrated in Figures 1[5] and 2[6] – a trend that gives no indication of abating.

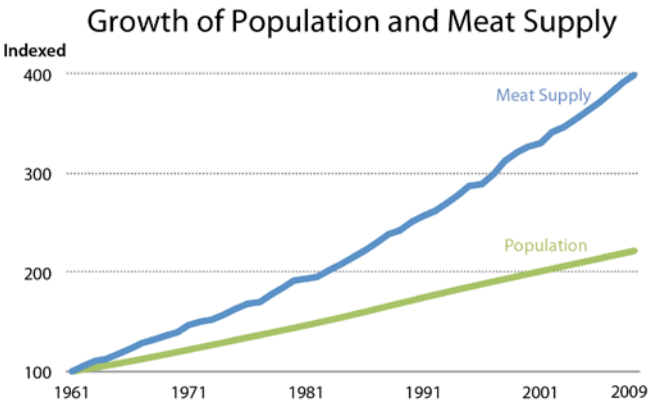

Figure 1. Global population growth and meat supply.

Currently half the world's meat protein source is seafood (fish, shrimp, mollusks). The capture (wild caught) fishery, traditionally the major source of seafood, has resulted in overfishing and thus an increased need for aquaculture. In fact, in 2012 the amount of seafood consumed originating as farmed was greater than wild caught[7] for the first time in history.

Today about 90 percent of the seafood consumed in the United States is imported –

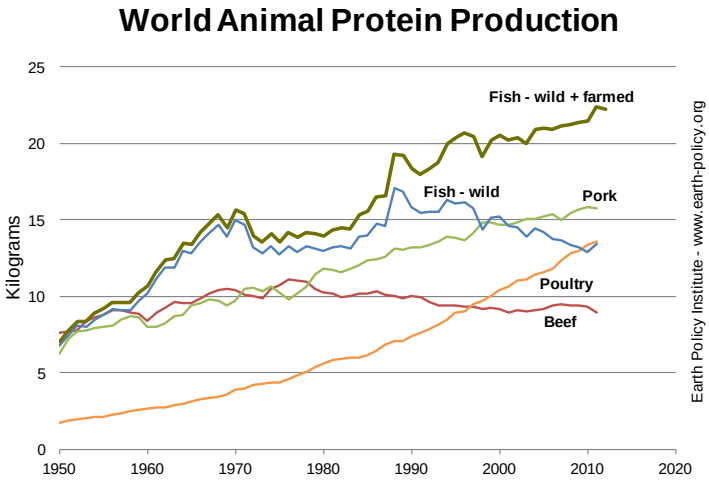

Figure 2. World animal protein production by type 1950 - 2011.

[5] United Nations 2012 http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=92
[6] Earth Policy Institute - www.earth-policy.org
[7] http://ww3.economist.com/news/finance-and-economics/21583296-fish-are-getting-more-expensive-they-do-not-all-move-same/print

and our seafood trade deficit is increasing by about $1 billion annually (see Figure 3[8]).

Recommendations from health experts include an expansion of seafood in the U.S. diet, from a 14.4 lbs per capita annual consumption (in 2012), to 26 lbs seafood per capita consumption.[9] Much uncertainty exists with regards to the safety of imported seafood and whether or not it's produced in an environmentally sound manner. Recent regulations proposed by FDA in the Food Safety Modernization Act [10] (FSMA), driven by domestic and global food safety problems, seek to provide some safety assurances for imported foods including fresh and frozen seafood. The FSMA is expected to drive global demand for foods sourced from the USA and other first-world countries that have well-established food safety regulation and practices, creating export opportunity across the food industry including the aquaculture sector.

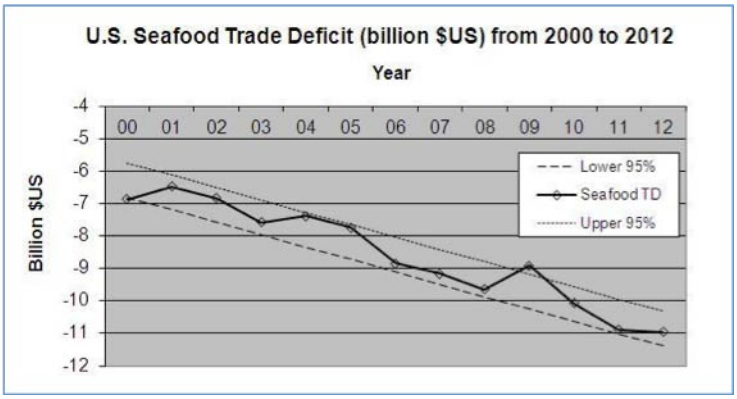

Figure 3. US Seafood Trade Deficits – Increasing Reliance on Imports

Food fish is the primary growth opportunity driven by changing market demands. While there may in fact be additional niche opportunity for development in stocking, bait, and in aquatic plants for food, feed, and aesthetic markets, these are currently not a focus of this plan.

These trends present great challenges, but also a significant opportunity

Commercial aquaculture development has the potential to contribute to food security in many places by closing the gap between the rising demands for fish and declining capture fisheries.[11] The challenge is to do it right. Put another way, the *how* is as important as the *what* when it pertains to aquaculture simply because of other high demands on freshwater resources including drinking, industry, and recreation. The UN FAO addresses the how question with its Ecosystem Approach to Aquaculture: "***An ecosystem approach to aquaculture (EAA) is a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems."***[12] Implied is that aquaculture, the rearing of aquatic animals or the cultivation of aquatic plants for food, is also a commercial economic activity, raising fish for food directly and/or for stocking in the wild to ensure a sustainable capture fishery and recreational supply of fish.

[8] Myers, Joseph J., New Jersey Department of Agriculture, Trenton, NJ – accessed June 2013 at http://michiganaquaculture.org/2013/05/03/2012-us-seafood-trade-deficit-what-can-pecans-say-about-aquaculture/

[9] US FDA Dietary Guidelines for Americans, 2010. http://www.health.gov/dietaryguidelines/2010.asp

[10] Food Safety Modernization Act, 2011 http://www.fda.gov/Food/GuidanceRegulation/FSMA/default.htm

[11] Hughes, Sara and Joan Rose. 2011. "Governing Global Aquaculture for Human Security," with Joan Rose, in *Sustainable Fisheries: Multi-Level Approaches to a Global Problem,* eds. Michael Schechter, Abigail Lynch, and William Taylor: Bethesda, MD: American Fisheries Society Press. P.3

[12] FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES, 5 Suppl. 4, AQUACULTURE DEVELOPMENT 4. Ecosystem approach to aquaculture at http://www.fao.org/docrep/013/i1750e/i1750e00.htm (sourced September 6, 2013)

One element of complexity is that society has relatively little experience managing an underwater food production system (as compared to land-based agriculture). Likewise, we are not masters of 3-dimensional production. All of our land-based farming, even our domesticated birds, operate at or near the 2-dimensional plane of the earth's surface. In an increasingly crowded world the harvesting of food needs to expend towards a third dimension. Farming the depths of oceans and lakes is a great opportunity to contribute to society's wellbeing. This strategic plan aligns with this ecosystem approach.

While commercial freshwater aquaculture in North America is still in its infancy relative to other animal and crop agriculture, the arts and sciences of fish husbandry are advancing rapidly. Aquaculture has expanded globally in the past few decades to the point where in farmed fish production has now surpassed the world capture fishery. The capture fishery cannot supply the growing seafood demand of a global human population expected to grow to 9 billion by the year 2050[13]. Society needs to figure out how to sustainably manage our water resources to include aquaculture, and Michigan is uniquely positioned for the creation of a thriving and sustainable aquaculture sector.

Sustainable Development: The Bruntland Commission coined what has become the most often-quoted definition of sustainable development: "***development that meets the needs of the present without compromising the ability of future generations to meet their own needs***."[11] Sustainable development gives consideration to the Triple Bottom Line – ensuring that economic (profit), ecological (planet), and social (people) needs are satisfied.

Thriving: To thrive is defined as: ***1. to prosper; be successful. 2. to grow or develop vigorously; flourish.*** Sustainable development is more than upholding the status quo. To meet the needs of the future a sector's systems – its economy, ecology, and society must advance in a way that is not only sustainable but results in growth and advancement. It must thrive. This can be achieved by applying the best science, economics, stewardship practices, and insight to the development of aquaculture.

Farm raised fish are efficient convertors of feed into meat protein. Feed conversions is the amount of feed required to produce a pound of meat. For example, cattle have a feed conversion ratio of approximately 7:1, hogs and chickens 2 or 3:1. Fish can achieve 1.5:1 and even 1:1 under ideal growth conditions. This presents a huge opportunity for fish culture.

Farm raised seafood has the ability to lower the pressure on wild caught fisheries and will result in a more sustainable source of meat protein for the world. Some fishmeal is utilized in farmed-fish production diets; however, improvements in both the use of vegetable protein (primarily soybean meal), genetic selection, and the re-use of fish processing offal into feed will reduce pressure on wild caught fish meal. The rendering of processing offal for re-use as fishmeal in feeds presents a complimentary business opportunity in the sector that can contribute to both economy and ecology by reducing waste.

As we consider how to develop aquaculture, we need a vision for the future – for the Michigan opportunity, rooted in the global context.

[13] The Economist - http://www.economist.com/node/18200618

In summary:

- ✓ **Aquaculture will be relied on to meet the growing demand for seafood**
- ✓ **Seafood is an efficient way to deliver healthy meat protein**
- ✓ **Michigan's freshwaters are underdeveloped as seafood production resources**
- ✓ **There is opportunity to develop a Thriving and Sustainable Aquaculture Sector in Michigan**

The development of sustainable aquaculture is a priority for the sector and also the topic of much discussion and writing in recent years. The following excerpt from July/August 2013 "Rethinking An Industry" highlights some of that dialog and points to the opportunity:

Rethinking An Industry: Examining a New Social Contract for Aquaculture

With many undersold health benefits and much untapped potential, seafood has an opportunity to become a much more important part of a typical western diet. Dr. Barry Costa-Pierce, a researcher with the University of New England says that aquaculture, in particular, has the potential to play a key role in this brave new world, but it will require some revolutionary thinking.

"The dream of Jacques Cousteau that we were going to farm the oceans sustainably to provide nutrient-dense foods essential for human health and wellness was a good idea then and it's a good idea for our future," Dr. Costa-Pierce told an audience at the Bay of Fundy Seafood Festival's Seafood Forum in June. "In a world of about nine to ten billion people, we're going to have to find a way to sustainably intensify aquaculture in the near shore."

Jones, Matt, Full story Published in "Aquaculture North America, Volume 4, Issue 4 July/August 2013, accessed online on Dec 24, 2013 at http://mattjoneswrites.com/2013/09/23/rethinking-an-industry-dr-barry-costa-pierce-examines-a-new-social-contract-for-aquaculture/

II - Framing the Strategic Plan

The strategic plan utilizes a SWOT analysis to examine the situation of the Michigan aquaculture production sector as it exists today. We also present a set of scenarios developed to envision what the sector could look like forward in year 2025. In addition a number of case studies are provided to help gain understanding how aquaculture has progressed successfully in other regions of the world and how other sectors of US agriculture have successfully grown.

SWOT

A SWOT (strengths, weaknesses, opportunities, threats) analysis of the Michigan aquaculture sector was completed in the fall of 2012 by Michigan State University (MSU) Product Center. The illustration in Figure 4 provides an overview of the SWOT outcomes. The full SWOT report is provided in Appendix 8.

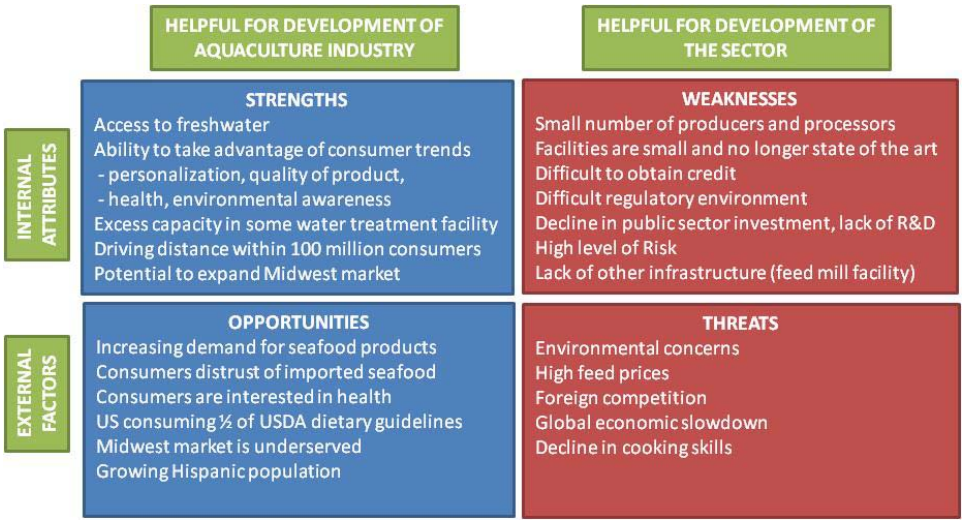

Figure 4. Graphic Overview of Michigan Aquaculture SWOT

The SWOT provides sound context in support of developing a scaled-up aquaculture in Michigan. Strengths include the water resources and a holistic thinking approach to sustainability in the region. Opportunities are market driven with seafood as a preferred healthy protein source in an underdeveloped market in the upper Midwest region. A key weakness is the small production base that exists in the state and the weak organic growth resulting from a difficult regulatory climate in past decades. A major threat is a softening global economy slowing growth and spending power of the middle class. Yet even with those threats seafood is extremely well positioned, as compared to other meat sources, because of its low carbon footprint and highly efficient feed and protein conversions.

The SWOT analysis suggests that current strengths and opportunities for the development of a thriving and sustainable aquaculture sector outweigh the weaknesses and threats. Moreover, a number of the threats can be overcome through pathways identified within this strategic plan.

Michigan Attributes

Building on the SWOT analysis 'snapshot' of the sector in 2012, this integrated assessment identified a number of key attributes that position the state well for aquaculture success. These are outlined below.

Michigan's Natural Resources:

Michigan is located in a very unique position to take advantage of increasing needs and demands for seafood products. We have sound legacy of natural resource protection that, while by some is deemed

constraining, can also be considered solid framework for a growing sustainable aquaculture sector in respect of societal demands on valuable water resources (drinking, recreation, aesthetic). The key? Development of aquaculture in Michigan must be accomplished in a sustainable manner.

The key to seafood production in Michigan is to do so in a sustainable manner

And we can learn from the experience of our neighbors to the north. Canada has invested in both commercial freshwater aquaculture and in research to study the impact of fish farming. For more than a decade research lead by Dr Cheryl Podemski in Canada's Experimental Lakes region has measured the impact of fish farming in an enclosed lake[14], with all indications that a sustainable ecosystem can be retained as a compliment to aquaculture operation. On the commercial front a dozen farms have operated successfully for 10-15 years as cage production facilities in Lake Huron waters. However, it must also be noted that these operations are not without constraints and controversy from regulatory issues, which we can learn from as well.

Michigan's 11,000 inland lakes and 36,000 miles of streams together equal almost 1200 square miles of water resources available to meet society's needs, including fish production. Add to that our 38,575 square miles[15] of Great Lakes water and together that totals more than 24 million acres of water surface.

And aquaculture is a very efficient use of land and water spatial resources. Less than 2000 acres of water surface area could achieve $1 billion of farm-gate fish sales through flow-through, open water cage culture and intensive recirculating systems.

Additionally, fish farming can leverage the heritage and expertise of Michigan's existing wild caught fisheries personnel and infrastructure. The fishermen know our waters and fish processing capacity is in place to help rapidly grow the sector. Moreover, these operations are typically located in rural areas where jobs are needed.

While there may be a tendency for people reading this strategic plan to place focus and scrutiny on cage culture in the Great Lakes, Michigan aquaculture expansion is envisioned across all types of aquaculture development across the entire state. The Upper Peninsula has existing wild caught fisheries and a culture of natural resources utilization and stewardship that could be complemented by open water aquaculture systems. The southern tier of counties in Michigan house vacant urban areas in and close proximity to major markets. These areas also offer potential to partner with existing municipal resources. Most of the existing aquaculture production in Michigan occurs in the middle third of the state alongside cold-water streams. While existing farms are currently limited in capacity, they could be renovated and/or expanded in fairly short time.

It is important to keep in mind that aquaculture is farming in water. It is a biological process, that when managed well, can contribute to healthy life cycles in water bodies. Therefore from a sustainability standpoint, maintaining proper balance must be the number one priority of the fish farmer. The point that clean healthy water is required for fish survival provides tremendous incentive for aquaculturists to

[14] Department of Fisheries and Oceans Canada, 2013 at http://www.dfo-mpo.gc.ca/science/publications/article/2007/27-09-2007-eng.htm
[15] http://www.michigan.gov/mdot/0,4616,7-151-9622_11033_11151-67959--,00.html

do it right and protect the triple bottom line, which is the foundation of sustainability, for the benefit of their own enterprise, the environment and society.

In a growing world facing shortages of food and water, we must utilize our resources to the very best of our ability

Michigan's Foundational Infrastructure:
Michigan, by being central to the Great Lakes region has representation, and often leadership, on the various commissions and committees charged with Great Lakes stewardship. Through sound science, and partnerships in sustainable development, Michigan can foster sustainable growth for future needs while ensuring stewardship of resources.

Michigan Sea Grant summarized well the various private and public Michigan organizations committed to aquaculture's future:

"*MDARD has jurisdiction over aquaculture farms, while MDNR controls species of aquatic animals that can be used for aquaculture in the state. MDNR also runs the largest aquaculture program in the state to produce fish for sport fishing and reintroduction. The U.S. Geological Survey, NOAA, and Great Lakes Fishery Commission all interact with MDNR on invasive species issues. Michigan Aquaculture Association (MAA) represents the businesses currently in Michigan's aquaculture industry. The Michigan Economic Development Corporation (MEDC) represents state initiatives for future economic development, including the aquaculture industry. NCRAC, MSU, and UM house researchers in technology and products. Michigan Sea Grant (MSG) has considerable expertise in seafood safety, marketing, and other technical areas. The addition of full-time personnel to support the aquaculture industry would significantly enhance additional targeted program efforts. Communities of Michigan, including Saginaw, Detroit, and Muskegon, as well as smaller rural settings in the Thumb and Upper Peninsula, have expressed interest in aquaculture businesses, as well as fish processing industries. Several nonprofits, including the Aquaculture Communications Group, LLC (Novi), Changing Seas (Port Huron), and Aquaculture Research Corporation (Tecumseh) have promoted aquaculture for the future of Michigan. A number of private investors have also indicated interest in promoting Michigan aquaculture. The combination of talent and conditions in Michigan makes this a perfect time to bring all of these resources together to develop a more coordinated aquaculture industry."*[16]

Seafood Markets:
Michigan is within a one-day drive of 70-100 million people – one quarter of the population of the USA and Canada. The Midwest currently imports more than the national average of 90 percent of its seafood – unlike the coasts, where they both capture and farm more seafood. The development of an aquaculture industry in Michigan would support the increased interest in local and regional food, and beyond, that contributes to a more resilient food system in the Upper Midwest.

Skilled Technical and Operations Workforce:
It might be oversimplifying to say that raising fish is about managing water quality, however, maintaining optimal water quality is critical to aquaculture success.

Michigan has a very technically trained work force. Our fisheries biologists are among the best in the world. And our engineering workforce is second to none. We have the engineering and water systems expertise that can be leveraged for commercial expansion of aquaculture. Granted, few today work in aquaculture, however skills in system controls, municipal water and sewer, food process design, quality

[16] Diana, James, September 20, 2013, personal communication to the authors

control and management, and mechanical engineering can be applied to aquaculture development. Furthermore, we know how to make stuff in Michigan. We can also leverage our plastics, metal, controls, food processing, water and sewer, and natural resources expertise to quickly develop a sustainable aquaculture sector.

Michigan also has overall experience in general food production and processing systems, including installed processing capacity for handling our capture fishery products for filleting, freezing, and roe processing. Aquaculture brings together nature (biology, nutrition) and technology (production, engineering). It could be argued that one area where we need more expertise is on the production side of fish farming, specifically experienced commercial operators. This strategic plan proposes that skill-sets can be secured by attracting established aquaculture firms and personnel from around the world to Michigan.

Michigan is well positioned to offer resources, infrastructure, skill sets and market opportunities to ventures interested in investing in aquaculture here; however, a different mindset from status quo is necessary. It's about people asking: "**How can we get the job done**?"

SWOT/Michigan Infrastructure Summary:

- ✓ **We have the natural resources: water, and land**
- ✓ **We have the foundational infrastructure: Leadership in natural resource stewardship**
- ✓ **We have the markets: 70-100 million people within a day drive**
- ✓ **We have the skilled technical and operations workforce: biologist, engineers, farmers that can be trained and adapt to support the aquaculture sector**

SCENARIOS – Views From the Future: What Michigan Aquaculture Might Look Like in 2025

In November 2012 a Scenario Planning workshop was facilitated to explore what the future of Michigan aquaculture might look like. Scenario Planning is a process wherein we look for options, asking, ***"What might we need to do?"*** as we develop a sector. The typical outcome of the process is a set of scenarios – stories set at some time in the future. In this case the year proposed to Integrated Assessment workshop participants was 2025. These stories then provide a framework within which, as we plan, allow us to ask, "***Are our proposed strategic actions 'wise' when considered from a 'future' perspective?"*** The goal is to act with wisdom ***in the present*****,** informed by a perspective ***from the future (the scenario stories),*** and not only the past. For a bit more background on why developing scenarios can be helpful in planning for the future see Appendix 6.

The outcome of the workshop was a set of four scenarios describing Michigan aquaculture in the year 2025. In the scenario planning process an analysis of forces and factors that may affect the sector's future are evaluated for importance and uncertainty, leading to the identification of what are described as critical uncertainties, described as "*The Dwelling-Places of Our Hopes and Fears*"[17], where importance meets uncertainty. Stakeholders then, through a process of elimination and prioritization, identify two

[17] Schwartz, Peter, 1991, The Art of the Long View, Currency/Doubleday, p. 115

critical uncertainties for use in framing the scenarios. For the aquaculture scenario exercise participants identified Social Acceptance and Capital Investment as those critical uncertainties.

Social Acceptance
In recent decades, through policy and practices, society and environmental regulatory agencies have preferentially designated water resources for recreation and conservation purpose over economic uses (Note: the shipping industry takes noticeable exception to this observation). While not always explicitly, this point was confidently identified as a reality. Policy therefore must be evaluated to achieve the best possible balance for water use in the state including aquaculture.

Capital investment
Obtaining capital remains a critical uncertainty for aquaculture development, especially in the United States. Regulations, historical lack of sector understanding in the region, and the foundational capacity from which to build upon are some of the causing factors. With the improving regulatory framework and government support that includes a simplified and streamlined permitting process, the stage could be set for the attraction of capital from local and global investors and entrepreneurs.

The Integrated Assessment Workshop Scenarios are summarized in the matrix shown in Figure 5.

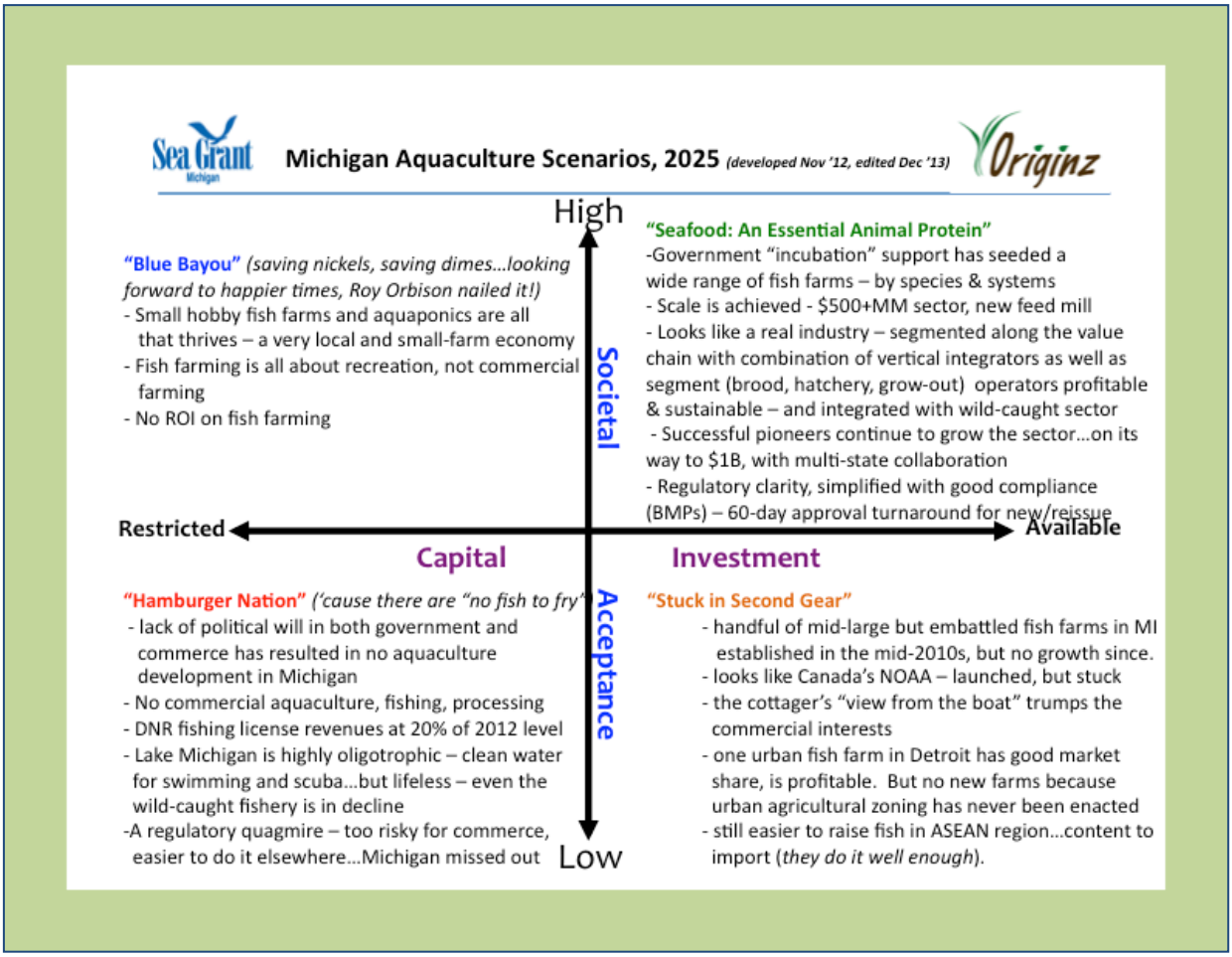

Figure 5. Michigan Aquaculture Scenarios

The scenarios that best illustrate the extremes of how the sector might develop over the next 12-15 year are the focus of this strategic plan: ***Seafood: An Essential Animal Protein***, and ***Hamburger Nation.*** However, we will first take a quick look at the other two scenarios.

The ***Blue Bayou*** scenario presents a future where very small scale fish production and aquaponics serve CSA (Community Supported Agriculture) and other local and direct markets, primarily because operators have determined to work at the cottage-industry scale to avoid regulation that was deemed too cumbersome when they considered scaling up. Aquaculture is by and large a part-time venture for most operators, akin to direct sale of freezer beef that has been a part of Michigan's rural landscape for decades. One difference from cattle is that an estimated 40% of the fish are produced by urban 'farmers', often in outbuildings in suburbia, and mostly by unlicensed facilities. In fact the estimated $30-50 million in sales is just that, an estimate, because so much of this sector goes unreported. No trade association is in place to champion development and policy issues, largely because most practitioners have no interest in collaborating or drawing any attention to their operation from anyone other than their customers.

Stuck in Second Gear **is the view from 2025** showing a sector that has been stagnant after initial growth in the mid 2010s. The sector made some headway, primarily through a handful of ventures funded by in-state entrepreneurs, but our regulatory framework and political will never advanced toward making Michigan a preferred place global-scale aquaculture development. All big investors in aquaculture found Chile, Peru, the ASEAN region and Canada as the "open for business" and preferred places to invest. Most frustrating for those who had hoped to grow a larger sector in Michigan is that Ontario, Canada has managed to increase trout, salmon and whitefish production across the international border in Lake Huron to $300 million in farm gate sale by 2024, with output projected to increase 5-8% annually to 2030.

The ***Hamburger Nation*** scenario portrays a 2025 situation that does not look very different from aquaculture as it exists today in Michigan – less than $5 million in fish sales. We are content to eat ground beef (and poultry) as preferred protein sources because they are low in price. In this scenario we have deemed our water resources for recreational and aesthetic uses and for long-established commercial industrial and agricultural sectors, while new uses including aquaculture have not been allowed to develop.

Looking back now to 2013 we recall when Economist Bill Helming predicted a future meat/protein market dominated by ground beef and chicken, driven by a cost-conscious marketplace where producers must be ever aware of input/production cost. For lack of alternative, the highly efficient chicken "rules the roost", due in part to good feed conversion[18]. The Hamburger Nation scenario is the realization of that future. Farmed raised seafood, even though it can be competitive and better than chicken at feed conversion to meat, remains underdeveloped in the Michigan and the Great Lakes Region, and imports remain our only alternative. Growth in aquaculture has continued globally, particularly with the application of technology to off-shore marine production in Asia, Europe, Latin America and even in the USA's Gulf of Mexico water, but freshwater aquaculture here flounders.

The aquaculture sector is not the only area of agriculture that has been constrained by our water use policy and practice in the Hamburger Nation future. The inability to leverage wetlands and state water

[18] Newport, Alan, "Beef industry will shrink with the economy", in The Beef Producer, January 2012 accessed on November 5, 2013 at http://magissues.farmprogress.com/CLF/CF01Jan12/clf032.pdf

resources for any development has kept blueberry production acres at 2005 levels and in fact growers are frustrated, continuing to shift their production base to the west coast and offshore. In 2020 a leading Michigan based fruit cooperative moved its global headquarters to Portland, OR, closer to its British Columbia and Oregon and other Pacific Rim primary production base, effectively giving up on its one-time Michigan home. Three of the coops ten largest farmer-members have also moved their headquarters out of Michigan to Georgia, Chile, and British Columbia.

And while hope for protecting Michigan's waters for recreational purposes continue to drive policy, recreational fishing in Michigan has continued to decline. Today, in 2025 the state's "everyman" fishing license sales are at 40% of 2010 levels. Sport fishermen are aging and the younger generations continue to lose interest in fishing as a pastime. Michigan waters are highly oligotrophic and invasive species continue to disrupt commercial and recreational fishing. There is still a charter fishing sector in our open waters that caters to a limited base of wealthier users, but for lack of growth some now question whether hatchery system support for stocking is economically sustainable.

The Preferred Future – "Seafood: An Essential Animal Protein": In 1987 the National Pork Board in the USA launched it's ***"The Other White Meat"®*** campaign to increase the consumer demand for pork. The campaign was very successful, resulting in a 20% growth in sales by 1991 to $30 billion nationally[19] – a $6 billion growth in less than four years. Early on in the 2012-13 aquaculture strategic planning process, the Pork Board's experience with this campaign enamored Integrated Assessment stakeholder participants to embrace calling the preferred future ***Seafood: The Other, Other White Meat.*** However, needing to respect the National Pork Board trademark, this scenario descriptor was dropped in favor of ***Seafood: An Essential Animal Protein.*** This strategic plan proposes that there is opportunity in the food marketplace for significant growth in the domestic aquaculture sector that is in fact now realized in 2025. Starting from a smaller base, inspired by the success of the pork campaign, and knowing that the world needs more fish, the billion-dollar sector was realized.

In 2014, through the leadership of a revitalized Michigan Aquaculture Association, the State government endorsed aquaculture development as a category that could make a significant contribution to citizen's health to the economy. Even today, in 2025, Michigan aquaculture is only a small fraction of what is a $300 billion sector globally. Aquaculture now sits alongside dairy, corn, soybeans and the produce sectors as an anchor of Michigan agriculture. Just as the southeastern states, with Georgia at their center, lead the US poultry sector, and beef in the western Great Plains, Michigan is now the recognized center and home for freshwater aquaculture in the USA. Aquaculture successfully leveraged Michigan's water technology, farming, engineering, and food processing capacity and assets to achieve this success.

Through the 50 years leading up to 2014 governments from the Great Lakes Region had secured a solid reputation for natural resource stewardship. The Council of Great Lakes Industries (CGLI), an agency advocating for a balance economic and environmental approach to development for society, then envisions "***the future of the Great Lakes environment is one that includes lakes which are appreciated for their beauty, healthful to mankind and to wildlife, and useful to the population***"[20]. Over the past 15 years the development of aquaculture in the region has solidified that reputation, with bi-national leadership from Michigan and Ontario. In fact the world looks to Michigan to learn how to achieve

[19] Dougherty, Philip H. "ADVERTISING; Dressing Pork for Success", *The New York Times*, January 15, 1987. Accessed October 9,2013

[20] http://www.cgli.org/vision.html

sustainable freshwater aquaculture, and our aquaculture systems, engineers and operational expertise have resulted in supporting technology exports alone that value $50 million annually.

A $1 billion farm gate sector produces an estimated 400-500 million pounds (225,000 MT) of seafood. This accomplishment is comparable to the Michigan fuel ethanol sector expansion from a zero base to $600 million[21] from 1999-2014. Just as with ethanol, the aquaculture sector has benefitted from a supportive policy framework and private investment, and while the sector has had a few failed enterprises along the way it is now a recognized contributor to the state's general and agricultural economy and contributes to domestic self-reliance in seafood.

CASE STUDIES

We can learn from the **experience of other countries**. China and southeastern Asia have had explosive growth in seafood consumption over recent decades and are projected to continue at a rapid rate (Figure 6)[22]; however, concerns have been raised in regards to environmental impacts and food safety standards. Scandinavia, in particular Norway, and Chile' lead the world in open water system production of salmon, with total aquaculture production values over $5 and $6 billion (US) respectively in 2012[23].

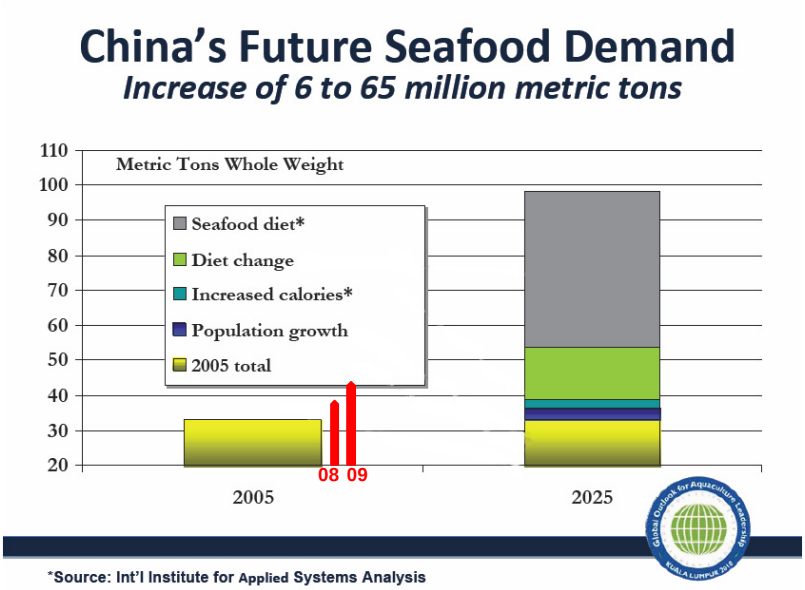

Figure 6. China's projected seafood demand 2005 to 2025.

Aquaculture in Turkey is rapidly developing and is being aided through policy and practices that leverage their capture-fishery legacy for the benefit of offshore aquaculture. And closer to home the trout farmers in Ontario have demonstrated success with near-shore freshwater cage culture and are now researching deep-water production using next generation technology for low access waters away from shipping channels, recreational fishing, and residential shoreline. Chile developed a multi-billion dollar sector from 1990-2009 leveraging technology and investment from other regions of the globe, demonstrating rapid growth is achievable.

Beyond aquaculture **we can learn from other sectors of US agriculture**. The Georgia poultry sector has grown to contributing $18.4 billion and 100,000 jobs to that state's economy in the past 30-40 years. In

[21] Michigan Corn Producers Association – available at www.micorn.org, accessed August 2013

[22] Modified from Yun H., C. Dan, L. Lu, G. Brown, A. Kaelin and L. Wei 2010. Effects of domestic market trends on Chinese trade of aquaculture species. Presented at GOAL10. Kuala Lumpur. 2001. – available at: http://www.gaalliance.org/update/GOAL10/ChinaMarket.pdf.

[23] FOA, Fishery Statistical Collections online database: http://www.fao.org/fishery/statistics/global-aquaculture-production/en

Michigan our turkey production sector is valued at $90 million and employs 600 people in a sector that is only $3.2 billion nationwide. Details on these case studies are included in Appendix 7.

Case Study Learning:

- ✓ **Large-scale sustainable sector development is achievable**
- ✓ **Globally there are aquaculture and other production agriculture systems, markets, regulatory examples, research, demonstration and outreach programs, and finance and investment models that can be used as models for Michigan aquaculture**

III – The Strategic Plan:

Overview: Towards creation of a thriving and sustainable sector

Having considered future scenarios for Michigan Aquaculture it's appropriate to revisit the history of Michigan aquaculture and gain perspective as to why now appears to be the opportune time to develop the sector. Background information on Michigan Aquaculture is provided in Appendix 1. In summary, a 1991 study[24] identified a number of accomplishments necessary for a high rate of growth for Michigan aquaculture. These included:

- Policy changes
- Aquaculture plan
- State aquaculture coordinator
- More research and extension
- Improved information flow (production methods, technology and marketing)
- Increased social awareness

In retrospect, it appears that some of these changes, but not all, have been attempted and implemented. Some, like state aquaculture coordinator, have been implemented part time and aborted. Others appear only now under development. Additionally, perhaps the biggest problem as to why the industry has not expanded significantly, is due to the lack of an overall concerted effort to accomplish and maintain all the points identified in the 1991 study.

Why is the need to advance aquaculture in Michigan DIFFERENT this time around compared to previous attempts to grow the sector? For one thing, the world has changed with respect to fish sourcing. In this decade we have witnessed aquaculture take primacy over capture as the leading source of seafood. Advances in technology, research and development and outreach education in aquaculture have made significant strides. At the same time, we acknowledge that commercial-scale aquaculture is still early-on in its development and that mistakes have been made by both entrepreneurs (for example poor designs, fish kills, etc., some resulting in bankruptcies), industry and governments (for example oversight of Asian

[24] Chopak, J. and J.R. Newman 1992. Status and Potential of Michigan Agriculture – Phase II (Aquaculture). Michigan State University Agricultural Experiment Station. Special Report 50. East Lansing, MI.

Carp introduction). However, if we are willing to learn from those mistakes, not repeat them, and build a sound, sustainable, and thriving aquaculture we can contribute to meeting the projected global seafood needs, starting with the local demand, and growing to meet other demand beyond our border.

"In the era of tightening world food supplies the ability to grow food is fast becoming a new form of geopolitical leverage. Food is the new oil. Land is the new gold,"[25] according to *Lester Brown of the Earth Policy Institute.* If we extend this thinking to aquaculture…"Water is the new liquid gold." With 20% of the world's available freshwater in the Great Lakes and half of that volume within the Michigan borders we have a responsibility and opportunity, as the world shifts to aquaculture for most of its seafood needs, to take a leadership in sustainable freshwater fish farming.

Michigan is well situated now to develop a sustainable aquaculture sector. Up till now, aquaculture has been a very small component of Michigan agriculture contributing less than $5 million to the broader economy. While the decline of the capture fishery in the Great Lakes over the past 3-4 decades might have presented opportunity for aquaculture adoption, the regulatory framework and significant importation of low-cost seafood have combined to limit expansion of the sector.

The State adopted the Michigan Aquaculture Development Act[26] in 1996. The 2012 Roadmap Through Regulations[27] has helped bring clarity and contributed to new enterprises engaging in the sector. The State governments Quality of Life departments (MDARD – Michigan Department of Agriculture and Rural Development, DEQ – Department of Environmental Quality, DNR – Department of Natural Resources) have a Memorandum of Understanding that commits them to work together to support the advance of aquaculture. Now is the time, according to current Governor Snyder, for "relentless positive action, in action" to advance our economy and improve our social and ecological stewardship. Furthermore, local entrepreneurs are engaging in the opportunity. Several new facility licenses for fish farm came forward in 2013, and two additional discharge permits were recently granted for expanding operations.

As the global demand for seafood grows there is also opportunity to displace imported seafood (trout, tilapia, shrimp, barramundi, etc) with domestic production. This will become more important as increasing market demands in Asia and elsewhere impact quantity, quality and pricing of imports to the US. Those market demands will likely also continue to shift prices upwards (as we have seen in other food commodities and sectors in the past five years), increasing the economic opportunity for aquaculture in Michigan.

Overview – Opportunity Exists:
- The shift from reliance on wild-caught to aquaculture: Fish farming is the future of seafood
- Food security: as Asia's demand increases USA should decrease reliance on imported seafood
- Leverage the progress made to date under Michigan's "Open for Business": Michigan Aquaculture Development Act, The AIM Process, Roadmap Through Regulations, and the QOL Aquaculture Streamlining Team

[25] Brown, Lester, 2013, Adapted from *Full Planet, Empty Plates: The New Geopolitics of Food Scarcity* in http://www.earth-policy.org/book_bytes/2013/fpepch1

[26] http://www.legislature.mi.gov/%28S%282ivoh1452nuufz55an5prb45%29%29/documents/mcl/pdf/mcl-Act-199-of-1996.pdf

[27] http://michiganaquaculture.org/wp-content/uploads/2012/09/20120801-AIM-Roadmap.pdf

Vision, Mission & Core Values for Michigan Aquaculture

With input from the various stakeholders (see appendix 2) through the 2012-13 strategic planning process the Vision, Mission and Core Values for the sector were developed in support of creating a thriving and sustainable sector.

Vision: A thriving and sustainable Michigan aquaculture sector

Mission: Grow aquaculture sustainably into a major industry sector by 2025 that complements our natural resource conservation and recreation uses of water

Core Values:

- Sustainability
- Economic success as key to funding natural resource stewardship investment
- Trust – stakeholders support

Support for the Vision/Mission: Through the Sea Grant Integrated Assessment (SGIA) process, based on forces and factors in the global seafood marketplace, a $1 billion projection came forward as an achievable seafood production potential for the state of Michigan. Production challenges to get to this mark were noted to be extremely high. Future demand for seafood and Michigan's vast water resources were driving factors in this projection. Michigan's legacy, along with neighboring states and provinces, at mastering ecological preservation while managing a thriving economy, was an important part of the SGIA dialogue. Other sectors of Michigan agriculture of this size currently include dairy, corn and soybeans, and together contribute to a diverse economy base for the State. Aquaculture likewise can contribute to our agricultural diversity, and do so on a much smaller footprint. We estimate that a $1 billion aquaculture sector could be achieved utilizing between 2000-5000 acres of land/water area, which is a small fraction of that used by the other commodities. Beyond agriculture, Michigan's automotive and medical device sectors demonstrate leverage capability in engineering and system design, and Michigan's expertise and capabilities in biological, chemical and physical sciences (water systems, ecology, design, etc) are amongst the best in the nation if not the world.

Seafood Demand: As the global demand grows there is significant opportunity to displace imported seafood (trout, tilapia, shrimp, barramundi, etc) with domestic production. This will become more important as market demands in Asia and elsewhere may limit how much seafood is exported to the USA. Those market demands will likely also shift prices upwards, increasing the economic opportunity for aquaculture in Michigan.

A thriving and sustainable Michigan aquaculture is not only possible, it may well be an important step for food safety and human health needs. The passage of the Food Safety Modernization Act (FSMA) is expected to further drive demand for domestic food in the USA. Meeting these regulatory requirements with domestic supply is preferred over relying on compliance for imported sources. In fact, the US regulatory framework, which some consider too restrictive, is also helping to drive demand for exports

to the developing world, where consumers desiring quality and food safety assurance would rather buy from the USA than eat un-trusted domestic supplies.

Jobs: Achieving a $1 billion sector is projected to contribute 8,600-17,200 direct jobs and total employment of up to 22,000 to the Michigan economy (Table 1). One related sector that could benefit from a thriving aquaculture is the capture fishery community, reportedly in decline due to changes occurring in the Great Lakes. Commercial fishermen have fishing industry knowledge and heritage, resources including boats and processing plants, and typically operate on a seasonal basis. Partnerships and expansion towards fish production provide a great opportunity for year round harvesting and processing of supplemented farmed fish. Also importantly, the establishment of fish farms in or near commercial fishing enterprises will provide employment economic stability to a number of areas considered low-income communities. The economic impact and employment projections for the four scenarios are outlined in Table 1. The *"Seafood: An Essential Animal Protein"* scenario can be a significant contributor to the future of Michigan's economy.

As the sector grows, aquaculture systems – both land-based and open water cage, will require engineering and water-technology expertise for design, construction and operations, presenting an opportunity to leverage Michigan's world-class engineering and manufacturing workforce. Just as the growth of the state's medical devices sector leveraged this capacity, so can aquaculture.

Table 1. 2025 economic impact and employment projections by Michigan aquaculture under four scenarios[28].

Scenario	Direct Impact ($million, farm gate)	Direct Employment	Total Economic Impact ($ million)	Total Employment
Seafood Preferred Protein	***500 - 1 billion***	***8,600 - 17,200***	***780 - 1.5 billion***	***11,000 - 22,000***
Stuck in Second Gear	**70 - 150**	**1,200 - 2,580**	**110 - 236**	**1,500 - 3,300**
Blue Bayou	**30 - 50**	**500 - 80**	**47 - 78**	**60 - 1,100**
Hamburger Nation	**< 5**	**80 - 100**	**7 - 20**	**100 - 130**

Species: Achieving a $1B sector would likely entail production expansion of species well known in the market and proven for aquaculture production in the region (shrimp, trout, tilapia). Others adapted/adaptable to our abundant cold-water resources (whitefish, other salmonids) could serve as incubators for the future growth opportunity. Figure 7 illustrates an example of what the sector might look like in terms of farm gate value under rapid expansion in response to global seafood demand projections. **It is important to note that cage culture comprises only a portion of expected output**.

An additional benefit from aquaculture is that it requires a very small area to produce a large quantity of high quality meat protein. A $1 billion farm gate sector in aquaculture can be achieved on less than 5000 acres of land/ water area. For comparison, the 2013 Michigan soybean crop was valued at $1.0 billion on 1.9 million acres, and the state's corn crop was $1.4 billion on 2.25 million acres. Aquaculture can be a channel for expanding the state's agriculture and natural resources economy significantly on a very small land base, and in reality, depending on the production system used, a relatively small amount

[28] Total economic impact and total employment derived from IMPLAN economic impact software

of water. Furthermore, aquaculture is not a consumptive use of water – it serves as medium for the production of fish, and the water remains available for other downstream uses.

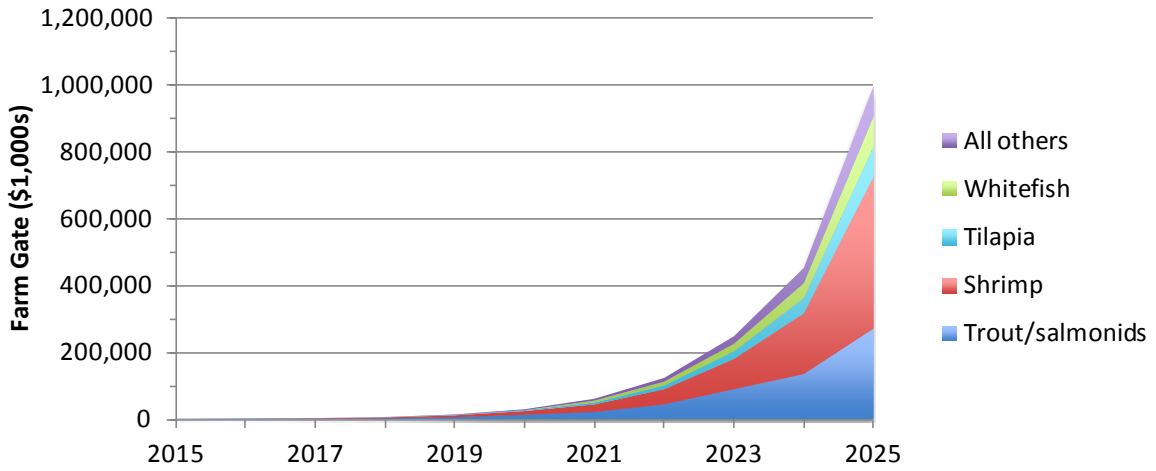

Figure 7. Illustration of how Michigan aquaculture could grow.

Productions Systems in Aquaculture

Several production systems could have applications for aquaculture development in Michigan. The goal of all these systems is to maintain a healthy environment for the production of aquatic species in an environmentally sustainable manner. The three major types that have potential for development in Michigan are: 1) Recirculating Aquaculture Systems (RAS), 2) flow through raceways and 3) cage systems.

These are described in more detail in Appendix 4. The preferred future is expected to include all three systems and research will likely identify variants as well as new designs. Economy of scale is expected to drive RAS and cage culture as preferred primary production systems; however flow-through raceway and pond systems are also necessary aspects of this plan. It is also important to note that extensive production systems – pond, flow-through and cage culture farms, currently require much less capital investment than intensive indoor systems and comprise most of the global production and nearly all international exports today. Intensive systems such as RAS and aquaponics will require further R&D, leveraging Michigan's broad engineering expertise and top-notch university system. A number of entrepreneurs feel we have that capability now! Through Michigan's expertise, sustainable aquaculture expansion can be realized through a combination of all these systems.

Major global exporters of aquaculture products have achieved that status using extensive, outdoor systems. Intensive indoor system development is a critical part of our future.

(A note regarding aquaponics: a system of aquaculture in which the waste produced by farmed fish or other aquatic animals supplies nutrients for plants grown hydroponically, which in turn purify the water. Since typical aquaponics systems derive the majority of their revenue from the marketing of hydroponic

produce it was determined early on in the planning process that it fits better with horticulture than aquaculture. It is acknowledging that aquaponics will develop – primarily selling fish as a compliment to produce sales into direct market channels. It is not expected to be a key driver of commercial aquaculture.)

As the sector develops to include the various production systems aquaculture will be distributed around the state to take advantage of the various water and land resources in rural and urban areas. Aquaculture can make a significant contribution to Michigan's Blue Economy[29]. As to the commercial use of public waters, this could be modeled after and managed similar to federal Bureau of Land Management tracts that are leased to ranchers for cattle grazing.

A sector with $500 million to $1 billion in farm gate revenue will almost certainly include all production systems. Half of the sector in 2025 would likely be comprised of 5-10 large integrated farms with $50-100 million in sales (likely a combination of open water cages and RAS operations). Another third of the sector would likely be comprised of 200-350 mid-size family farms with revenue of $500,000 to $10 million annually, possibly clustered around a regional processing facilities –and also predominately cage and RAS systems. The remaining 10-15% of the sector would be comprised of 300-1000 smaller operators – either start-ups or part-time farmers or aquaponics operators meeting local/regional demands for a range of species and specialty markets, including among them enterprises incubating the next generation of opportunity.

Urban Aquaculture Considerations: One legacy of Michigan's declining cities is excess water and sewer capacity that could be seen as an opportunity for aquaculture. However, challenges include zoning and full acknowledgement that aquaculture is an agricultural activity, and under Michigan's Right to Farm Law. The exploration of urban aquaculture opportunity will require dialog with municipalities and community members to ensure aquaculture is an acceptable practice. A second consideration is securing the land base, particularly for situations where aquaculture is envisioned as a solution on brownfield sites. The third factor is price of water and sewer from municipalities with excess capacity. The typical practice is flat-rate pricing and a reluctance to offer lower pricing for aquaculture. Thus urban production using municipal water and sewer may be more expensive than rural wells and land-applied waste disposal cost on land zoned for agriculture. Incentives need to be part of the urban aquaculture movement.

Key Objectives and Activities: Towards Achieving the Future of a Thriving & Sustainable Aquaculture Sector

This strategic plan presents a set of seven key objectives and recommendations for supporting activities that the sector should undertake in 2014 to advance the development of a thriving and sustainable aquaculture in Michigan. Those key objectives are:

1 – Social Acceptance & Political Will: The sector leadership, preferably the commercial operators, must act to secure public and government endorsement of this strategic plan and an "Open for Business" approach to aquaculture.

[29] http://greatlakesecho.org/2013/11/06/michigan-economic-developers-eye-blue-economy/

2 – Achieving Trust: Branding, Regulation, & Certification: Convinced that stewardship of the natural resource and production of seafood can be synergistic through the adoption of Best Management Practices there is a need to communicate to society these practices. Strong branding to fully capture the value of sustainable seafood and ensure ongoing reinvestment will be required. A solid regulatory framework – clear, simple, free of undue burden - further builds trust on behalf of society. Furthermore, there is a role for Third Party Verification to provide market-based, adaptive certification of best practices, ideally limiting the need for reliance on legislated regulation.

3 – Invest: Research/Education/Extension: Both private and public investment is necessary for research , education and outreach in technology, genetics, nutrition, people, processing, practice, product and placement in support of sector sustainability and economics.

4 – Design for Sustainability: RAS/Cage/Flow-Through Systems: Acknowledging that commercial aquaculture is still early on in its development, particularly when compared to land-based agriculture, production systems specifically is important. Investment in sustainable system development and practices are critical to a growing aquaculture sector.

5 – Leadership: A Sector Champion: The sector will require an Executive Director to focus on the development – including relationships, investment, and policy.

6 – Improving Business Plans: The sector is dynamic and developing and operators as well as lenders need to clearly articulate the story of the people and the finances that will make commercial aquaculture ventures viable. There can be a role for public economic development agency support in developing sound plans.

7 – Financing: Attract New Investors: The current Michigan sector is very small and the desired growth will require bringing in new investment from experienced aquaculture operators from around the world along with local investors desiring to capture opportunity in an "Open for Business" state.

These objectives are illustrated in Figure 8 as four clusters (1/2, 3/4, 5, 6/7) encircling the Michigan Sea Grant ***Informed Decisions*** graphic – and further articulated in the following sections.

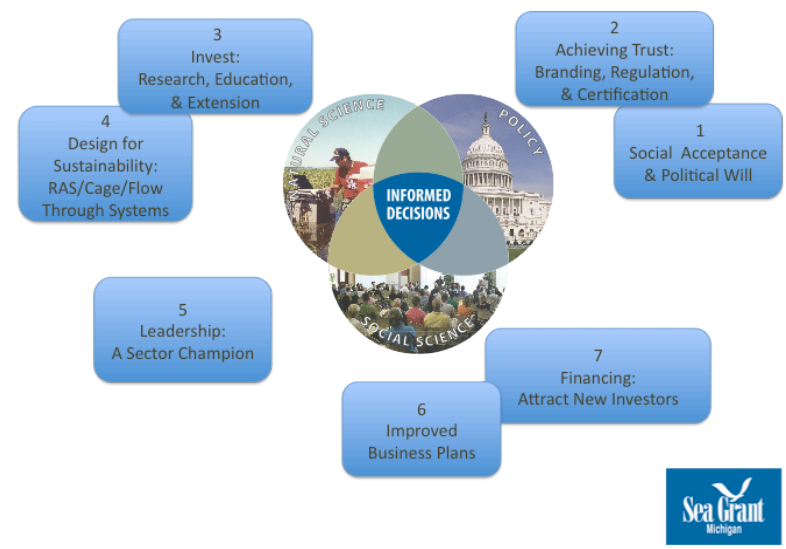

Figure 8. Key objectives for a thriving and sustainable Michigan aquaculture sector.

1 – Social Acceptance & Political Will

The argument is made that Michigan residents value the state's water resources for recreational use including tourism and sports fishing – which have been quoted as contributing an aggregate $2.5 B annually to the state economy. As commercial aquaculture is developed it should not negatively impact the recreational and sport fishing sectors. In fact an argument could be made that aquaculture could compliment the sport-fishing sector. Recreation depends on jobs – employed people have the resources to vacation and enjoy sport. Aquaculture policy and growth must address economics as a sustainability factor linked to social benefit and environmental stewardship. The first priority in developing a thriving and sustainable aquaculture sector is securing broad social acceptance that use of public water resources for fish production is beneficial for society and our wellbeing. Key to achieving social acceptance is leadership from the commercial operators and state government – the collective political will – to champion and endorse this development.

Social Acceptance & Political Will Priorities:

- **"Open for Business" - Securing endorsement of state government agencies and Governor's office**
- **Engage Tribal leadership and state regulators on Great Lakes water usage**
- **Developing siting criteria for aquaculture facilities**
- **Engage other stakeholders: recreational uses and sportsmen, commercial fishermen**
- **Collaboration with Ontario and neighboring states – leverage learning to accelerate Michigan aquaculture development**
- **Advance aquaculture as vital part of the Michigan "Blue Economy":**
    - **Engage business, environmental, and social NGOs with a track record for advancing sustainability in other sectors of the economy (i.e. The Nature Conservancy, The Council of Great Lakes Industries)**
- **Leverage credible environmental assessment tools for defining and validating sustainable practices**

We can learn from our neighbors to the north and east. From the Ontario, Canada experience we know that one cage-culture trout farm[30] can produce in excess of 400,000 lbs of trout in a 5-month grow-out season, on a farm that takes up less than 5 acres of water area. Like terrestrial farming fallowing practices can be utilized to maintain proper balance with the environment. An analogy is to rotational grazing of livestock – a sustainable practice that is widely adopted in land-based agriculture. This is equivalent to the total sport-fishing take of salmonids in Lake Huron.

Evidence suggests that aquaculture, under the right conditions and properly managed, can improve natural fisheries, and hence provide benefits to both commercial and recreation fishing. In Parry Sound, Canada it is hypothesized that managed nutrient addition from fish farming to the sound's waters has contributed to restoring native lake trout. When trout farming was initiated in 1982, there were an estimated 200 lake trout in Parry Sound. Now these waters have in excess of 100,000 lake trout and a

[30] Cole, Gord, Aqua-Cage Fisheries, Personal Communication to the author September 2013.

restored recreational fishery in what had been an oligotrophic water body. Experimental lake studies in Ontario examined impacts by excessive nutrient loading from a cage culture unit on a small lake ecosystem. Both positive and negative changes were observed. Abundance of lake trout in one study (Lake 375) during the fifth year of cage culture, 2007, was more than twice the number before the experiment started in this lake[31]. Most of the increase in abundance is due to increased recruitment. Lake trout growth and condition remained higher than pre-cage-culture. Negative impacts were mainly attributed to excessive sediment buildup under the site and low oxygen in hypolimnetic waters caused from effects from nutrient loading. These impacts can be minimized through additional research, siting, and management practices as being demonstrated in Ontario.

In the Parry Sound situation, other factors such as the closure of the commercial lake trout fishery no doubt supported the observable lake trout rehabilitation; however, based on growing evidence we can reasonably conclude that recreational sport fishing and aquaculture can be complimentary when managed well for sustainability. Ongoing research and monitoring will be required as part of developing a sustainable aquaculture, but there is no reason not to advance. The key is moving forward with complete focus towards sustainability.

Furthermore:

a. The world supply/demand equation is shifting as China in 2011 has become a net importer of seafood and its middle class grew to be 700 million people by 2020[32]. This presents opportunity for Michigan to capture domestic markets as Asian supply shifts to meet the China demand as well as an export opportunity. Wealthier Chinese citizens are looking for safe supplies of seafood from well regulated, sustainable producers like the USA.

b. Aquaculture can be complimentary to other uses. For example the Michigan sector can learn from the IMTA (Integrated Multi-Trophic Aquaculture)[33] approach that is currently targeted at marine aquaculture. This approach should be considered for freshwater aquaculture as a possible solution for the restoration of oligotrophic Great Lakes waters into thriving ecosystems.

c. The Native American Tribes are very interested in a sustainable fishery and several tribes and fishery operators have expressed interest in developing a framework for aquaculture as a compliment to the capture fishery. The sector leadership should actively engage tribal councils and Native American commercial fishery operators in a dialog on sustainable aquaculture development. This dialog will require discussions on water access within context of the Consent Decrees with various tribes (for example with the 1836 treaty tribes).

d. As a result of industrial development, the resulting pollution of waterways, and the follow-on required environmental remediation of Michigan and Great Lakes region, waterway policies have been defined over the past 60+ years targeted at keeping stuff (industrial chemical, process co-products, etc) out of water. That policy was targeted primarily at cleaning up the industrial pollution – and preventing recurrence. Some of that policy, inadvertently, precludes or makes difficult the development of aquaculture, primarily a biological activity, in those waters. Policy distinguishing adding 'adapted biologicals' (fish, fish food, treatments, etc.) to water – which are different than

[31] http://www.experimentallakesarea.ca/images/ELARES2008.pdf
[32] http://www.gaalliance.org/update/GOAL10/ChinaMarket.pdf, slide #3
[33] http://www.dfo-mpo.gc.ca/aquaculture/sci-res/imta-amti/DFO_Aquaculture-IMTA-eng.pdf

industrial chemical pollution is required.

1. The freshwater aquaculture sector can learn from and can reference the ocean-base experience (including the mistakes) of the past and then design better systems to avoid future problems. For example current best practices reduce fish density within production facilities to improve fish health, reducing disease and stress pressures and allowing for reduced treatments and other interventions.

2. Closer to home, as pertains to aquaculture in the Great Lakes region, Michigan can learn from how Canada did it well – with proper site selection practices, and the adoption of farm operator Best Management Practices that have evolved over thirty years. A great example is the point that in 2013 several large cage operations achieved organic certifications for their farms.

3. We also have some key insight available on trends and attitudes towards commercial aquaculture by policy makers in a Great Lakes Fishery Commission (GLFC) report from a roundtable discussion hosted by the GLFC and International Joint Commission in 1999[34]. There were 41 participants in all, with 3 from commercial aquaculture. According to the report "Roundtable participants noted that an aquaculture operation can become a problem when operators attempt to grow more fish than a given area and water volume can sustain." The report further elaborates on issues such as water quality and long term impacts, prevention and abatement of impacts, protection under law, roles and responsibilities, loss of habitat and precautionary approaches, monitoring strategies and research needs.

e. The opportunity exists to refine regulations in the context of developing a sustainable aquaculture,such as designating certain water bodies or areas for aquaculture, others as preserves. Regulation is a required framework for compliance - to demonstrate and assure the citizens of sustainability, stewardship and food safety. Done right and as a compliment to Best Management Practices effective and fair regulations could be established by governmental agencies through partnering in various ways with industry. In recent years there has been discussion within Michigan state government on the option of using some MDNR land holding for commercial purposes including farming incubators and other uses, driven in part by the realization that there is a need to invest in and support the development of the next generation of farmers (since the farmer population continues to age). Such a strategy could be used for aquaculture and fish farmer development through designating waters for commercial farming, and defining contracts for operators with interest in access to those waters. Federally recognized tribes in the state, specifically those that have Consent Decrees, need to be engaged on water access issues and how aquaculture can be a compliment to the capture fishery, whether for subsistence or commercial fishing. The tribes have a legacy of understanding balance in nature that can contribute to the goal of a sustainable aquaculture sector.

> Through fair and effective regulation, industry promotion can be achieved

f. Aquaculture can be a complement to other uses of the public resource. For example aquaculture can provide a year round supply of seafood products that are now only available seasonally.

[34] Tulen, L. 1999. Addressing Concerns for Water Quality Impacts from Large-Scale Great Lakes Aquaculture: http://www.glfc.org/research/reports/TulenWaterQuality.PDF

Whitefish culture development could compliment the season wild-caught supply and allow year-round marketing with a premium positioning as a cold-water raised, local alternative to tilapia in the upper Midwest market and beyond.

So, what comes first – society acceptance of farmed fish produced in Michigan or the political will and determinations within government to put in place a structure to allow sustainable aquaculture development? Both will have to be developed concurrently – with industry leadership and government endorsement. Achieving this "buy-in" lays the foundation for trust – the trust that the sector will indeed be a good steward and creating a sustainable aquaculture sector. One key factor in the realm of earning trust is siting.

Siting: Siting of facilities is critical in terms of resource allocation, social benefits and economics. Siting is also an important factor in regards to mitigating environmental risks (for more on Environmental Risk Assessment see next paragraph). The 2012 Roadmap through Regulation is a resource for use in land-based farm siting. As pertains to cage culture in Michigan open waters of the Great Lakes we have little experience beyond siting small research facilities, typically only as temporary installations. Information pertaining to impact on environment and the fate of the nutrient discharge of nitrogen and phosphorus from these aquaculture facilities exists in other jurisdictions and can be applied as base for developing Michigan cage culture siting regulation. This is currently being studied in the marine environment[35]. More pertinent to the Michigan situation is the experience in Ontario, Canada with rainbow trout production. In the spring of 2014 NOAA (Northern Ontario Aquaculture Association) and the Canadian Department of Fisheries and Oceans, along with Agriculture Canada will be publishing a peer reviewed report on the 30 years of experience with rainbow trout cage culture and the impact on the environment. Contact NOAA (noaa@manitoulin.net) for status on these pending reports that are expected by April/May 2014. Additionally in early 2014 the Canadians will publish revised Coordinated Guidelines for Cage Culture Operations in Ontario (note, the 2009 draft is available online[36]). Michigan does not have to start from scratch, rather adoption or adaptation of those practices and guidelines can help jumpstart the implementation of cage culture production farms. See also the "Designated Water Uses" section (p.34) for strategic considerations that would ensure water can be available for economic, aesthetic, recreation and other uses by society.

Environmental Risk Assessment Overview: The subject of environmental risks has been well researched and documented over the past 40 years, as various initiatives to remediate industrial-era contaminations and prevent and/or properly manage ongoing risks have been undertaken. Deborah J. Brister and Anne R. Kapuscinski of the University of Minnesota completed one of the most comprehensive resources for risk assessment to waters in the Great Lakes region, "Environmental Assessment Tool for Aquaculture in the Great Lakes Basin Version 1.2" in 2002[37]. The tool can be utilized as a useful resource for siting and risk analysis. The Canadian Department of Fisheries and Oceans has done extensive experimentation in the Experimental Lakes District on the impact of fish culture on water bodies,[38] demonstrating that it can be done sustainably. Net/net, Michigan and the Great Lakes states and provinces have an excellent track record improving and protecting the waters in

[35] Welch, Aaron W. "The Fate of Nitrogen and Phosphorus Discharged From Open-Ocean Aquaculture Facilities – A PhD Dissertation Proposal, in http://www.cunadelmar.com/images/pdfs/AW.Prelim.Res.Prospectus_ShortV_V3.pdf

[36] https://www.ontario.ca/environment-and-energy/draft-guidelines-cage-aquaculture

[37] http://www.glfc.org/boardcomm/clc/eatq/, also available online at http://www.glfc.org/pubs/pub.htm#misc

[38] http://www.dfo-mpo.gc.ca/science/publications/article/2007/27-09-2007-eng.htm

the Great Lakes Region, while allowing economic activity to continue. We can build on this experience as we expand aquaculture.

The aquaculture sector can also learn from other sectors of industry about how to keep economic activity and natural resource preservation in balance. Some of the best work on this subject is done by the Council of Great Lake Industries (CGLI - www.cgli.org), and aquaculture operators should consider participating in and learning from the CGLI experience. In fact, at the 2013 Council of Great Lakes Governors the subject of sustainability was addressed and summarized, ***"I really don't see the commitment to sustainability and a good environment as antithetical to economic growth," Governor Quinn said. "It's the exact opposite. If we want to have economic growth in the 21st century we have to have a green way of thinking and a green way of acting."***[39] Aquaculture fits to the goal of the Governors and Premiers to "collectively advance the 'blue economy'…"[40] A blue economy strategy should include aquaculture development.

Tribal Community Roles and Engagement: While we tend to think in terms of state and federal government jurisdiction, much of the open water harvesting of fish in the northern Great Lake waters is ceded to Native American tribes through consent decrees (see map "1836 and 1842 Treaty Boundaries"). This adds a degree of complexity and uncertainty as to how aquaculture could operate in those waters. Dialog with tribal stakeholders will be required to advance aquaculture in open treaty boundary waters (Figure 9).

Regional Collaboration: Making our lakes and water resources a sustainable medium for aquaculture as a contributor to positive future economic growth must be a collaborative undertaking. Because the Great Lakes waters are shared with Canada and other states, a regional approach in support of developing a thriving and sustainable aquaculture provides benefit to everyone involved. Michigan can take the lead on such an initiative since we are central to the region, have responsibility for the largest share of the water, and we share borders with most of the states and Ontario.

Initial stakeholder engagements included integrated assessment planning sessions, meeting with private, public and agency personnel, press releases and presentations. A final draft of the

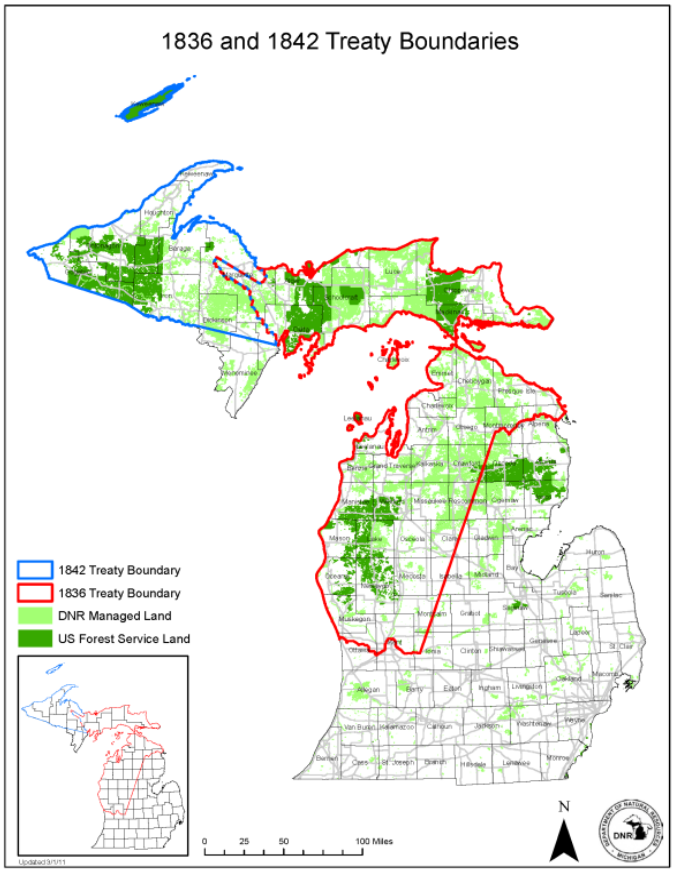

Figure 9. 1836 and 1842 treaty boundary waters.

[39] Leadership Summit on Mackinac Island, May 31-June2, 2013, Council of Great Lakes Governors, page 6
[40] Leadership Summit on Mackinac Island, May 31-June2, 2013, Council of Great Lakes Governors, page 7

strategic plan was presented at the following venues:

- Michigan Aquaculture Association Meeting January 2014
- Michigan Fish Producers Association January 2014
- Aquaculture America in February 2014
- US Trout Farmers in February 2014.
- North Central Aquaculture Conference February 2014
- Wisconsin Aquaculture Association March 2014

We have also engaged in, and stressed the importance of, a working relationship with members of the Northern Ontario Aquaculture Association. On a national level, we anticipate cooperative involvement with east and west coast marine aquaculture groups (e.g. Maine Aquaculture Association) utilizing open water systems, as well as the newly formed Coalition of U.S. Seafood Producers (CUSP). CUSP is made up of aquaculture and feed producers, retail and restaurant customers, researchers, technology and feed suppliers, and public aquariums, and was formed to provide expertise and support of government action that will create growth in aquaculture development.

There are global models we can also learn from. For example in late 2013 a group of 60+ stakeholders in Mediterranean and Black Sea convened a UN-FAO Global Fisheries Commission for the Mediterranean (GFMC) Aquaculture Multi-Stakeholder Platform to discuss the future of aquaculture in their region[41].

2 – Achieving Trust: Branding, Regulation, & Certification

Achieving trust involves societal and marketplace activity to earn confidence in the sector as well as the individual operator level. Beyond requisite marketplace requirements for seafood quality, food safety, taste and eating enjoyment, there can be benefit from a concerted effort to assure society that production is done in a sustainable manner, by operators acting as good stewards of the natural and other resources used in production, distribution and marketing. To that end there are roles for commercial branding, for government regulation, and for independent certification of practices. These help support of building and communicating trust that the sector will in fact operate in a sustainable manner. The illustration in figure 10 provides a graphic of how these three

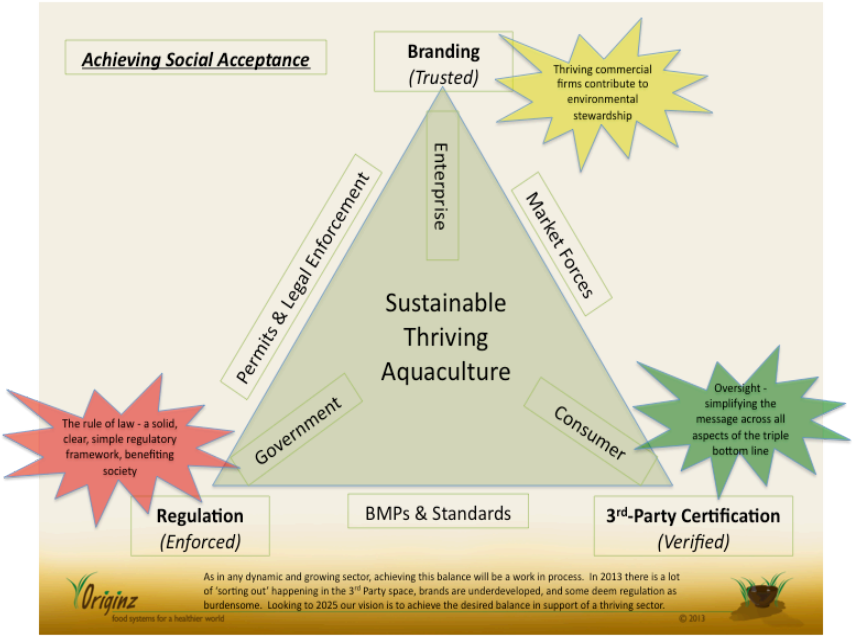

Figure 10. Elements for achieving social acceptance and trust for growing

[41] http://www.fao.org/fishery/nems/40534/en

elements can be combined in support of achieving social acceptance and trust for aquaculture.

Achieving Trust Priorities:

- **Branding – commercial enterprises telling the story of their sustainable seafood product of high quality, great taste and product consistency.**
- **Regulation – a sound legal framework, trusted in society, increasingly nimble in response to fostering thriving and sustainable sector growth**
- **Certification – leveraging third party accreditation as a market driven verifier of best practice**

The three elements of achieving trust are further elaborated:

Branding & Marketing: The first responsibility lies with the commercial enterprise in their development of brands that achieve trust. Those strategies are best developed by the specific enterprise in the context of the competitive marketplace.

Enterprises operating in Michigan could well leverage a regional/state positioning that should resonate both with Mid-western consumers and with global export markets because there is opportunity to leverage the region's water resource stewardship legacy. Seafood is a particularly important meat protein source in ethnic markets, particularly the various (Asian and other) communities in cities including Chicago, Toronto, and in many smaller cities in the nearby market. Accessing those markets could also lead to export markets in the "home country" where "Product of the USA" is deemed to be of superior quality and often marketed for a premium.

Furthermore, as seafood demand increases and farmed product is required to meet that demand there may be wisdom in selling seafood on the basis of its product merit. Recognizing that both farm-raised and wild-caught are linked, there is a need to eliminate the artificial divisions that exist between aquaculture and fisheries. These sectors have long had an adversarial relationship, but they can accomplish more good in the delivery of seafood by working together.

Howard Johnson in his 2008 ***"US Market Opportunity Assessment for Freshwater Trout"*** for the Canadian Fisheries and Oceans Department Office of Aquaculture Directorate[42] suggested, "…*the growing US seafood market represents a very attractive market opportunity."* He then quantified US

[42] Johnson, Howard, H.M. Johnson & Associates *"US Market Opportunity Assessment for Freshwater Trout"* Prepared For: Canada Department of Fisheries and Oceans Office of Aquaculture Management Directorate – Available from Northern Ontario Aquaculture Association at ontarioaquaculture.com

trout imports at 5000 metric tonnes, mostly from Chile and Argentina. Displacing these imports with sustainable domestic production could have a significant positive impact for aquaculture, with a farm gate value of $20-40 million ($2/lb in the round) and a gross sector contribution (5x multiplier) of $100-200 million to the economy. Such a sector in Michigan could equal or surpass the Canadian farm-raised trout industry and approach the scale of the Idaho sector, and be realized using proven sustainable production practices validated in Canadian waters of Lake Huron over two decades. The trout market sector has never been aggressively marketed because of the supply constraints in Michigan, the Great Lakes and globally. The sector could grow and thrive by applying Michigan's engineering, agricultural, and biology technical skills, with improved feeds and sustainable practices.

Regulation & Permitting: Another element of social acceptance is confidence that appropriate regulations are in place to form legal framework for sustainable aquaculture development. This includes other benefits from aquaculture such as increased fish production and relief on wild caught fisheries. Current regulations exist that will insure that any aquaculture project is developed in an environmentally sustainable manner. In fact, there are many who believe current regulations are overly restrictive, impeding aquaculture development. As previously stated, fair and effective regulations are critical.

"Increased attention has been paid in recent years to both positive and negative effects of increasing numbers of regulations on businesses in the United States. The decline in U.S. aquaculture has been attributed in part to increasing volumes of imports and high feed prices. However, there is increasing concern that the U.S. regulatory environment, as compared to that of international competitors, may also have contributed to this decline. More than 1,300 laws apply to U.S. aquaculture and even though the majority has been issued by individual states and apply only to specific types of aquaculture businesses in that state, the cumulative regulatory burden has increased over time."[43] Even as Michigan has adopted the 2012 "Roadmap Through Regulation", there remains a need for regulatory simplification to create a favorable business climate, while protecting the state's natural resources.

Guidance and understanding of operational issues have been recognized as important to the compliance framework by various organizations. The U.S. EPA has developed a compliance manual[44]. Also, a project through Wisconsin Sea Grant developed a Best Management Practice Manual[45] for aquaculture which can be adopted by Michigan fish farmers. The Canadian Ministry of Fisheries and Oceans has conducted significant work on the freshwater cage operations on Manitoulin Island.

Any open water system would have to meet at a minimum the types of expectations placed on other public natural resource utilizations like commercial timber harvest, oil and gas extraction and mining operations. This would include compensation to the public for resource utilization.

Designated Water Uses: As pertains to fish farming in the Great Lakes, Michigan should at least consider designating certain sections of the lakes for aquaculture. This idea then considers effective agricultural zoning, potentially managed under a version of the Right to Farm (RTF) legislation and possibly Michigan Agriculture Environmental Assurance Program (MAEAP). It would also be appropriate

[43] Competitiveness of U.S. Aquaculture within the Current U.S. Regulatory Framework
Carole R. Engle a & Nathan M. Stone, Aquaculture/Fisheries Center , University of Arkansas at Pine Bluff, Pine Bluff , Arkansas , USA in Aquaculture Economics & Management, Published online: 19 Aug 2013 at http://www.tandfonline.com/doi/abs/10.1080/13657305.2013.812158#preview - Quote from Abstract
[44] http://water.epa.gov/scitech/wastetech/guide/aquaculture/guidance_index.cfm
[45] http://aqua.wisc.edu/publications/ProductDetails.aspx?productID=485

to designate other areas of the Great Lakes as "Freshwater Protected Areas (FPAs)", much like the Marine Protected Areas (MPAs)[46] designated in the oceans of the world, as sanctuaries and park wildlife refuges to encompass a variety of conservation and ecosystem preservation and rehabilitation goals. Such designations could bring needed clarity to water utilization, particularly in the future as there will be competing demands including use for seafood production. Advancing these designations will require engaging other governments in the Great Lake region – state, federal, tribal and Canadian. Michigan is positioned to take a leadership position as it defines a Water Strategy through the leadership of the Office of the Great Lakes.

Third Party Verification: Third party verification and certification can add objectivity to branded product claims and when done well, such standard can establish a framework that can simplify and reduce the need for regulatory structure. Certifiers also serve as market-based agents helping to set the Performance Standards to which operators can, through establishing Best Management Practices and compliance, protect the public and consumer interest – be that for food safety, operational practices, environmental stewardship, or employee practices. Michigan aquaculture should consider engaging with both credible standard-setting agencies and with standard-verifiers.

A secondary benefit of working with a third-party set of standards is that they tend to be more market and environment responsive than government regulation, and as such can allow the industry to better respond to advances in science, society, and ecology. This could be particularly important in what will be a dynamic sector in the next two decades. There must be an acknowledgement that there are a number of agencies providing these services and that this space in the marketplace includes both credible verifiers/certifiers and entities that are yet proving themselves as trusted. In that context it is important for individual firms and groups within the sector, that might seek certification, to do good research on which service providers to engage. Specifically caution is advised to avoid "*greenwashing*" – the appearance of being independently verified, although the actual practice is in-house certification. This misses the point and can be perceived as misleading.

Pursuing third party certification must be a market-based decision of the aquaculture enterprise and make sense for its specific operation, brand positioning and market. Providers include NGOs, retailers, and specialists in standard setting and auditing, often in some form of alliance or partnership.

3 – Invest in Research, Education, Extension

The need for Research, Education and Extension exists because large and mid-scale commercial aquaculture, particularly in freshwater is still relatively early on in its development cycle. Investment is required across all three areas.

The research investment priority should be on the production/supply side of the sector. This is not to the exclusion of market/demand side research, which will be required by specific enterprise in their business plans (see Objective 7), it's just that the more immediate need is increased supply.

The Education and Extension focus should be in support of developing the personnel needed to run the sector, and equipping them with the knowledge, skills, and information needed - again with a focus on

[46] http://oceanservice.noaa.gov/facts/mpa.html

production, the supply side. Additionally broader education in society on the benefits of aquaculture will need to be undertaken.

Research
This plan concludes that focus and investment is needed in support of increasing production/supply – growing more seafood efficiently, cost effectively, improving consistency in the output, and ensuring fish health.

Research Education, Extension Priorities:

- **Research: the production/supply opportunity for the sector**
  - **Feed cost reduction**
  - **Genetics, broodstock, processing/utilization, energy use**
  - **Production systems (Objective 4)**
- **Education and extension**
  - **Personnel development – knowledge, skills, information**

Diets and feeding: Because feed can range from 50-80% of the cost of raising seafood, a continued focus on research towards feed cost reduction, improved feed conversions and fish nutrition is necessary. An example of the types of gains that have been achieved is that of Ontario trout farmers, working with their feed suppliers, have refined their feed rations to now achieve feed conversion rates of 1.14:1 and phosphorus discharges well within regulated limits – a vast improvement from 2.0-2.4:1 conversions of 15-20 years ago. The sector feed companies will likely lead this innovation; however, support from public institutions could make this development area more efficient.

Areas for future feed research include:

1. Species specific diets
2. Reduced feed conversions
3. Reduction in fish meal use and inclusion of plant based protein/ingredients
4. Higher nutrient availability for human health

Before considering production systems research (Objective 4 following) there are a number of other areas of aquaculture research needed to grow this young sector and improve production efficiency, resource stewardship, and to meet market expectations:

Fish Genetics: Very few species, beyond salmon and trout, adapted to the Great Lakes Region have been subject in extensive breeding and selection programs for optimized commercial production. Investment is required, ongoing for trout and salmon, and additionally for species such as whitefish, yellow perch and others.

1. **Investigate other species:**

   a. Lake Whitefish as a cold-water alternative to warm water tilapia
   b. Any number of other species on the current approved or research list as identified in the Michigan Aquaculture Development Act.
   c. Carp and other low-value rough fish.

d. Others – at the lead of entrepreneurs and researchers (such as barramundi)

2. **Species Broodstock Development and Adaptation for Aquaculture:** Advanced research in trout, tilapia and shrimp is still required. Another species of high interest in MI is whitefish – a unique Great Lakes opportunity for using a native species. In addition, with inland based recirculating systems, high value new and exploited species production is possible.

Transportation/Distribution/Delivery:

1. Moving fish to markets –
   a. Whole and live to fresh markets, focusing on those within a day's drive of the farm
   b. Whole on ice optimizing efficiency and ease of transport vs. live shipment

Fish Processing

1. Start by leveraging installed capacity with operators currently focused on the capture fishery product
2. Leverage the in-state Expertise of Pisces inc., a global leader in fish processing technology base in Wells, Mi
3. Processed and value added: targeting optimum fillet yields on specific species and sizes, and beyond that realizing as much value-added product yield as possible before rendering residuals to feed and other uses including fertilizers
4. Build out as the market demand is identified
   a. Like in most other categories of food, consumer (and food service restaurant operators - a main market channel) expectation for convenience and ease of preparation/serving will drive value added opportunity in the sector. Exactly what that is, needs to be determined. This also presents opportunity for higher yields from fish – use of parts other than the main fillet for value-added and convenience foods or other products.

Energy Utilization: Leveraging economical sources of input. The production of warm water species in Michigan will require the heating or conditioning of water and in the case of RAS systems energy to pump water. There exists opportunity to leverage waste heat from other industries for this. Municipal central heating districts, energy plants, and bio-fuel digesters could be sources of waste non- contact heat for aquaculture water. Furthermore there is opportunity for system design advances that will reduce the water-pumping and purification system energy need, particularly in RAS systems. For example circular tank flow and design optimization can significantly reduce pumping requirements when compared to raceway type design. More research is needed.

Leverage R&D expertise: This strategic plan suggests that R&D across all of these areas will need to be driven in large degree by the private sector, and on a platform of sustainability. That R&D must consider the triple bottom line needs (environmental social and economic) of a thriving and sustainable sector. Based on progress to date, reliance on university research may be limited; however, we do see opportunity in partnership roles for public institutions. Schools including GVSU, LSSU, UM and MSU could be leveraged to study specific water and/or environmental aspect of an expanding sector. For example, research towards benthic community impact below a cage farm can build in prior R&D from Ontario's Lake Huron studies and could be conducted by any and all of these institutions. So too could program development towards RAS and commercialization of new species like whitefish. The Grand Valley State University (GVSU) Annis Water Research Institute has expressed interest, including the opportunity to leverage their work, to explore options for cage culture production in Lake Michigan.

The Lake Superior State University Biology Department and the hatchery resource and aquaponics facility are training students interested in both aquaculture production and research. Tribal interests, expertise, R&D and investment (e.g. CORA the Chippewa-Ottawa Resource Authority) can be leveraged, particularly where aquaculture and fisheries intersect. In addition private aquaculture research entities including the Aquaculture Research Center, Tecumseh, MI and the Freshwater Institute, Shepherdstown, WV and others can play a role in delivery of science and technology for aquaculture.

Collaboration and coordination of R&D effort will lead to better outcomes, and R&D is necessary to assure that the public water resources can and are being well managed, using the best available knowledge, to protect the environment while benefitting both recreational and agricultural/aquacultural uses.

Education & Extension

According to the MEDC Michigan is home to 87,000 engineers, 70,000 R&D professionals and as many skilled trades-people[47]. We have a top-rated university system that includes leading agricultural, water resources, and biology schools. Training or retraining a small percentage of these people to work in an expanding aquaculture sector will be required, and is entirely achievable. Fisheries biologists and other fishery related field technicians and graduates would make excellent fish production managers with some added skills and training. A water resources engineer previously trained to work for a public utility, with an understanding of fish biology, can also design or operate a fish rearing facility. Produce and breakfast food marketing skills can be applied/transferred to seafood market development.

Training and education needs / opportunities within the aquaculture sector include:

1. Skills and expertise along the value chain
    a. farm operations, processing, shipping, and handling
2. Professionals – biologist, systems engineers, fish culturist, breeders/geneticists,

Private training can be accomplished through a variety of ways including universities, community colleges, workshops, seminars, internships and on the job experience, to advance the education and skills of the workforce.

National and global interests, more to the point, needs, are aligning with the concerns of meeting future protein demands, and traditional extension services in the state (Michigan State University Extension, Michigan Sea Grant, and the North Central Region Aquaculture Center) would benefit from additional FTE's in support of the sector. Acknowledging that future investment in these public entities for aquaculture may be limited, there will be opportunity for suppliers to the sector such as feed, technology, equipment and service providers to step in and provide necessary support.

The funding of such services and other sector investment in R&D could be secured several ways. In some cases commercial suppliers to the sector will build the cost of services and support (education & training, tech support, etc) into the product cost. Or the services could be provided on a fee for service basis by those same firms, independent consultants and knowledge service firms. Consideration should also be given to the establishment of a check-off program[48] for the sector. Check-off programs have been invaluable in other agricultural commodities for not only R&D and education investment, but also

[47] http://www.michiganbusiness.org/start-up/talent/#talent-connect

[48] Check-off Programs – learn more at http://en.wikipedia.org/wiki/Commodity_checkoff_program or http://blogs.usda.gov/2011/09/21/industry-insight-checkoff-programs-empower-business/

in fostering pre-competitive market development that benefits the entire sector. While a check-off program will generate significant funding only as the sector realizes critical mass, setting a structure in place early is advisable. Such programs could be defined narrowly by species or production systems, or include a broader approach (e.g. all seafood in Michigan). This would require collaboration across state and national boundaries, and could extend to include both farm-raised and wild-caught seafood. A broader base for a check-off program could be more effective at addressing all three elements of a sustainable sector – economic issues to ensure the sector thrives, environmental issues to ensure the sector operates as good stewards, and social issues including jobs, food for health, and the training of sector personnel and the education of the consuming public. While there has been resistance to such programs in the past in aquaculture, the broader experience in agriculture is that check-offs can be effective in funding R&D, market development and staffing necessary to lead and grow a sector.

4 – Design for Sustainability: RAS, Cage, and Flow Through Production Systems

As mentioned, commercial large-scale aquaculture is still in its infancy and more testing and R&D is required. Yet there are technologies that are proving to be viable. One consideration that should be a priority for the state is the establishment of demonstration farms – operating commercial fish farms that are willing to keep an open book on their practices, inviting scientists and regulators to work along side of them, together developing best practices across a range of production systems. For a starting point we simply look to the primary seafood production systems used in Michigan today – RAS, flow-through, and cage culture.

Design Priorities: Production Systems

- **RAS: Reducing energy requirements – water heating and water movement**
- **Flow-Through: maximizing water use, technology to mitigate discharge water quality risk**
- **Cage Culture: optimizing robust design for offshore use, siting and zoning for farms**

RAS – Optimizing energy requirements in recirculating aquaculture system (RAS) for water pumping/movement, heating and related water treatment will require research to make the systems cost effective. These challenges could well be addressed with the large engineering talent pool in the state. In addition, higher value and new species (e.g. marine shrimp, barramundi) are likely better suited for competing in processed value seafood markets (fillets) from RAS than traditional species, which is currently dominated by tilapia for live ethnic markets.

Flow-Through Systems – Design priorities for land-based flow-through systems need to minimize risk associated with effluent discharge regulations. Discharge limits and zoning issues may preclude physical expansion of existing facilities, and regulations appear to be the main impediment to expansion of flow-through systems in Michigan. Development and utilization of cost effective water treatment technology is expected to result in additional output. For example, technology such as aeration, mechanical solids removal, and water reconditioning could allow for additional water reuses before discharge to streams, wetlands, or other public waters, realizing a production gain without compromising other downstream uses. At this time cost effectiveness limits more widespread use of nutrient reduction by technology in flow-through. Proper siting, best management practices and better utilization of resources can help

realize expansion of flow-through systems in Michigan, while cost effectiveness and technology are being achieved.

C**age Culture** – While Michigan does not have experience with Great Lakes cage culture, Ontario has been successfully and sustainably producing 10 million pounds of trout in open water cages for 20+ years. While the Ontario industry attributes slow growth over this time frame to permitting and regulatory problems they continue to refine their practices, providing for and allowing a solid basis of learning from which a Michigan cage culture model can be developed. Does our sector need to look just like that in Ontario? Not exactly, rather we can learn from their latest technology advances and experience, as well as that of marine aquaculture systems operating on both east and west coasts.

Up until the release of the draft of this Strategic Plan, regulations pertaining to Michigan commercial cage operations in Great Lakes waters of Michigan have been viewed as overwhelmingly prohibitive, or at the very least highly uncertain. Perhaps due to recent interest in the prospect for cage culture in the state, the Quality of Life Group released a document in May 2014 entitled "Permit Application Process for Net Pen Operations in Michigan". This document is provided in Appendix 10 and considerably an important step by state agencies towards potential commercial development.

Michigan can and should adopt the best management practices and sitings for specific conditions. For example land access cage systems should only be located where they provide minimal impact (environmental, social, navigational) and/or benefit to existing user groups, stakeholders and social needs (jobs, economy). In some cases recreational fisherman have shown preference to fish next to cage culture sites (Figure 11). Sitings should not be considered in sensitive, residential or high navigational areas.

Figure 11. Recreational fisherman showing preference for fishing near a cage culture site in Ontario Canada (courtesy of Northern Ontario Aquaculture Association).

Cage culture in the Great Lakes must also address structural issues (ice out, storms) and bio-security (disease from open water, escapes). Adoption of offshore systems such as the Aquapod™ design[49] or other robust structures (for example the Oceansphere™ concept[50]) should be considered. Placing more robust design cages in offshore locations moves them into deeper waters away from the view of the shores. It may also provide better flow, fish and ecosystem health and environmental risk mitigation. However, they also likely require higher operating costs than land accessible systems. As the technology develops offshore siting might preferentially be done in areas like those traditionally designated for capture fishery trap net siting away from shipping channels and other uses. Commercial fisherman from existing capture fisheries familiar with Michigan waters are prime candidates for partnerships with offshore fish farm operations.

[49] http://oceanfarmtech.com/index.php/aquapod-net-pens
[50] Oceansphere design concept offered by Hawaii Oceanic Technology, see http://www.hioceanictech.com/

Species identified with high potential for Great Lakes cage culture operations include trout, salmon and whitefish. Our neighbors in Ontario are experts at freshwater rainbow trout cage culture, and we can look to our US coastal states of Maine and Washington for models of sustainable salmon production. Value of Michigan caught whitefish appears to be on the rise, and aquaculture production in the Great Lakes could compliment the commercial fishery by supplementing product at key points in a variable and seasonal harvest.

When considering options and opportunity for Michigan aquaculture open water, offshore cage culture must be considered, if simply for no other reason than the sheer volume of water available in the Great Lakes. Given opportunity fish production can be sustainably managed without compromising society's other use for transportation, recreation, subsistence and commercial fishing, and aesthetics. Michigan Sea Grant, institutions such as Michigan State, the University of Michigan, Lake Superior State, Grand Valley State, tribal entities such as CORA (Chippewa Ottawa Resource Authority), and/or private research entities such as the Aquaculture Research Corporation could partner to study and pilot these production systems.

There may be additional opportunity for fish culture, in cages or free-swimming, in abandoned quarries and like water bodies. In these types of systems fish loading must be balanced with ecosystem conservation and performance. Management practices such as fallowing may be required between crops, similar to what is done in good pasture management in land-based animal agriculture. Extensive research in Canada's Experimental Lakes District[51] provides a foundation of knowledge, practice, and data for which to advance commercialization.

As of 2013 open water cage culture is proven to be a low-cost, competitive and sustainable production system for commercial finfish aquaculture in other parts of the world including the Ontario side of Lake Huron. Siting research will be needed, building on the Ontario experience.

Since commercial aquaculture is still very early on in its life cycle, we can move forward with the expectation that research and creative problem solving will lead to many new breakthroughs. Demonstration farms as well as more formal commercial and institutional research effort will help provide those breakthroughs.

5 – Sector Leadership – A Sector Champion

This Strategic Plan is developed to grow a commercial sustainable thriving aquaculture in Michigan. The preferred champion of the sector's growth and this Strategic Plan is a strong and vocal trade association speaking for, and leading, sector development. The Michigan Aquaculture Association (MAA) could fulfill this role. To grow the sector the trade association should be staffed with an Executive Director charged with advancing this plan and securing the needed finances, entrepreneurs, and engagement of the various stakeholders.

The development of this Strategic Plan was led by a steering committee that included MAA along with NCRAC, MDARD, and MSU. It was funded by Michigan Sea Grant and foundational support as a Sea Grant Integrated Assessment (SGIA). As such the deliverable from the project is both the Strategic Plan and a research report (this document).

[51] http://www.dfo-mpo.gc.ca/science/publications/article/2007/27-09-2007-eng.htm

The sector leadership must take the SGIA project learning, and internalize the strategy, drive its implementation, deliver results, advance discovery, and fine tune the strategy ongoing (Figure 12).

Leadership Priorities:

- **Champion the Strategic Plan**
- **Lead in Michigan achieving "Open for Business" status for aquaculture**
- **Engage a broad base of stakeholders in creating a thriving sustainable aquaculture**
- **Implement the Plan, refine as needed**
- **Deliver Results – create a trade association of commercially enterprises that fosters ongoing success**
- **Lead Discovery – in technology, markets, methods, investors, simplified regulation**

Interviews and interaction with the current MAA membership has revealed that, while there are a number of members interested in developing large-scale aquaculture in the state, most are lifestyle fish farmers and/or too far along in their life and career to engage in the needed drive to grow the sector. It then becomes incumbent on the progressive leaders of MAA to drive the change needed as articulated in this strategic plan to sector growth. With that said, however, the MAA is very resource constrained, and the association's funding base is simply very small due to the current size of the sector. Resourcing of development funds through grants and the attraction of new well-funded members interested in participating in the sector growth will be required.

MAA leadership should also actively engage the AIM process initiated in 2011 to ensure government and academia remain engaged in advancing aquaculture, first in removing remaining roadblocks, and beyond that in supporting the creation of the needed regulatory, business and research climate for a thriving and sustainable aquaculture. The Executive Director should lead the sector in achieving "Open For Business" status with the state government, securing broad endorsement of this plan (among consumers, general farm organizations, environmental groups, market channels), and advancing a policy framework for aquaculture development including cage culture in the open waters. The leaders should also engage the Native America Tribal leadership and the commercial fishermen engaged in wild capture under the Tribal Consent Decrees, seeking a harmonized and sustainable approach to water access and utilization for fish culture. Decline in the capture fishery has resulted in several tribes expressing interest in aquaculture as a business opportunity that, through due diligence, science and acquired knowledge, can contribute to native species and ecosystem restoration.

Figure 12. Sector leadership roles of aquaculture development in Michigan

It would be incumbent for a repurposed trade association, the MAA or another manifestation, to solicit endorsement for the Strategic Plan from other stakeholders including the North Central Regional Aquaculture Center (NCRAC), Michigan Sea Grant, the State QOL Departments – MDARD, DNR, DEQ, its counterparts in Ontario (Northern Ontario Aquaculture Association), and the trade associations in

adjoining states since regional collaboration will be required to best leverage water resources in ways to advance aquaculture not only in Michigan, but throughout the Great Lakes Region.

Alternatively, if the trade association cannot resource an Executive Director, then one or more individuals or enterprises, visioning a future and have the drive to achieving it, could champion the plan. The risk in this case is that the sector might be narrower in focus than if a broad-based trade association such as MAA, or other, leads the sector forward.

Leadership requires political will within the commercial sector to drive growth and development, and political will in government to support development by engaging the sector and structuring a regulatory and permitting framework conducive to economic growth while protecting other public interests. Hughes et al (2010)[52] identified political will as key to the successful development of aquaculture. While Hughes paper speaks from a position of scarcity and concern for ecosystem degradation we propose that the planet can also be viewed from the perspective of abundance and ecosystem health through sound management. Humankind has responsibility as stewards of creation to find and achieve balance between environmental integrity and societal needs for sustainable food systems. Developing aquaculture will not be perfect, but cautionary advancement is indeed possible. Because seafood will be critical to feeding the 9 billion people that will be our heirs and neighbors on the plant, we must actively manage our resources to the best of our ability. Through expertise, best management practices, and sound science, Michigan, blessed with resources and talent, can, and has responsibility to, contribute to this global challenge.

6 – Improved Business Plans

The dynamics of aquaculture business opportunities are changing rapidly around the world. In 2012 for the first time aquaculture brought more fish to market than did sources from the capture fishery. Concurrently demand for seafood continues to increase, driven both by an increasing global middle class, specifically in China and South East Asia, and by broader recognition that increasing seafood in a balanced diet can contribute to improved health, particularly the inclusion of species with high omega oil content. This presents a business opportunity in the Great Lakes Region, specifically for Michigan.

The market is primed for more Michigan seafood. Food distributors and retailers that contributed to this strategic planning process have unmet demand for rainbow trout, fresh shrimp, and a range of other species that can be produced in Michigan.

Improved Business Plans will:

- **Be market-based, leading to thriving and sustainable enterprises**
- **Leverage state and regional resources to improve likelihood of success**
- **Come from in-state, national and foreign investors**
- **Leverage state QOL working group resources for streamlined permitting**

[52] Hughes, Sara, Joan B. Rose, Governing Aquaculture for Human Security, 2010, p.3 & 16 available from the author at shughes@bren.ucsb.edu

Already in 2014 a number of Michigan-based entrepreneurs are launching new ventures to capture some of those markets and within the next two years the goal of sector growth to double/triple/quadruple fish out-put will be achieved. Commercial rainbow trout sales should surpass one million by 2016, with more to follow.

As a growth sector that starts from a small base and is not well understood yet by investors, the sector's entrepreneurs could benefit from support in business plan development from agencies interested in advancing the Michigan economy such as the MEDC (Michigan Economic Development Corporation), the MDARD Office of Agricultural Development (OAD) and regional/county/city economic development authorities. Since 2013 there has been expressed interest from Delta County, the Saginaw regions, Detroit, and the St. Joseph/Benton Harbor areas in developing aquaculture.

The prime drivers to sector expansion must be commercial operators interested in fish farming or related support businesses. While there is fish processing capacity to handle short-term growth, there will be need for processing and input suppliers to support the sector. Since our current production base is very small this plan suggests that a major source of new business plans will need to be from established aquaculture from outside of Michigan – likely foreign firms, but some domestic as well, that have identified market opportunities in Michigan. These firms could bring experience to developing necessary business plans and venture start-ups, but would need some level of confidence that Michigan is truly "Open for Business" on the aquaculture front, and that the regulatory framework is conducive to achieving timely approvals in support of venture start-up. The state government QOL Aquaculture Working Group established in 2012 is an important step in this direction and ongoing refinements towards simplified permitting and regulatory compliance will enhance the opportunity for successful business plan and sector growth.

Any solid business plan depends on a market for the product. This strategic plan does not have a primary focus on market development beyond the acknowledgement that there is and will continue to be a significant and expanding market for seafood. As outlined in the Executive Summary, global aquaculture is growing at $10 billion annually, and expected to surpass $195 billion by 2019 and $330 billion by 2030. Enterprises need to identify market segments for their area of focus. The biggest current challenge, however, is production – increasing the seafood output to meet the existing growing demand.

7 – Financing: Attract New investors

Building on the need for solid business plans, this Strategic Plan recognizes that a key factor in achieving the rapid growth will require attracting new investors to Michigan.

Attract New Investor Priorities:

- **Invite global leaders in sustainable aquaculture to operate/produce fish in Michigan**
- **Catalyze in-state investors to establish production and support service enterprises**
- **Inform and educate lenders on aquaculture and related opportunities**
- **Engage in economic development agency programs that help secure working capital for start-up and growth phases of enterprise operation**

Growing aquaculture is first and foremost a production agriculture opportunity. To that end, like other sectors of agriculture, it will rely on farmers utilizing personal financial resources in order to grow. The sector is likely only to generate few, if any, patents or other intellectual property that normally attract venture capital. Nor is production aquaculture likely to generate returns and capital turnaround typically sought by venture capital investors. The sector will need to grow with owner equity and patient capital, much like any other start-up production business (see Figure 13).

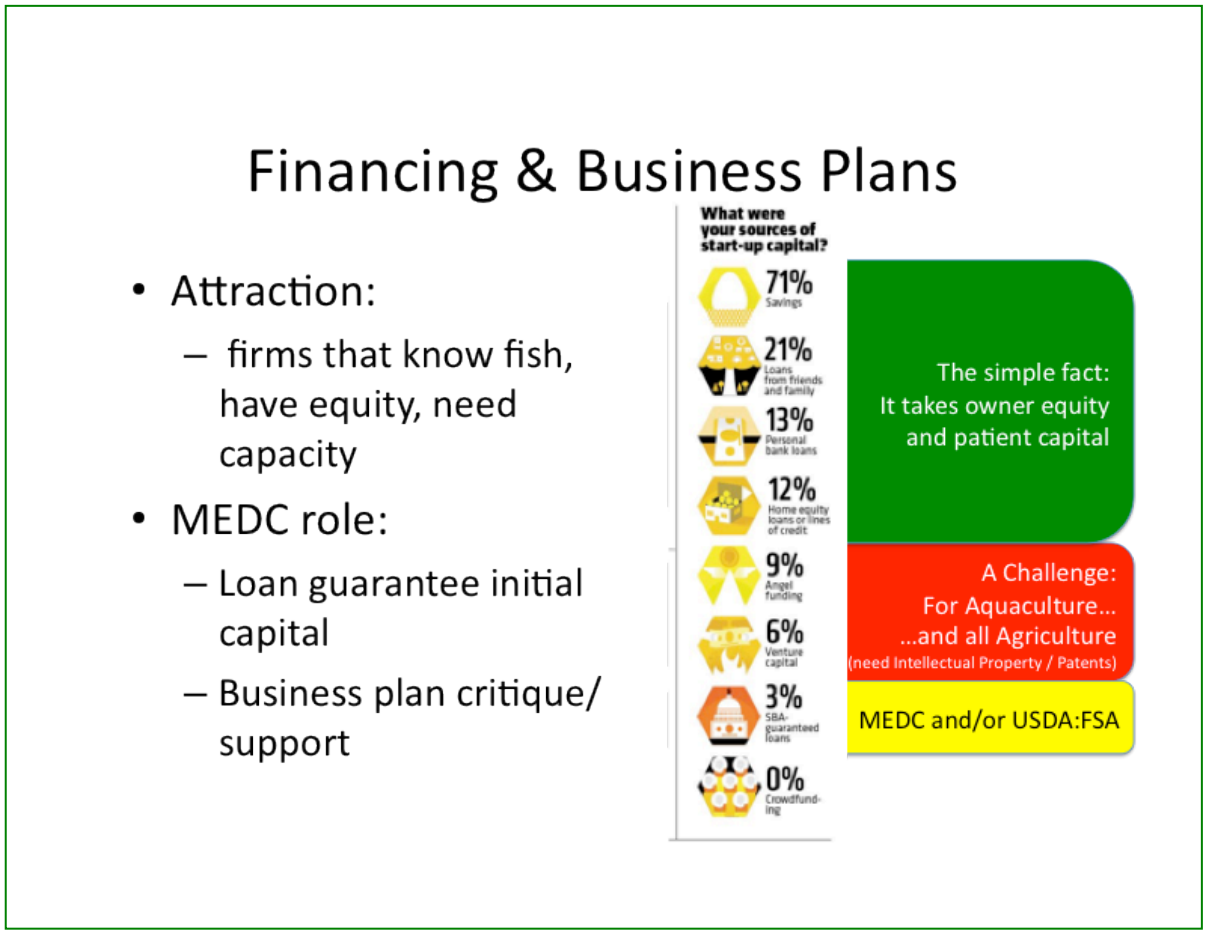

Figure 13. Financing potentials for a thriving Michigan aquaculture sector

Attraction – Global Aquaculture Enterprises: As our current sector is undercapitalized and small, Michigan will need to attract global integrators, using a selective attraction method to attract operators with a good track record of sustainable practices, food safety, environmental stewardship, and general compliance to best management practices. Through a strategic planning process global integrators with established markets were identified that could leverage market channels for marine species to produce and supply freshwater species. In Michigan it's logical to start with growing the sector through meeting the unmet demand of distributors already operating in the state. These include Superior Foods, Sysco, Gordon Food Service, Meijer, and Spartan. It's known that many retailers and food service distributors prefer to leverage existing suppliers for new products, so targeting the attraction of global operators to

Michigan should be a priority. They can bring not only the financial resources, but also experience with best practices and vendor relationships that can attract additional support services from other states as well. For example feed mills and equipment suppliers will need locations in Michigan to support a growing sector, yet critical mass is required before that will happen. To operate on a global scale processing plants may need capacity of 4,000-6,000 metric ton annually in the next decade. Global integrators – firms that both produce and process fish can help realize the opportunity.

Global integrators, along with established in-state seafood value chains, will further catalyze additional organic growth of Michigan production sector. These firms will need supplies of eggs and fingerlings, of feeds and technology, and they may need processors of value-added fish products as channels to new markets. They may need additional production capacity to compliment/supplement their output. These all represent opportunity for new Michigan firms.

In-State Investors: And there are Michigan investors that can bring new capital to aquaculture. As 2013 closed out there were several farms with new permits in hand and other applications in the works. This too needs encouragement and development. Some will bring new money to the sector, from investors willing to work over the intermediate timeframe of 2-5 years to get to positive cash flow, profitability and the desired long-term return on investment for further reinvestment and growth. Others are still 'bootstrapping" – earning the sweat equity needed, which will also increase the base of start-up farms that could be candidates for either organic growth or future buyout by well capitalized investors.

A Role for Lenders: A growing sector will need sources of borrowed capital to support the expected business plans. The legacy in Michigan is that, primarily due to lack or experience with and limited exposure to aquaculture, bankers have not invested in aquaculture. This is not pointing fingers at the lenders – there has been a concurrent need for stronger business plans. As the aquaculture sector is better understood lenders are becoming better informed about aquaculture. This will allow them to better critique business plans, help farmers build a stronger base to get to creditworthiness, and mitigate risk. In 2013 Greenstone Farm Credit assigned Michael Niesyto, Financial Services Officer, Ann Arbor, MI as its lead for the aquaculture sector in the state. Mike has fully engaged the sector, eager to learn and help the sector grow. Other banks and agricultural lenders should be encouraged to learn more about aquaculture.

Commercial aquaculture operators are encouraged to engage their bankers/lenders and educate them on the basics and nuance of their specific ventures. As in any business sector, banking for aquaculture is as much about knowing the people involved and trusting that they have the necessary skills, a solid plan, and finances needed, first to protect the farmers own capital, and then to grow the business with borrowed capital from a banker who also likes to sleep at night knowing he/she has lent/invested well.

Government Economic Development Support & Investment: For Michigan seafood production expansion to succeed, there are various roles for the Michigan Economic Development Corporation (MEDC) and other county and regional EDCs to take in order to help 'jump-start' enterprises in the sector. Loan guarantees, bridge financing, business planning support and critique, are good examples of actions that increase the likelihood of venture success. As stewards of what is often public money, EDC investments, and incentives provided, towards aquaculture must be sound. Lenders must be able to place trust in the hands of the venture operators. It is recommended that operators interested in such support develop strong relationships with their EDC agents. The MEDC's CAP (Capital Access Program) and LPP (Loan Participation Program), in partnerships with lenders, are resources that could benefit aquacultural businesses. LPP is a program specifically helpful in situations where working capital is

required for growing and expanding operations to 24 to 36 months needing continued cash flow. More about MEDC programs can be found at michiganbusiness.org.

Additionally, MDARD's Office of Agricultural Development (OAD) should be engaged in advancing aquaculture through their various production and value-added agriculture programs. Also, the State of Michigan Office of the Great Lakes is currently developing a Water Use Strategy for the Great Lakes. Michigan Aquaculture and seafood production systems could play a major role in this office's programs.

Sector Input Supply and Seafood Processing Capacity: The attraction strategy should extend beyond bringing new seafood farmers to the state. There will be a need for input suppliers and additional seafood processing capacity investment. Some of that investment will be Michigan companies that service other sectors and see aquaculture as an opportunity to expand their business base. Beyond this organic growth, there will be opportunity to attract new investment by companies from outside of Michigan that see an "Open for Business" aquaculture sector as attractive for growth.

Feed and Other Inputs: Beyond the farming of fish, investment opportunity in the supply chain is expected in high degree as the sector grows in Michigan and the Great Lakes region. Currently the nearest fish feed processors are in Ontario (Martin Mills, Elmira – see http://www.martinmills.com/profishent_index.php), Pennsylvania (Ziegler – see http://www.zeiglerfeed.com/html/aquaculture.htm), Utah (Skretting/Nutreco - see http://www.skretting.us), Ohio (Enviroflight – see http://www.enviroflight.net/), and recently in Indiana (Bell Farms™ Aqua Feed). Transportation costs factor considerably in feed cost. Current thinking is that attracting a dedicated aqua-feed feed mill will require a sector that consumes 30,000 – 50,000 plus tons annually. Before that is achieved more economical bulk freight (rail, truckload/intermodal) and the addition of fish pellet extrusion capacity at an existing animal feed mill will need to be investigated to ensure that the sector can expand with manageable feed costs. In additions RAS systems will require tank manufacturers and water treatment technology. Cage culture will require supporting ports/harbors and manufacturing of the cages and support infrastructure.

Processing: While Michigan does have some processing capacity for whole fish for the capture fishery, it is limited. Currently Michigan processors handle less than 5 million pounds of fish annually, primarily the seasonal whitefish harvest that in 2012 was 3.7 million lbs. Year-round use of this capacity, with some modification to other species and fish sizes, could provide 5-20 million pounds of capacity as the sector grows. However, in order to realize economy of scale in processing, Michigan will need viable new ventures with capacity to process from 5-50 MM tons/yr. This is simply a factor of the scale needed to competitively meet today's food safety verification, meat processing and other market standards at an economy of scale. It is expected that, as Michigan becomes "open for business' in the aquaculture sector, that it might well be vertical integrators that bring this new capacity to Michigan. Alternatively and/or additionally, established whitefish and trout processors may capture the opportunity, expanding their enterprises substantially. Michigan is also home to Pisces Inc., a global leader in fish processing equipment (http://www.pisces-ind.com), and well positioned to support processing capacity build-out and further contribute to the Michigan economy.

The initial primary processing will not only target processed fillets, but also other value added products (spreads, finer pieces, caviars, etc.) that add profit while providing seafood in more convenient form for food service home consumption. This value-added processing will be market driven while providing opportunity for higher yields of consumable food from the fish. In addition, processing co-products

ranging from the production of fertilizers, compost, oils for food/feed/industrial uses will result in substantial value contribution to the economy.

Next Steps:

Initial Strategic Actions for 2014: This strategic plan recommends seven specific actions in 2014. Implementation of these actions should set the stage for sector growth in 2015 and beyond (see text box titled "Initial Strategic Actions (2014)" on following page and in the Executive Summary of this document.

For further consideration a summer 2014 Sea Grant and or MAA sponsored workshop to bring together a broad stakeholder group is recommended. Participants could include future partners like NOAA-Ontario, other states, tribal leadership/CORA, The Nature Conservancy, other experts including 4Links Marketing (www.4links.ca), and the current AIM process participants. This could serve as a rallying opportunity to further advance action.

CONCLUSION:

The development of a thriving and sustainable Michigan aquaculture sector that can contribute to the state economy, provide jobs and food, while ensuring that our natural resources are preserved and available for recreation is desirable and achievable – another opportunity for "relentless positive action" by Michigan, for the benefit of Michigan and the world.

Initial Strategic Actions (2014)

Expand and Establish Aquaculture Enterprises Along the Supply Chain

– BASED ON PROVEN SPECIES, TECHNOLOGIES, AND MARKETS TO DEMONSTRATE SUSTAINABLE GROWTH

- By: 2014-2016
- Through: Commercial enterprise – achieve near-term targeted quadrupling to $3-8 million in farm-gate sales

"Open for Business"

(1 - Social Acceptance/Political Will)

– AQUACULTURE IS ENDORSED IN THE MICHIGAN GREAT LAKES WATER STRATEGY AS A NEEDED ECONOMIC ACTIVITY

- By: Q1, 2014
- Through: Office of the Great Lakes, with support from Quality of Life Departments, MEDC, Governor

Engage Tribal Leadership & State Regulators in Great Lakes Water Usage

(1 - Social Acceptance/Political Will)

– DEFINE WATER AREAS FOR SHIPPING, FISHING, PRESERVES, RECREATION, **and AQUACULTURE** AS PART OF A COMPREHENSIVE USE PLAN THAT CONSIDERS THE NEED FOR COMMERCIAL ACTIVITY FOR THE PUBLIC GOOD FROM PUBLIC RESOURCES.

- By: Initiate dialog in 2014, work towards definition ahead of expiration of current 1836 Consent Decree (by 2020)
- Through: Negotiations and/or legislation towards consensus that seeks the economic/social/environmental welfare of all stakeholders in society

Permitting and Regulation

(2 – Achieving Trust)

– Continue to DRIVE SIMPLIFICATION OF PERMITTING THROUGH STATE GOVERNMENT, building on the current QOL Working Group process, ACHIEVING WORLD-CLASS TURN-AROUND (< 60 days)

- By: Year End 2014
- Through: Continuous Improvement practices, while handling new incoming applications

Drive RAS Operations Cost Reduction

(3/4 – Research/Education/Extension)

- By: 2104 and ongoing - secure research grant for 2015 and implement research program
- Through: Research Program to Improve on Energy Usage and Capital Costs per unit of Production - secure first research grant funding through Michigan Sea Grant or other sources

Funding Sector Leadership

(5 – Leadership: a Sector Champion)

– HIRE A CHAMPION FOR A THRIVING AND SUSTAINABLE MICHIGAN AQUACULTURE, ENGAGING STAKEHOLDERS, ATTRACTING INVESTORS, LEADING PUBLIC-SECTOR PARTNERING

- By: year-end 2014
- Through: The trade association (MAA), with private and/or public funds (with matching "kick-start" funds for up to 5 years from an MEDC Aquaculture Development Program – negotiated or legislated)

Attracting Investors and Financing Growth

(6 Improved Business Plans & 7 Attraction)

– BEGIN MESSAGING IN SUPPORT OF "OPEN FOR BUSINESS"

- By: 2014 & 2015 aquaculture sector annual meetings and conferences – and ongoing
- Through: MAA Leadership, in partnership with AIM stakeholders including MEDC and MDARD-OAD

Appendices

Appendix 1: A Brief History of Aquaculture in Michigan

The culturing of fish in Michigan goes back to the late 1800's, with primary objective at the time to enhance the wild caught commercial fishery. For the most part these activities were conducted by the state government. As recreation and tourism became a larger part of the economy the production shifted to species to enhance the recreational experience. Private fish farming industry got started as demand for trout for roadside fee fishing ponds grew and stocking of private ponds became popular. In the 1980s commercial production grew fairly rapidly and averaged 23% growth per year from 1988 to 1991[53]. Trout was the number one species with sales in 1991 of $2.4 million. In 1991, approximately 70 active commercial producers in Michigan raised over 17 species fish. The majority of these fish were sold for stocking as game fish, although 9% producers had fee fishing, and 6% of producers sold to the food fish market.

The Aquaculture Development Act, 1996[54] was significant in defining aquaculture as agriculture and establishing a framework for sector development. However, even with passage of this act, growth of the sector has stalled since 1991, and the landscape in terms of facilities, producers and production level remains relatively unchanged. In actuality production is down from 1991 levels, while value of product has increased. For the last year in which data was collected by USDA, the value in 2005 was $2.4 million, the same amount reported for 1991.

The question is often raised as to why the industry has not continued to develop and become much greater established. That very question is a basis for the integrated assessment project undertaken herein.

In a study conducted by Chopak and Newman in 1991, researchers made projections of how the industry would progress to the year 2000. They projected two scenarios: one under a current rate of growth and another of high rate of growth. Under the current rate of growth, without a more favorable investment climate the authors stated it is unlikely that number of growers nor production levels would increase appreciably. Under the high rate scenario, new investors would be attracted to Michigan aquaculture, production levels would raise considerably as would the size of facilities. In order for the latter scenario to occur, the authors indicated the following changes were necessary:

- Policy changes
- Aquaculture plan
- State aquaculture coordinator
- More research and extension
- Improved information flow (production methods, technology and marketing)
- Increased social awareness

[53] Chopak, J. and J.R. Newman 1992. Status and Potential of Michigan Agriculture – Phase II (Aquaculture). Michigan State University Agricultural Experiment Station. Special Report 50. East Lansing, MI.

[54] Aquaculture Development Act, 1996 is at:
http://www.legislature.mi.gov/%28S%282ivoh1452nuufz55an5prb45%29%29/documents/mcl/pdf/mcl-Act-199-of-1996.pdf

In retrospect, it appears that some of these changes, but not all, have been attempted and implemented. Some, like state aquaculture coordinator, have been implemented part time and aborted. Others appear only now under development. Perhaps the greatest reason why the industry has not expanded significantly is because a concerted effort to accomplish and maintain all the points identified in the 1991 study never truly materialized.

Case Study – The Michigan DNR Hatchery System

A case study of how a segment of the industry has grown and evolved is the Michigan Department of Natural Resource Fish Hatchery System. This system started to enhance fish stocks of commercially harvested wild stocks, such as whitefish. In the early 1900's the program shifted into more stocking of inland lakes and streams with coldwater species. Most of this production consisted of rainbow, brown and brook trout, and production systems were scattered around the state in small facilities to provide local sources of stocking fish. In the mid 1960's with salmon stocking underway in the Great Lakes, disease issues and water quality concerns moved the MDNR to centralize fish rearing facilities into 6 hatcheries that provided fish statewide. A number of renovations to state of Michigan hatcheries have been undertaken since 1994 including Marquette $6 million in 1994, Oden $11 million in 2022, and Platte River $8.5 million in 2003. The DNR currently operates six large fish hatcheries, five permanent salmonid egg-take stations and up to 40 rearing ponds. The fish-stocking program supports a $2.4 billion-dollar sport fishing-related sales economic impact in 2011[55]. In 2013 the State of Michigan DNR stocked approximately 20 million fish in Michigan waters[56].

[55] http://greatlakesecho.org/2013/01/22/hunting-fishing-provide-boost-to-michigan-economy/
[56] http://www.michigandnr.com/fishstock/

Appendix 2: The Project Process – How the Strategic Plan Was Developed

The concept for the Strategic Plan (SP) was developed under the guidance of Dr. Christopher Weeks, Michigan State University Department of Fisheries and Wildlife, under his role as regional aquaculture extension specialist for the North Central Regional Aquaculture Center (NCRAC). This project became part of the 2011 Aquaculture in Michigan (AIM) initiative that brought together a wide range of stakeholders to drive the advance of fish culture in the state. Late that year Originz, LLC was awarded a contract by MDARD on behalf of AIM to develop a Roadmap Through Regulations[57]. The Roadmap helped bring clarity on the various regulations and permits required of aquaculturalists operating in Michigan. In mid 2012 Originz, LLC was sub-contracted to support Dr Weeks and lead in developing the Strategic Plan (SP) process for the sector.

Originz kicked off the SP process with engaging stakeholders holding interest in aquaculture. We interviewed fish farmers, regulators, extension staff, non-governmental environmental organizations, general farm organizations, economic development personnel, tribal agencies, bankers, wild-capture fisheries operators, fish processors and distributors within the state. We also engaged aquaculture-interested parties in neighboring states and Ontario, Canada – to learn of the status of aquaculture and their plans for the future, realizing that a Michigan strategic plan for aquaculture could have implications across the Great Lakes region.

Many conversations resulted from combination of face-to-face meetings and telephone interviews, participation in stakeholder annual meetings and conferences and in a series of five stakeholder workshops in 2012 and 2013. Invitations were extended to 50+ individuals and organizations and the participation ranged from 22-35 across sessions. The first workshop was a Scenario Planning session where we collectively developed a set of four scenario stories to describe possible futures for Michigan aquaculture in the year 2025. These scenarios provided a framework for developing the Strategic Plan, keeping the stakeholder community focused far enough into the future and will continue to guide our thinking and action as we advance. For more about the logic for Scenario Planning and the process see also Appendix 6. An excellent resource on the subject is the book "The Art of the Long View: Planning for the Future in an Uncertain World" by Peter Schwartz[58]

Subsequent workshops engaged stakeholders in developing and testing strategies that we might engage in advancing aquaculture. Early in the year we 'went wide' opening up to any possibilities as a result of the ongoing learning, then refining the context for a strategic plan to key activities that the sector needed to engage by the summer. Throughout this timeframe we (the Originz team) continued to check back with stakeholders and experts regionally and nationally, gaining additional insight and learning to bring to the project.

Between the workshops Originz and Dr Weeks met quarterly with the project collaborators (MAA, MSU, Herrick Foundation, MDARD) to review progress and confirm direction.

[57] Originz, LLC for the Aquaculture in Michigan initiative, Roadmap Through Regulations, at http://michiganaquaculture.org/strategic-plan/michigan-aquaculture-roadmap/

[58] available at http://www.amazon.com/The-Art-Long-View-Uncertain/dp/0385267320

The project also engaged the MSU Product Center (MSU-PC) for the creation of a SWOT (Strengths, Weaknesses, Opportunity, and Threats) analysis of the aquaculture sector. This provided additional context for the SP. The MSU-PC also developed a supply chain analysis of aquaculture and a set of enterprise models for appending to the SP as tools those interested in expanding or starting fish farms in Michigan could use as templates in developing business plans.

Early on we recognized the need to have some 'quick-wins' to show progress in growing the sector – the stated goal being to double or quadruple commercial food fish production in the first few years (by 2015). To advance this effort we also engage a number of established fish farmers and entrepreneurs – to share our learning to date and learn from their successes and challenges along the way. While at this writing we have no quantified increase in food fish shipments, there are a number of new licensed farms operating in Michigan and at least two farms are expanding production that could have this goal realized by 2015 – one with new external financing new to the sector. Others are developing business plans. Taken together this progress shows more interest in the sector than in the previous decade.

In late 2013 the focus shifted to writing the plan and report – along with the requisite ongoing 'reality checks' and ongoing research to support incorporation of current information in a rapidly changing and developing aquaculture. This report was completed at year-end 2013, and presented in draft form to both the Michigan Aquaculture Association (MAA) and Michigan Sea Grant on January 31, 2014. MAA adopted the draft as a Strategic Plan in February 2014. The draft also went through a peer review process facilitated by Michigan Sea Grant. PI (Weeks) has addressed comments made from reviewers of the peer review. This report is the culmination of much effort and input from a wide range of stakeholders across the state of Michigan.

Appendix 3: SGIA Acknowledgements

First and foremost we would like to acknowledge Michigan Sea Grant for funding this project, and for their continued effort, insights and expertise in sustainable use, protection and development of Michigan's coastal resources. We also wish to acknowledge NCRAC in support of aquaculture development across the North Central Region US, including this SP. Numerous individuals and groups also supported this effort with contributions of time and input. The first is the Sea Grant Integrated Assessment Core Group, consisting of Chris Weeks, Principal Investigator, Dan Vogler, Bill Knudson, Mike DiBernardo and Kent Herrick. The group met periodically to discuss the direction of the project and offer insights on the various aspects of the project.

A second group was made up of stakeholders originally organized as part of the Scenario Session, which kicked off the Integrated Assessment. This group was designed as a broad based assembly to provide input from various perspectives. Included were State of Michigan departmental representatives, non-governmental entities, entrepreneurs interested in fish production, technical experts in livestock production, fish processors, financial and business development advisors. These people are noted in the participation list.

The Sea Grant Team in Ann Arbor also provided valuable insights as the Integrated Assessment process moved forward. Michigan Sea Grant also provided graphic support with illustrations used in the Assessment. These people included Jim Diana, Lynn Vaccaro, Stephanie Ariganello and Todd Marsee.

A fourth source of input to the Strategy was the large number of people that were interviewed or participated in various meetings around the State. These included two trips to the Upper Peninsula to meet and consultant with local governments, Tribal entities and development people about aquaculture. Visits to Indiana, Ohio, Wisconsin and Ontario to meet with aquaculture producers and governmental regulators were conducted. Commercial fishermen were contacted about interest in aquaculture. Various municipal entities and other interested individuals were met with from around the State for input and interest. Strategy members also participated in the Aquaculture in Michigan workgroup. The team also provided updates to the Michigan Farm Bureau's Aquaculture Policy Group meetings on three occasions.

Below are listing of some of the key meetings held to communicate and gain insight for the project:

Core Groups Meetings: Aug. 10, 2012; Sept 20, 2012; January 8, 2013; June 14, 2013; October 1, 2013

Stakeholder Group Meetings:	November 8, 2012	Kettunen Center, Tustin, MI
	May 14, 2013	University Club-East Lansing, MI
	July 23, 2013	University Club-East Lansing, MI
	October 30, 2013	University Club-East Lansing, MI

Presentations on Aquaculture Strategy:

Michigan Fish Producers	January 26, 2013	Traverse City, MI
MAA	January 19, 2013	Tustin, MI
Wisconsin Aqua Annual Mtg	March 3, 2013	Pewaukee, WI
Aquaculture Canada Conf.	June 4, 2013	Guelph, ON

The tables below list the core project team along with a number of people we would like to acknowledge for their participation in the Integrated Assessment. These are comprehensive lists

compiled over the 18 months of the project; however, if we inadvertently did not include your name, we give thanks for your contributions as well in the development of the Integrated Assessment project's Strategic Plan.

SGIA
Participants and Stakeholders Engaged in the Development of the Strategic Plan for a Thriving Michigan Aquaculture

Core Group

MSU	Chris Weeks
Michigan Aquaculture Association	Dan Volger
MSU	Bill Knudson
Herrick Foundation, Aquaculture Research Corp.	Kent Herrick
Originz LLC	Joe Colyn
Originz LLC	Gary Boersen

Stakeholder Group

MEDC	Gil Pezza	The Nature Converancy	Patrick Doran
Hannahville Tribe	Dave Anthony	The Nature Converancy	Helen Taylor
Michigan Farm Bureau	Ernie Birchmeier	Greenstone FCS (former)	Jack W. Kelly
GLEQ	Diane Durance	Greenstone FCS	Michael Niesyto
Michigan Soybean & SAA	Andy Welden	Rushing Water Fisheries	Peter Fritsch
Superior Foods	Jim Osterhaven	Wisconsin Dept Ag	Ron Johnson
MSUE	Ron Kinnunen	Aquaculture Communications Group	Dave Conley
Greenstone FCS	Paul Anderson	Herbruck's Poultry Ranch	Greg Herbruck
Michigan Sea Grant	Chuck Pistis	MEDC	Terri Fitzpatrick
Cultivian	Ron Meeusen	Recovery Park	Gary Wozniak
Lake Superor State Univ	Barbara Evans	Superior Food	Tyler Keuing
Aquaculture Comm. Group	Tor-Eddie Fossbakk	MDARD	Nancy Barr
Mackinac Straits Fish Co	Jill Bentgen	MDNR	Gary Whelan
MDNR	Greg Andrews	MDNR	Ed Eisch
Herbruck's Poultry Ranch	Mohamed Mousa	Seafood Systems Inc.	Russ Allen
MDEQ	Christine Alexander	Sysco Foodservice - GR	Jim Linton
MDARD	Scott Corrin	MDEQ	Jim Goodheart
Superior Foods	Charlie Vanderploeg	MSUE / MSU-PC	Mark Seamon
	Thomas Ward	MI-Sea Grant	Lynn Vaccaro
GVSU	Jason Pliml	MI-Sea Grant	Stepanie Ariganello
MEDC	Isaiah Wunsch	MI-Sea Grant	Elizabeth LaPorte
MDNR	Dan Sampson	MI-Sea Grant	Todd Marsee
MDNR	Jim Dexter	MI-Sea Grant	Jim Diana
MDNR	Keith Creagh	Delphi	Mark A. Hester
MDEQ	Dan Wyant	Delphi	William R. Schikora
MDARD	Jamie Clover Adams		

Participants involved in Integrated Assessment

MI-SBTDC	Joel Schultz	MSU-E	Jim Lucas
MI-SBTDC	Jason Pliml	MSUE Retired	Chuck Pitsis
MEDC	Lois Ellis		Charles Gould
MEDC	Tino Breithaupt	Ontario AFRA	David Alves
MEDC Water	Gil Pezza	Ontario AFRA	Jennifer Stevenson
MEDC	Isaiah Wunsch	OMNR	Sarah D
MEDC Tribal	Tom Durkee	WI DATCAP	Myron Kebus, DVM
Delta Co. EDA	Vicki Schwab	Rushing Waters Fisheries	Peter J. Fritsch
Saginaw Co. C of C	Veronica Horn	Silver Moon Springs Trout Farm	Tim Winkle
WUPPDR	Jerald M. Wuorenmaa	WI-Sea Grant	
WUPPDR / TheMktDeptInc.	Karyn Olsson	OH-Sea Grant	Laura Liu
MDNR	Dennis Knapp	NOAA	Karen Tracy
MDNR	Steve Sutton	North Wind Fisheries	Dan Glofcheskie
MDNR	Ed Eisch	Meeker's Aquaculture	Mike Meeker
MDNR	Dan Sampson	Pisces Fish Machinery	Mathew Wastell
MDEQ	David Fiedler	Trout Lodge	Andrew Barfoot
MDEQ	Jon Allan	Herbruck's	Greg Herbruck
MDEQ	Tom Graf	Aquaculture Systems Technologies	James Ebeling
MDEQ	Michael Beaulac	Delphi Corporation	Mark Hester
MDEQ	Rick Ruiz	Marquette City Commissioner	Jason Schneider
MDARD	Nancy Barr, DVM	Hannahville Tribal Community	Dave Anthony
MDARD	Michelle Crook	Bay Mills Community College	Steve Yanni
MDARD	Scott Corrin	Rays Feed Mill	
MDARD	Mike DiBernardo	Michigan Farm Bureau	Matthew Smego
Michigan Legislature	Darwin Booher	Aquaculture Communications Group	Tor-Eddie Fossbakk
The Shrimp Market	Russ Allen III	Aquaculture Communications Group	Dave Conley
Harrietta Hills Trout Farm	Dan Vogler	Mackinac Straits Fish Company	Jill Bengen
Aquauculture Research Corp.	Kent Herrick	CORA	Mark Ebener
Great Lakes Entrepreneur's Quest	Diane Durance	New E.R.A. Comm. Group	Delores McKinney
Recovery Park	Gary Wozniak	King Fisheries	Ken and Bob King
MSU/NCRAC - retired	Ted Batterson	Woodside Farms	Shawn McWhorter
MSU	Tom Coon	Thill's Fish House	Ted Thill

Appendix 4: Aquaculture Production Systems

Several production systems could have applications for aquaculture development in Michigan. The goal of all these systems is to maintain a healthy environment for the production of aquatic species in an environmental sustainable manner. The three major types that have most potential for development in Michigan at this time are: Recirculating Aquaculture Systems (RAS), flow through raceways and cage systems. They are described below.

Recirculating Aquaculture Systems (RAS)

Figure A4.1 is an illustration of a generalized RAS. The primary feature is that water is recirculated with a treatment system between reuses in order to continually maintain a suitable environment for the cultured species. Currently these types of systems are being used for a range of aquatic species including shrimp, tilapia and barramundi, although nearly all the commercial output from RAS is tilapia for live ethnic markets. These systems are typically indoors, in tanks and allow for large production capabilities on reduced water quantity. The type of treatment between reuses is dependent on the water quality demands of the species being raised. Critical steps include mechanical filters for solids removal, biological filters for converting toxic ammonia to nitrate, nitrate removal (often dilution), and oxygenation. Waste products produced are generally routed to a municipal wastewater treatment system, or treated further (possibly) and can discharged to the environment. Discharge permits may be required depending on the size of the operation. A portion of the water is usually cycled out of the system with discharge and/or for overall water quality control. These systems are popular for the culture of warm water species because they allow for the conservation of heat in the water. Energy of water heating and pumping can be a significant contributor to operation cost, and RAS typically requires higher capital outlay than flow-through or cage culture systems. Extensive controls are needed to maintain an environment for production. RAS also allows for production of species that would otherwise not be possible because of climatic conditions. Disease management can be a challenge because water is distributed through the complex biological systems and tanks.

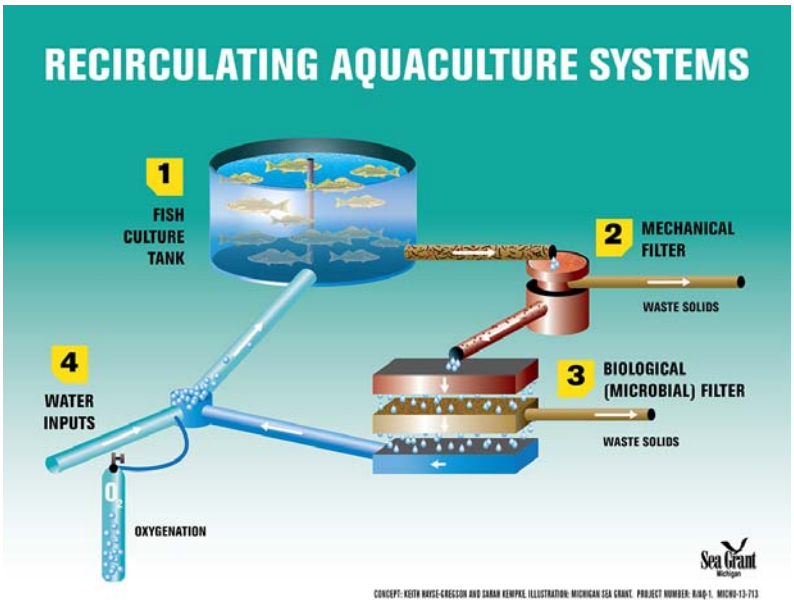

Figure A4.1 - Illustration of a Recirculating Aquaculture System

RAS is still relatively early on in development as a production system, and standardization and design optimization remains a work in progress. The book "Recirculating Aquaculture Systems, 2nd Edition" by M.B. Timmons et al[59] is a good resource; however, anyone considering RAS should be aware

[59] http://www.amazon.com/Recirculating-Aquaculture-Systems-2nd-Edition/dp/0971264619

there is a large learning curve associated with these types of production systems.

Flow-Through Systems

The majority of aquaculture production in Michigan to date has been in flow through systems (*Figure A4.2*). Water is sourced from either surface water or groundwater supply. The water is routed through "raceways" or shallow ponds where continuous flow maintains suitable water quality for production. Water can be reused several times with the addition of dissolved oxygen. Temperature of the water supply (ambient, seasonal) limits production to species tolerant of those temperatures. Control of waste products can consist of several different management techniques and/or physical structures to capture solids. Because these systems rely on surface or groundwater supply siting in wetlands and flood plains, which is historically where these systems were often located, can constrain expansion due to changing regulations. If using surface water, there is elevated risk of disease entering the farm from influent open water sources. One big advantage to flow through systems is taking advantage of gravity flow to minimize water operating costs to the greatest possible extent. In most cases, water use is "free", for surface flow and certain artesian flow regions. Cost can rise rapidly if pumping groundwater is required. Existing flow through systems generally have high social acceptance in Michigan because of their limited size and "quaint" positioning in the landscape and the fact that many of these facilities also offer fee-fishing and other public goodwill services (parks, picnic areas, smokehouses, etc.). In a recent case, however, planned production expansion activities resulted in debates over shared water resource use with local fishing and environmental groups.

The limited size of many of the established flow-through farms also constrains the economic viability of the enterprises. The largest flow-through farms in Michigan produce less than 200,000 pound of fish annually and typically generate less than a living wage for the farmers that is often supplemented with off-farm income.

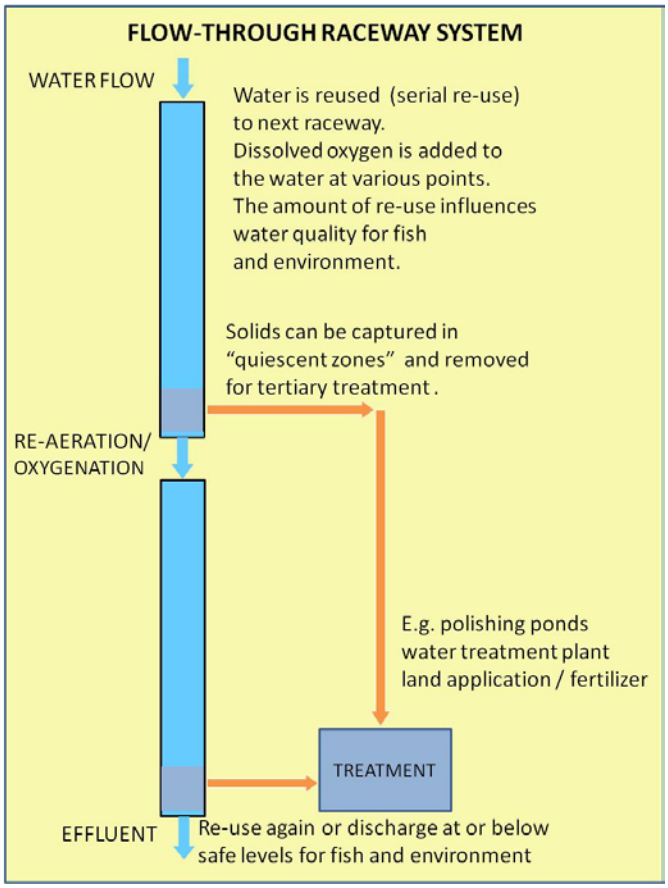

Figure A4.2 - **Illustration of a flow-through raceway system**

Cage Systems

Cage systems are open water systems usually anchored to the bottom and floating in the water (*Figure A4.3*). Bottoms and side containments are often made from durable plastics with nylon and polyester resins. The net mesh size must be small enough to prevent fish escapement, but large enough to reduce biofouling and clogging of the nets. Fish are placed in the cages at a predetermined size, fed from the surface and harvested by pulling the net up and removed by hand or fish pumps. Placement of near-shore cages is limited to sites with very specific characteristics as they generally remain in place the entire year and thus subject to ice and wind. Cage systems are moderately to low cost to install, efficient management characteristics, smaller footprint and relatively low cost of operation compared to land based systems. Management strategies employed at marine salmon farms on East and West Coast, and by Ontario trout farms, Lake Huron include low densities, and sustainably driven best management practices to minimize disease and environmental impacts from farming. Studies in Ontario using ultra intensity systems in small lake ecosystems showed both positive and negative effects of this type of system on local aquatic communities, and demonstrated that with appropriate siting, freshwater cage aquaculture can be an environmentally sustainable activity[60].

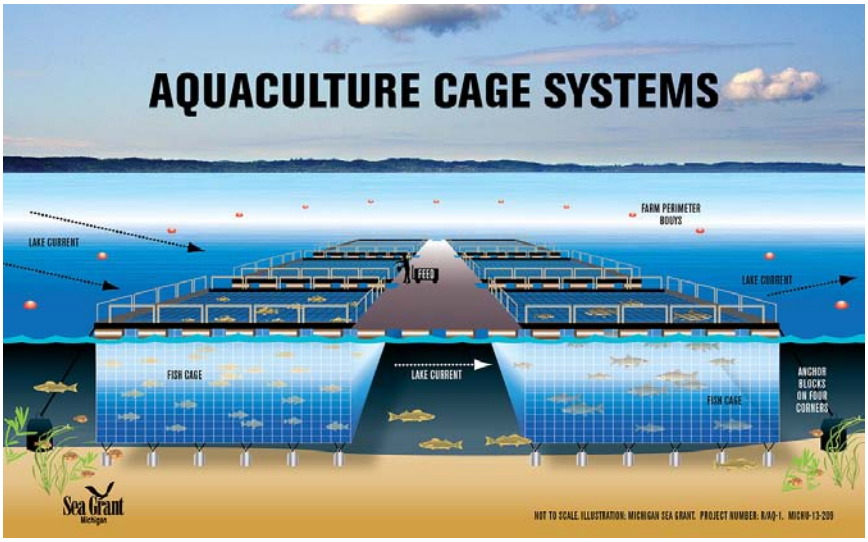

Figure A4.3 - Illustration of a Cage Culture Farm

Cage Aquaculture is more widely practices in marine environments at this time. A global overview of this technology is published by the Unite Nations as "FAO Fisheries Technical Paper. No. 498 Cage aquaculture: Regional reviews and global overview"[61]. Leaders in freshwater cage culture are the member farmers of the Northern Ontario Aquaculture Association (NOAA)[62] in Canada. They have partnered with University of Guelph and Fisheries and Oceans Canada on sustainable cage culture research and development, and have offered expertise and support in similar development for Michigan. Cage culture in Ontario waters of Lake Huron has dominated rainbow trout production in the Great Lakes region since the mid 1980s, supplying large grocery chains like Meijer's and Kroger here in Michigan.

Figure A4.4 - Aquapod (TM)

Newer technology is being developed to better adapt cage culture for offshore farming in deep water to

[60] http://www.dfo-mpo.gc.ca/science/enviro/aquaculture/rd2011/aqua-eng.html
[61] http://www.fao.org/docrep/010/a1290e/a1290e00.htm
[62] http://ontarioaquaculture.com/

take advantage of better water flow and the related health benefits for fish. An early example is the Aquapod ™[63] design (*Figure A4.4*) from Ocean Farm Technology that is currently in commercial testing in both marine and freshwater application.

The feasibility of a cage culture venture in Michigan of being able to meet state regulatory standards, and clarification of standards themselves, unfortunately remain questionable. In May 2014 Michigan's Quality of Life group released a report entitled "Permit Application Process for Net Pen Operations in Michigan" to help clarify regulatory issues. The practicality of meeting these requirements for commercial purposes has not yet been tested.

A variation on the siting of a cage system would be to utilize abandoned mining pits. Several potential such locations exist, although there has not been any major consideration towards facility development. The advantages to using these types of systems include more shelter against storms, ice out conditions (moving ice) and private versus public property issues and permitting. These systems should however undergo careful consideration in terms of water quality, temperatures, and chemical, physical, and biological carrying capacities prior to facility construction.

Urban Aquaculture

Urban Aquaculture could be a significant contributor to a thriving and sustainable system by the year 2025. This may include repurposing of existing building and land infrastructure in cities, towns, and industrial parks. Many Michigan cities have overbuilt water and sewer capacity that could be leveraged for fish culture purpose, likely using recirculating systems, to get maximum use of the water. Planning and zoning changes may be required to allow an agricultural activity such as aquaculture in urban/industrial areas – including, where appropriate, Michigan Right to Farm consideration for an urban use for fish production. In recent decades society's bias has been to shift food production to the rural venue, however, shifting values and the desire for local food and the realization that we will need creative solutions to meet the food demand of a 9 billion global population is expected to result in more interest in urban and suburban food production, not limited to aquaculture, as is evident already in the urban gardening movement and widespread interest in urban small animal husbandry.

[63] http://oceanfarmtech.com/index.php/aquapod-net-pens

Appendix 5: Targeted Species for Michigan Aquaculture

Several aquatic species are currently raised for seafood in Michigan. On a commercial scale the majority of the seafood production is rainbow trout, but shrimp and other species such as perch and tilapia are also produced. The most efficient recourse for Michigan aquaculture rapid growth is to leverage known species with established markets. To that end rainbow trout and other salmonids fit the strategy well. Whitefish production to displace some imports – and capturing a portion of the "white fillet" market once satisfied by cod – now met primarily by tilapia, also can be contributors to a thriving and sustainable Michigan and Great Lakes aquaculture sector. The graph in *Figure A5.1* provides a projection for one scenario of how a $1 billion can be achieved with a focus on species that provide the best combination of market demand and commercial-ready, and/or near-ready, species.

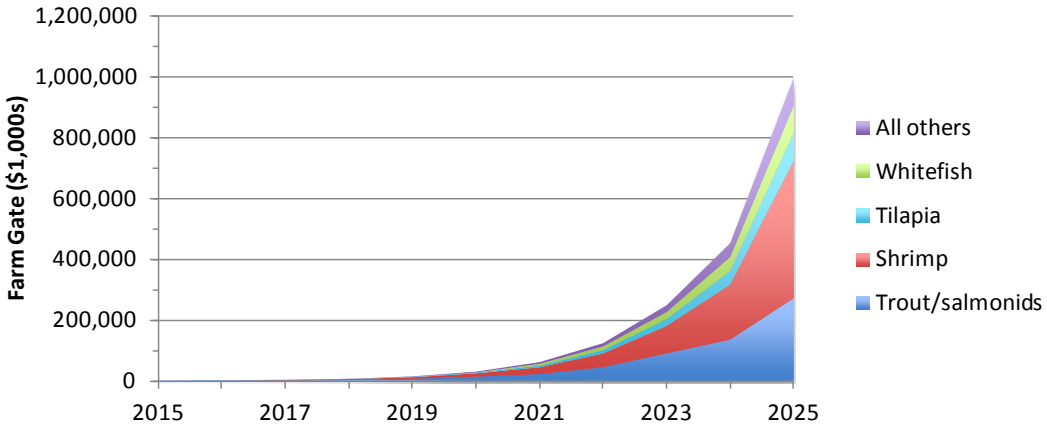

Figure A5.1. **Illustration of how Michigan aquaculture could grow.**

Types of species that will be targeted include two general groups: one group of species that are native to Michigan and can tolerate seasonal conditions; the other group will be those that can be raised in RAS systems where rearing conditions can be controlled to meet the species specific environmental needs.

Rainbow trout, currently the most produced aquaculture species in the state, appears to have the greatest potential for immediate growth. Present supply of locally grown rainbow trout falls well below current demand of established markets. Greater volumes could be achieved through expansion of existing facilities and adoption of proven culture techniques (e.g. Ontario cage culture). Other salmonid species such as salmon, brook and brown trout could also receive future interest for seafood markets in the state.

One native species that has increasing interest is Lake Whitefish, which has a traditional wild caught fishery in Michigan. This is a highly desired fish, but inconsistent seasonal harvests are causing significant price swings. Work in Michigan and Finland suggests that this species has great potential for aquaculture and could compliment the wild caught markets. In addition, research conducted in Indiana, Minnesota and Michigan over the past 30 years has demonstrated that commercial whitefish can be successfully spawned from the wild, and cultured from egg to harvest.

Aquatic species that have warmer water requirements could be produced through the utilization of RAS. Present species of significant interest include shrimp, tilapia and barramundi. These species are currently farmed on small scales in the state and have markets already established that could be significantly expanded. In excess of $4 billion in shrimp are imported into the USA annually. Prices are

rising as bacterial infections (EMS- Early Mortality Syndrome) in Southeast Asia producing countries have resulted in 20-50% decreases in output. Domestic production of more shrimp is an opportunity to achieve better food security.

Live fish like largemouth bass and bluegills have market potential in cultural markets for food fish, as well as stocking for recreational fishing. These native fish can be produced in both indoor (RAS) and outdoor systems.

Perch is a native species that has generated significant interest for culture primarily because of the traditional Friday night fish fry in the Great Lakes Region. Substantial investment has been made to culture this species for the fillet market in both outdoor and RAS systems. Even so, economic production of this species on a commercial scale has encountered significant challenges, particularly in fry (immediate after hatch) and fingerling stages of production. Walleye and saugeye (walleye hybrid) culture is also currently under research and development in Wisconsin at the Northern Aquaculture Development Facility[64] (NADF), and saugeye is currently under a commercialization phase at NADF.

Baitfish production also has potential for growth. Much of the bait sold in the state is wild capture or imported from out of State. Concerns over invasive species from out of state sources and disease from wild capture bait offers potential for growth of this aquaculture sector and displacing imports and wild harvested baitfish with native/adapted and local-source options that can mitigate these risks.

[64] https://www.uwsp.edu/cols-ap/nadf/Pages/default.aspx

Appendix 6: Scenarios

Included are an overview on scenarios (below) and scenarios developed for aquaculture (six pages).

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The Art of Scenarios that Lead to Learning – *Preparing for the Future in Uncertain Times*

Scenarios are very powerful tools for learning about the future, especially when they are designed with the needs of leaders and learners clearly in mind.

The Institute for Alternative Futures has found that the best scenarios are engaging short stories that help leaders introduce their organizations to the potential for significant change. Shorter scenarios are effective in learning processes like workshops and retreats. People must be able to read them quickly and move into a strategic conversation about the changes they describe.

Even when a scenario describes a very different alternative future, they must seem plausible to learners. "People have to be able to project themselves into the stories. If the scenario writers push too far out there with provocative images of the future, we risk inhibiting their ability to believe they can lead change toward a preferred future. Scenarios have to be plausible so the audience can buy into the possibility of transformative change," said Marsha Rhea, IAF Senior Futurist.

One of the scenario techniques used most often by IAF is the archetypal approach. The archetypal approach to scenarios makes it easy for people to see possibilities and explore their fears and aspirations. An IAF scenario set would include three or four different stories. One story will be about the ***expected future*** that projects current trends into a future that seems more familiar than other scenarios. Another story will be about the ***feared future*** that illustrates the consequences of failing to deal with challenging conditions. And two stories about the ***preferred future*** that explore different pathways to a preferred future including new technology, developments, values or collaborative approaches that lead to structural transformation or a mind change.

The most important learning may be self-discovery, as Rhea witnessed in a recent scenario workshop with school superintendents in Alabama. The creative titles of these education scenarios took on powerful meaning for the participants. A group working with a feared future scenario entitled *Fighting for What We Believe In* started questioning whether the scenario captured what they really believe in or should they instead be fighting for something far more innovative and effective. A group working with a preferred future scenario entitled *Setting Learning Free of Boundaries* recognized that they are the ones helping creating boundaries in education. "Both insights could be seen as breakthroughs in understanding what it might take to create a preferred future," Rhea said.

One of the most difficult parts of creating a winning scenario is getting the subjective context right. Each profession and organization has its own set of values, norms and language. Creating scenarios that honor these differences helps facilitate individual and group awareness, and creates connections for learners. When creating scenarios, a futurist needs to use a voice the target audience will recognize.

Providing insights into motivation also can be helpful. Rhea has created scenarios that intentionally appeal to different psychological preferences to draw people into stories about the future. In one scenario set, she developed the stories for the expected, feared and preferred futures around the psychological types who would love those alternative futures. "The group really hated the character that thrived in the feared future, but it was a way to make them recognize that not everyone shares the same values," Rhea said.

When scenarios are treated as thinking rather than learning tools, it is easy to get hung up on creating the objective facts that drive the story. Quite often people sprinkle dates into scenarios to show the progression of events. While this may enhance the plausibility of the stories, it also invites people to debate the rate of change. "Saying when something will happen can be a distracter from the really important learning about the future," Rhea said. "People do not have to wait for some future date to start creating a preferred future. Once they understand what their preferred future requires of them, they can go to work tomorrow making it happen."

Adapted from: Institute for Alternative Futures, July 2007 "Alternative Futures"
Highlighting by Joe Colyn, Originz, LLC
Provided as a learning resource for Originz clients interested in being prepared for the future. Call to discuss how Originz can help you prepare.

File – 20110120 SP Overview

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Michigan's Aquaculture Strategic Plan - Scenarios *file: 20140127 Scenarios v.IV*

This document incorporates four scenario stories developed from the November 8, 2012 Michigan SeaGrant Aquaculture Scenario Planning Workshop at Tustin, MI. This document is stamped with a "draft" watermark because we still need your ongoing input as we use and refine these scenarios to stimulate our thinking in developing the aquaculture sector strategic plan.

These scenario stories view the world of Michigan aquaculture from the year 2025. Remember, with scenario planning we are not attempting to predict the future, rather to illustrate, in story format, how the future might unfold. Then on the basis of this understanding we can adapt to the forces and factors that play out in the future, and with planning, begin to influence how the real future plays out. In the broader context of the Michigan SeaGrant Integrated Assessment project these scenarios provide a framework within which a robust Strategic Plan can be developed.

Our preferred future is now called ***"Seafood: An Essential Animal Protein"*** **(***Formerly titled: "Fish, the other, other white meat")* and illustrates a thriving sector with Michigan contributing significantly and sustainably to the food fish needs in America.

The ***"Hamburger Nation: 'cause there are no fish to fry"*** scenario paints a bleak picture of the future, with aquaculture illustrative of a poor Michigan economy.

The ***"Stuck in Second Gear"*** and ***"Blue Bayou"*** stories, while less developed, portray alternate future scenarios to help challenge our thinking of what might be – and to further guide our decisions and action.

Please read the scenarios. And ask yourself how these stories might cause us to plan and act differently is support of creating a sustainable fish production sector in Michigan in the next decade. Then share your insights – send your comments back to me and we'll incorporate into the strategic planning process. Or collect you thoughts over the next few weeks and be prepared to discuss again with the group. We are working towards a late-March, early-April reconvening in follow-up to the November session that will delve into the developing strategic plan – stay posted, we'll finalize the date by the frist week of February and get back with you.

(For reference, the original scenario matrix developed as an outcome of the November 8 workshop and shared mid-November is inserted at the end of this document)

Joe Colyn
Originz, LLC
January 27, 2014 – revision of January 10, 2012 draft)

This initiative funded in part by Michigan SeaGrant, an Integrated Assessment project, 2012-14.

Seafood: An Essential Animal Protein *- Scenario #1 – A preferred future*

(Formerly: "Fish, the other, other white meat")

Its 2025, and since the 2013 prioritization by Michigan to make aquaculture a growth industry it has grown to be a preferred source of freshwater seafood in the USA and a $1 billion contributor to the state economy, producing fully one third of the country's fish output. And it's a robust sector, diverse not only in the number of species produced, lead by whitefish, trout, shrimp and tilapia and including a dozen other food fish species. Indeed the $1.5million MEDC aquaculture incubation fund of 2013-14 helped seed the sectors growth by providing the needed loan guarantees and venture funding that allowed for successful model systems to ease regulatory concern and allowed the industry to show that by the adoption of Best Management Practices could indeed protect the state's water and natural resources. This was helped along considerably with regulatory flexibility adopted by the Michigan legislature at the encouragement of industry, MEDC, and the QOL departments that allowed for model-fish-farms, supported by an MEDC Incubation Fund established in 2013, as demonstration sites to show that BMPs could indeed be a preferred solution that allows for production while safeguarding wetlands and natural rivers. These model systems allowed fish production to reach 2 MM pounds – half in rehabilitated open water systems – by 2015 and, based on that success new entrepreneurs increased output to 10 MM lbs by 2017.

Today's sector includes a wide range of technologies. In fact, using advanced waste capture technology developed by Pisces the now 80-year-old open water land-based trout farms have been re-invigorated and produce $50 million of fish annually and are complimented by a $100 MM Great Lakes cage production from 50 farms scattered around the shores of Lake Superior and northern Lake Michigan. Tribal fishermen who have also branched out into Whitefish cage culture to compliment their trap-net wild-caught business now also operate a dozen of those trout farms. The whitefish catch is now consistently 10 MM pound annually and it's complimented by a 20 MM pound cage production, all done within the footprint of the historical trap-net bottomlands. The adoption of next-generation, cost effective water-cleaning technology in fish farming along with GIS tracking and remote realt-ime monitoring of water quality has ensured environmental sustainability – in fact Michigan aquaculture is a model user of water. We regularly host delegations from around the world to learn how we have applied our engineering prowess to the sector. Warm water species production centers in the southern two tiers of counties with half of the 200 MM lbs of production coming from six large farms in Detroit, Battle Creek, Saginaw, and Benton Harbor/St Joseph that leverage excess water, sewer, and steam for cost effective production of tilapia, shrimp, and more recently perch – since the supply of high-survival, feed-trained fingerlings from Bell Aquaculture is now commercialized for others to use in grow-out. By 2027 farm-raised perch are expected to represent 90% of perch sold, as the Lake Erie Canadian catch has stagnated. Muskegon because of their large capacity for wastewater treatment, water holding capacity and irrigation has also welcomed two farms producing 30 MM pounds. During the summer they can land-apply waste water and in winter water goes into existing holding ponds till spring land application can resume. Another significant contributor to achieving economy of scale was the opening in Zeeland of the ZFS/Zealand Fish Services fish-feed plant in 2015.

This keeps the state's fish processing plants busy 12 months of the year, and had brought the consistency of supply need to allow for market development – and success beyond expectation leveraging the Pure Michigan® Seafood campaign that resounds well within the state, has won over the Chicago market, and is now having success on the US east coast.

And the growth prospects look good for the future as this milestone was achieved in a truly sustainable manner. In fact the development of a fish culture in the Great Lakes region, lead by Michigan producers in cooperation with state agencies has resulted in complimentary growth of recreational fishing and rejuvenation of the Great Lakes wild-caught whitefish and perch fisheries as well. The whole mindset has changed from water natural

resource preservation to technology-enhanced stewardship of water that allow for maximized benefit both economically and ecologically.

Michigan now also leads in the production of baitfish for the expanding Great Lakes recreational market. Five thriving baitfish farms include 2 new ones have displaced 90% imports from Arkansas and other states. Fishermen love the fact that there is no invasive-species risks associated with using local-raised, native bait.

Michigan's success has spilled over the state boundaries into Ontario and the Great Lake states. In fact early learning from Ontario's cage culture experience and Wisconsin's 2012 regulatory simplification and the resulting collaboration and standardization of both regulation and practices have resulted in each of those jurisdictions expanding aquaculture to be $400 million sectors. Some of that growth is from warm-water species in production systems that utilize captured waste heat from pulp and paper plants to cost-effectively hatch and grow out market size fish in as little as 9-12 months.

Michigan's simplified registration and permitting has resulted in 3-5 new facility registrations annually and has attracted Coldwater and Meeker Aquaculture from Canada and Clear Springs Foods from Idaho, among other expanding into Michigan. These attracted firms now produce 28% of the seafood in Michigan and provide reach to global markets for our premium fish. Superior Foods has surpassed the $200 million in sales mark, largely through the sales of local seafood, and traditionally commercial wild harvest processers have expanded substantially. Overall the future looks very bright – Michigan fish are in demand because they taste great and they are produced using the best environmental practices that leave our water clean and ecosystems thriving too.

"Hamburger Nation": *'cause there are "no fish to fry":* *Scenario #2 – A feared future*

We tried – in the 1980s, and again in the 2010s – to kick-start the aquaculture sector in Michigan, but here we are in 2025 with a sector that is still less than $10 MM in value. Sure, we have a next generation of fish farm operators, but they all remain very small scale hovering under the cloud of the 20,000-pound limit that keeps them from needing an NPDES permit. Not that these new farmers did not try to expand, by 2015 four entrepreneurs including two graduates of LSSU had agreements to purchase fish farms from retiring farmers, however, much like a generation earlier regulatory obstacles impeded at every turn, and the farms remain part-time hobby-farm operations. A real paradox that we have not grown aquaculture in Michigan when considering the increased demand for seafood globally, now at 134 million metric tonnes (MMT) – up from 79 MMT in 2009. Alongside this dozens of small aquaponics systems are scattered around the state, each supplying very limited quantities to local markets. Aquaculture is anything but a sector.

Despite the best efforts of the AIM initiatives of 2012-13 to achieve a simplified permitting and regulatory climate to stimulate sector growth, the political will never came together within the state government and industry to allow the addition of anything to water. Since before the Clean Water Act of 1972 the regulatory mindset has centered on keeping 'stuff' out of water, a lofty goal when viewed from the perspective of fire on the Cuyahoga River in 1969. But aquaculture by its nature requires putting 'stuff' – fingerlings, feed, equipment, and occasionally treatments – into water. Yet a do no harm mindset pertaining to water prevails and aquaculture has continued to languish, not only in Michigan but nationwide. Indeed the threats identified in the 2012 SWOT Analysis of Michigan Aquaculture produced by the MSU-Product Center have been borne out – environmental concerns have trumped sector growth, critical mass was never reached for cost effective fish-meal processing and feed manufacturing, higher prices have driven the whitefish wild-caught fishery to the brink of collapse as short-sighted fishermen focused on quick cash – a scenario very similar to the east-coast cod sector collapse in the 1980s with history repeating itself.

So we eat hamburger. Since 2015 when China began to reduce its export of seafood, keeping it at home to satisfy the demand of its exploding middle class, USA seafood consumptions has dropped precipitously – down from 16 pound per capita in 2006 to nine pounds in 2023. Not because we don't want to eat it – there is simply a very limited supply as imports decrease and prices escalate driving consumers to buy less expensive animal protein

Fish farmers are not the only ones affected. Water-related regulation including wetland protection, and discovery of Asian Carp in the St Joseph and Grand Rivers in 2016 have resulted in paralysis as pertains to water use in Michigan. In fact blueberry acres are now down by 50% in the past decade as farmers could not plant new acres and 50-year old stands were simply no longer competitive with the new varieties being planted in more open-for-business regions including Georgia, Oregon, Chile, Argentina and various Asian nations. In fact MBG Marketing moved its head office to Portland, OR to be closer to its largest member-growers.

The regulatory quagmire has not only constrained aquaculture. The Great Lakes fishery continues to decline as well due to oligotrophic waters that can't sustain enough life. The whitefish catch in 2021 came in at only 3 million lbs for fillets, and that only as a by-product of the October roe harvest for export. Sure, our waters are clean – and we expected a thriving tourism sector as a result of these clean waters and a the Pure Michigan campaign – however, the significant drop in recreational fishing, harvests, and licensing continues to seriously impact Michigan's tourism

Moreover the broader Michigan economy has taken a significant hit, and in the Spring 2024 legislature the House, desperate for some economic growth actually, allowed export of Lake Superior water – inclusive of the 6% sales tax – as a way to generate revenue from our Natural Resources base. It's the least we could do as the world looks with envy at our freshwater resources while they thirst. What more could we have done with our Great Lakes water resources, and what else might we do as the world grows beyond 8 billion to 9.3 billion by 2050?

Stuck in Second Gear: *Scenario #3 – An alternate view to the future*

The development of aquaculture sure looked promising a decade ago when new fish farms were established and the sector actually made some significant progress, increasing output to 5 million pounds and a net economic impact of $18 million by 2016. But then it stalled.

The 2014 discovery of Asian carp in the St Joseph River created a lot of angst statewide among environmental activists and within the DEQ, and permitting of new aquaculture facilities ceased the following year. So, while the progress made by the AIM initiatives did in fact result in clarity in regulation and permit processes, the sector is caught in a no-growth situation for the past decade. The Grayling and Baldwin stream-fed farms combined produce a million pounds of rainbow trout annually for the food market in facilities renovated with state-of the art technology and both are models of environmental stewardship and water quality preservation – we've just not been able to get permitting for repurposing other sites. The decline of the recreational fishery brought on by the arrival of invasive species like zebra and quaga mussels and Asian carp, combined with state budget cuts have resulted in the closure of three more DNR hatcheries. These could be repurposed for food fish production, but have been abandoned.

The Recovery Park Aquaculture (RPA) has had success with warm water species serving the greater Detroit market. After 2014 start-up and a few rocky years developing the fish-farmer skill-set, production reached a million pounds in 2016 and has since grown to 1.8 MM lbs. Urban based, and using discharging to the DWS sewer

system RPA has easier permitting requirements than traditional less expensive to operate surface water discharge systems that have historically shown various benefits to receiving environments Aquaculture has been a success story within the Recovery Park suite of initiatives – primarily based on learning from partners in the Metro-Agriculture Global Network, not so much on in-state resource. We simply have not built the support infrastructure needed in education, training, supply or research.

Constrained on the supply side, Michigan's fish farmers have been reluctant to invest in marketing for the past decade. While they have a steady market in foodservice where the local, farm-raised positioning holds steady, retail seafood is now 95% imported. And Michigan seafood consumption remains below the national 16 lb/yr average that has not increased in 15 years. The predictions that the health benefits of seafood would see demand increase have not been born out as import prices have risen as China and the ASEAN nations restrict their exports – preferentially satisfying their domestic market demands.

Michigan aquaculture made a nice shift to grow the sector in the early 2010s, but since then it has been stuck in second gear and not been able to increase output – not because the producers have made mistake or adopted poor practices, in fact to the contrary, they use some of the world's best management practices. External factors have simply put a choke-hold on the sector.

Blue Bayou: *Scenario #4 – an alternate view to the future*

Michigan may not be in the south, but our aquaculture sector peaked and then waned, very similar to what the catfish industry did 15 years ago. Michigan's fish farmers can only dream of good times, and a few lines from Roy Orbison's ballad, **"***Saving nickels, saving dimes, working till the sun don't shine. Looking forward to happier times on blue bayou."* capture their sentiments.

But happier times have not come. The regulatory and business conditions for investment in midsize and large fish farms have not materialized in either Michigan or other upper-Midwest states. Banks have remained reluctant to invest – not so much due to regulatory concern like we had in 2010, but we've never developed the cohort of aquaculture professionals or the infrastructure (local feed and input suppliers, processing capacity, etc.) needed to kick-start commercial aquaculture.

In fact viable fish farming has been limited to small-scale operations – part-time and hobby farmers with small ponds, indoor tanks, and aquaponics operations producing 500- 5000 lbs annually dot the states landscape. We know they are out there, but the NASS Ag Census does not capture the data. Informal estimates are that 800,000 to one million lbs of fish are now produced in Michigan. But outside of showing up with their product at Farmer's Markets, a few roadside signs advertising "Fresh & Frozen Local Fish", and deliveries to various Asian markets in urban communities these farms operate at a very low profile. It is simply too burdensome to try and scale up.

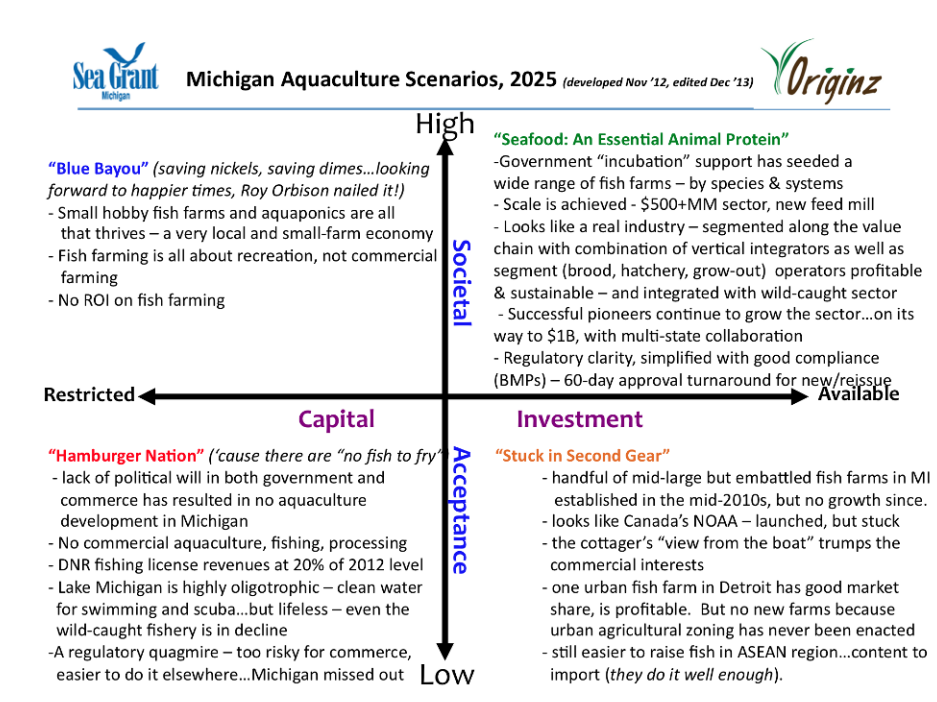
And those consumers that can afford it love their locally sourced fresh seafood. They enjoy going to the farmers market to buy right out of the cooler – be it a gutted fish or a prepared fillet. And even at prices that range from $12-18/lb at these markets, the part-time fish farmers are just above breaking even once you factor in the labor of manually preparing the product, the labor and the high cost of feed that all still comes into the state in 50 lbs bags from Pennsylvania and the west. The state's aquaculture producers are too small to capture economies of scale that would reduce their costs and enhance their profits.

Farmers that also raise a host of other crops raise about half of these fish – and other livestock too – to satisfy their Community Supported Agriculture (CSA) and farmers market customers. The fish add a nice compliment to

their product portfolio and thanks to standardized systems from several suppliers the production is relatively easy to integrate into the farm operation.

In the grocery store there is a good supply of frozen seafood, but much like 15 years ago, 95% of it comes from imports. It's reasonably priced, and consumers are satisfied with the quality. The Chileans, Norwegians, and ASEAN producers have all adapted Seafood Watch's sustainability, quality, and transparency standards developed for farm-raised product. It has become accepted in America's consumer mind that seafood comes from outside the US – just like we get our coffee and bananas from 'over there'. Michiganders are happy with the imported product, and see our state's water resource as a recreational resource, not a source for food.

And its *Blue Bayou* for those who once aspired to have a commercial scale, mid-size full-time-income generating fish farm operations and distribution businesses in Michigan – these do not exist. The industry remains at a near subsistence level.

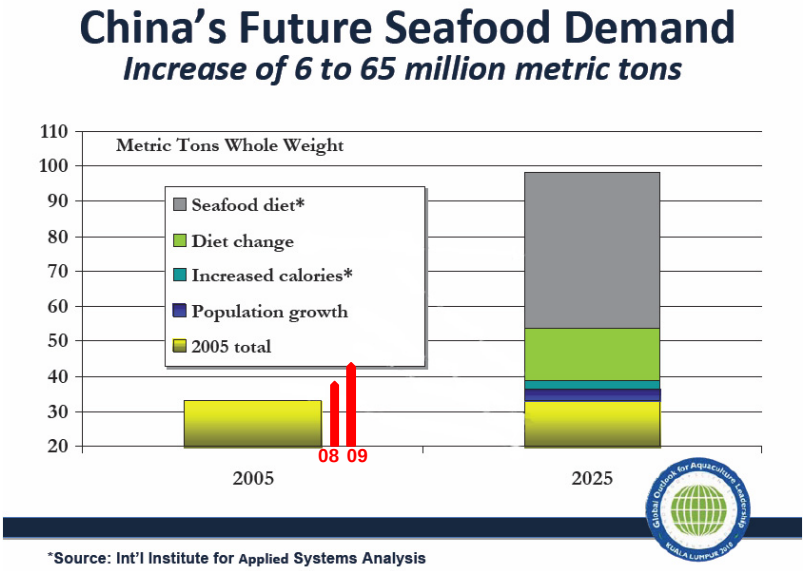


Joe Colyn Originz, LLC January 9, 2013 *(revised the scenario names January 27, 2014)*

Appendix 7: Case Studies

Case Studies:

We can learn from the experience of other countries. China and southeastern Asia have demonstrated significant aquaculture growth in recent decades; however, some concerns have been raised as to the sustainability of their practices. Scandinavia, in particular Norway, after correcting from some early mistakes a few decades ago, is a global leader in sustainable salmon aquaculture, and Chile developed a multi-billion dollar sector in a few decades by leveraging technology and investment from other countries. Aquaculture in Turkey is under rapid development at this time and is being aided through changes in policy, practices. In addition Turkey is leveraging the value chain of their capture-fishery for benefit of offshore aquaculture. Closer to home the trout farmers in Ontario have demonstrated success with near-shore freshwater cage culture, and currently experimenting with offshore, deep-water production using next generation technology, for production at sites away from shipping channels and recreational shoreline residents and users.



Beyond aquaculture we can learn from other sectors of US agriculture. The Georgia poultry sector has grown to contributing $18.4 billion and 100,000 jobs to that state's economy in the past 30-40 years. In Michigan our turkey production sector is valued at $90 million and employs 600 people in a sector that is only $3.2 billion nationwide compared to the $15 billion national aquaculture sector.

CHINA - The Shift to being a Net Seafood Importer:

China's aquaculture sector has exploded in the past few decades, achieving 50 million metric tonnes annually (or 110 billion pounds -200-300 times the output of a $1B Michigan sector), and continues to grow. While some questions have arisen about Chinese production methods and their sustainability, in fact China and other ASEAN nations today produce the bulk of seafood imports into the US (and Michigan) under the watch of FDA.

And this is just the past. China's domestic demand for seafood is projected to continue to grow, to as much as triple their 2005 consumption by the year 2025. A number of factors contribute to that increased demand (see graph above, note: 65 MMT translates to 143 billion pounds annually). The result is that the domestic demand in China has begun to impact the global trade as they shifted, in

2011, from being net exporters to net importers – as has been observed in a number of other agriculture and food sectors including soybeans and poultry. This shift presents an opportunity that Michigan and the Great Lakes region can capitalize on by leveraging water resources for sustainable fish production to meet domestic and export demands.

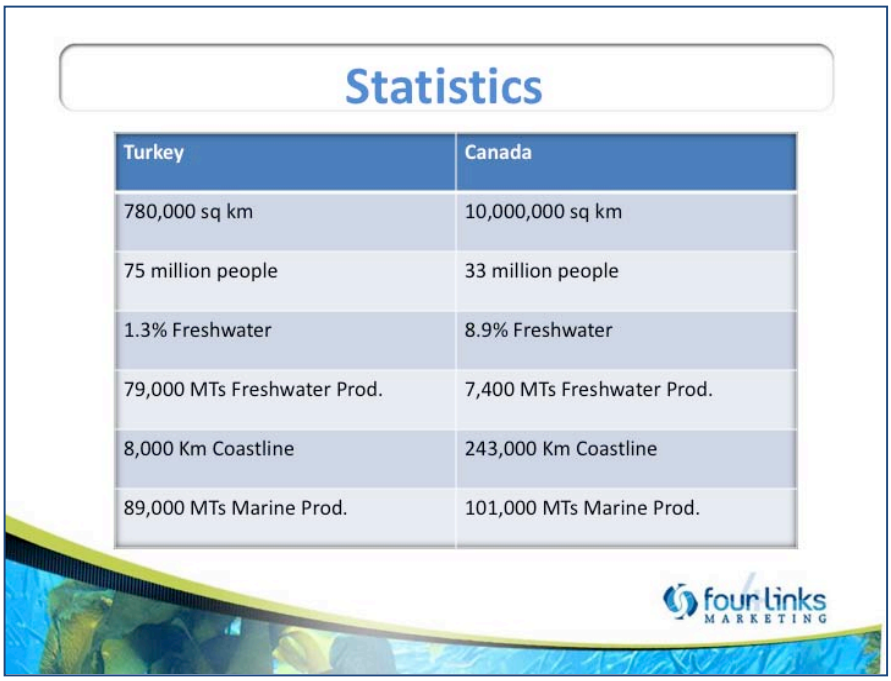
Furthermore China's water supply situation is now deemed critical, potentially limiting its aquaculture expansion. The water supply is low, and the quality is poor, with over 70% of its freshwater deemed unfit for human contact, let alone clean enough for growing food fish within.[65] In the past 50 year the number of rivers with significant catchment areas has fallen from more than 50,000 in the 1950s to 23,000 now. Quite simply, with only 6% of the world's available fresh water and one fifth of the world's population and demanding more animal protein food as the middle class grows, the ability to meet that demand domestically seems to be on collision course. As China's demand grows it will look to the rest of the world for supply. It simply must.

There may be value in assessing how China's explosive increased demand in other sectors of agriculture is trending. For example, earlier this decade China was a net exporter of soybean and in 2013 expected to import 26 million tons of US soybeans. China was estimated to take up 64% of world soybean imports from the 2012 crop, and its 2013/14 imports are projected to increase by 9-10 million tons[66]. Will the world be ready to meet the demand when China's seafood imports follow a similar trajectory in the next few decades? And how can Michigan participate in this market opportunity?

[65] http://www.economist.com/news/china/21587813-northern-china-running-out-water-governments-remedies-are-potentially-disastrous-all?spc=scode&spv=xm&ah=9d7f7ab945510a56fa6d37c30b6f1709
[66] http://soyatech.com/news_story.php?id=31961

TURKEY – Expanding Sustainably:

Turkey is an example of a nation determined to grow aquaculture in order to capture opportunity presented by both the current market and future demand of a 9 billion people world. Before the 1990s Turkey's policy framework and political will to develop aquaculture was weak at best. In the past few decades, through sound policy, clear siting criteria, and political will, Turkey has aggressively invested in growing aquaculture. Today they have surpassed Canada in total output, even with fewer resources, and the sector now provides 25,000 jobs in Turkey (2007).[67] Furthermore, Turkey continues to expand its aquaculture, targeting a 500,000 MT (1.1 B pounds) output by the year 2020, aiming to quadruple output in the dozen years beyond 2007.[68]



The Michigan opportunity is not unlike that being realized by Turkey. Michigan is surrounded by approximately 20% of the world's usable fresh water, with about 10% within Michigan boundary waters, and a coastline of 5000 km (3126 miles), placing it above the rest of the world for resources primed for development of sustainable aquaculture.

ONTARIO – Establishing Best Practices: In the past 30 years Ontario has advanced its rainbow trout production primarily using cage culture in the near-shore waters of Lake Huron around Manitoulin Island and Parry Sound. Collectively this sector is contributing approximately $51 million in sales and supports 229 full time jobs in 2007, the latest publically reported data. As this sector grew, it shifted from all land based to open-water cage culture for grow out because it offers greater economic returns sustainably (social, environmental, economical). In fact studies show, under sustainable practices farms, located in oligotrophic waters, have contributed to the revitalization of native species including lake trout and the supporting benthic food chain in those waters[69]. In 2013 Ontario's largest farm, Aqua-Cage Fisheries, Ltd., increased capacity by 10% to achieve three million lbs of output from two protected sites with good water flow in Parry Sound. In fact the 10 million pounds of trout produced in Ontario's

[67] http://www.faosipam.org/gfcmwebsite/CAQ/WGSCC/2009/Crete/Turkish_Road_Map_Okumus.pdf - slide 3.
[68] Personal communication from Terry Drost, Four Links Marketing, September 27, 2013. The slide is from his Presentation to the Aquaculture Canada Conference, Guelph, June 4, 2013.
[69] http://www.dfo-mpo.gc.ca/science/enviro/aquaculture/rd2011/aqua-eng.html

cage production sector occupy less than 100 acres of bottomlands, a small fraction of the available waters in Lake Huron. In 2013 the sector is poised for expansion, with 2 new farms pursuing license, and the testing of the Aquapod™ technology for deep-water offshore production. While still a first-generation sector in Ontario, much research has been undertaken to ensure sustainable practices. This is considered an important leverage to advance Michigan aquaculture's growth. Regulations, that likely predate current production methods, classifying water use as industrial waste rather than biological production systems; however, remain a primary constraint. A prime example is the Parry Sound region of Ontario. This water is now being revitalized from a water wasteland as a result of the iron ore and steel sector production and shipping of the early 1900s. Lake trout populations that numbered in the 100s and 1000s in the 1970s are now counted in the 100,000s – to the point that surveys are no longer conducted on this restored population. And the research in Canada continues. By the end of 2014 two comprehensive peer-reviewed research reviews will be completed: one addressing the true impact of Aquaculture Phosphorus in the Great Lakes, the second quantifying the impact of cage culture production of trout on the wild fish population and fishing. Endorsed by the federal DFO and AAFC and with the support of the Prime Minister's office these studies address the thesis that cage culture is in fact sustainable and beneficial to the lake ecology. These reports are expected in 2014.[70]

With the very credible legacy that Ontario and Michigan share with the other Great Lakes' states as stewards of these water's care and restoration, there is a great opportunity to collaborate on setting uniform standards for open water cage culture to create a win/win for a bi-national sustainable aquaculture.

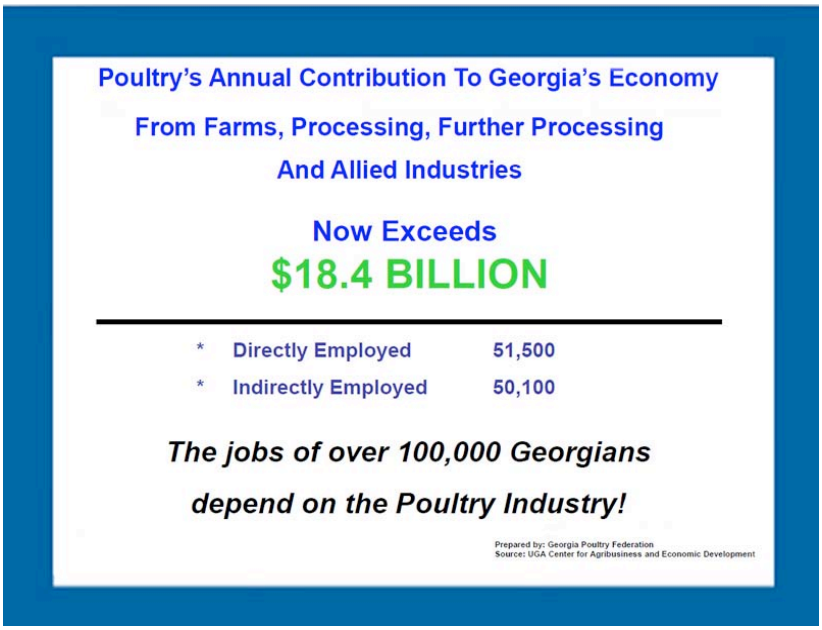
Chile:

Chile built a thriving $3 billion aquaculture, employing over 35,000 people, over two decades to the mid 2000s, evidence that growth to the billion-dollar range is achievable. The sector grew on the strength of foreign investment primarily from Japan, and leveraging salmon genetics and production technologies from Norway and North America (primarily Canada). In fact growth exceeded 25% annually over this development phase. In 1990, Chilean farms exported nearly $100 million worth of salmon to Japan, the US and Europe. By 2000, it was $1 billion. Six years later, it was $2 billion[71]. In 2007-2008, they experienced a disease outbreak (infectious salmon anemia or ISA) and experienced high mortality. From this experience they learned that the outbreak was due to poor management practices (high density, health monitoring) and made substantial changes to production programs. By 2012 Chile was back with record exports, having adopted best practices including reducing fish density to half that of before, adopting bio-security practices along the entire production chain, establishing new government rules and inspections, and building new hatcheries with self-contained water supplies to minimize contamination risks from external environment sources. Some might call the Chilean experience of the 2007-2010 a failure and cite it as a reason to avoid aquaculture. It might be more astute to chalk it up as a lesson learned in a time period when commercial aquaculture is still in the early phases of its development. A sustainable thriving aquaculture pays attention to fish density and bio-security, applies best management practices, and benefits from operating in the context of sound regulation that consider the triple bottom line for the benefit of society, including the creation of good jobs and food that contributes to health.

[70] Tracey, Karen, ED Northern Ontario Aquaculture Association, Personal Communication to Joe Colyn, November 27, 2013
[71] http://www.foodsafetynews.com/2012/04/chilean-fish-farms-and-the-tragedy-of-the-commons/#.UpOQXI1Q1tc

The opportunity for Michigan is to learn from the experiences in Chile and Ontario. To avoid the mistakes of growing too fast in an uncontrolled manner (Chile) but still grow rapidly, using best practices (including those developed and used nearby, in Ontario).

The Georgia Poultry Sector:



Over the past 40 years the center of American poultry production has shifted to the southeastern states, centered in Georgia. Before then the sector was much more widely distribute across the nation. Today the poultry sector contributes more than $18.4 billion and 100,000 jobs to that state's economy (see illustration, right). Georgia's climate and agriculture is well suited to poultry. The analogous Michigan opportunity is the stewardly use of our vast water resources to become a trusted and thriving center for freshwater fish production for the nation and Canada. This Strategic Plan proposes a sector that would be less than 10% of the size of Georgia poultry sector – an achievable goal and a sound compliment to the many other sectors of Michigan's diverse and robust $90+billion agriculture, food and natural resources.

Michigan Turkey Producers Coop: Closer to home we have had success in Michigan at retaining a $90 million turkey sector. Sixteen farmers on 43 farms produced five million birds while employing 600 people and supplying one third of the state's turkey consumption (Dan Lennon, WZZM interview, 2012) – a significant contribution in the context of the $3.2 billion national turkey sector. The seafood sector in the USA is $15 billion, 5 times the size of the turkey sector.

The learning from these other sectors of US agriculture and the other country's experience in expanding aquaculture provide invaluable context for what is achievable in realizing a thriving and sustainable Michigan seafood sector in the next 12-15 years.

Appendix 8: SWOT Analysis (Strengths, Weaknesses, Opportunities, Threats)

A SWOT Analysis of the Michigan Aquaculture Sector

Knudson 1/8/13

Introduction

A SWOT analysis studies the strengths (S), weaknesses (W), Opportunities (O) and Threats (T) facing a particular organization or sector. The focus of this SWOT analysis is the Michigan aquaculture sector. In this case strengths refer to aspects internal to the Michigan aquaculture sector that enhance its potential to grow and prosper, whereas weaknesses are aspects internal to the sector that make success more difficult to achieve. Opportunities are trends and other factors external to Michigan aquaculture that enhance its potential to grow and prosper. Threats are outside factors that adversely affect the sector.

This SWOT analysis considers the entire supply chain, from input supplies to the retail sector with a particular emphasis on restaurants, the primary outlet for seafood. This assessment only considers aquaculture for human consumption; the bait fish and other sectors are not considered. Aquaculture accounted for less than 20 percent of global seafood in 1990 and is estimated to be more than 50 percent by 2020. The global aquaculture sector is now likely larger than the beef sector (ReThink and CAS, p.4). Also it is estimated that world per capita seafood consumption will increase from approximately 28 pounds in 1992 to about 39 pounds in 2020 (Vannuccini). The increased acceptance of aquaculture and the increased global demand for seafood create an environment conducive to the growth of the aquaculture industry in Michigan.

Despite the growth in the global aquaculture industry the U.S. only accounts for about 1 percent of the world's aquaculture production. Global production is dominated by China which accounts for two-thirds of total production (Weeks). The U.S. trade deficit in seafood is $10.8 billion (Weeks).

For the most part the focus will be on restaurant products because restaurants account for 70 percent of the seafood sold in the U.S. (Mintel, p.66). The emphasis on convenience and the continuing decline in cooking skills indicate that restaurants will continue to be the primary outlet for seafood products. Seafood products that Michigan can produce such as shrimp, trout, walleye, tilapia, perch and are well suited for the restaurant market. While a smaller market, retail food stores are also interested in Michigan seafood.

Overall Michigan has several strengths that can be exploited to grow the industry, which are outlined in the strengths section of the report. The Michigan Aquaculture Association believes that the industry can grow from $5 million and100 jobs to $100 million and 1,500 over the next 10 years. While this is a major increase it is a small amount given that U.S. consumers purchased $15 billion in seafood in 2011 excluding restaurant sales (Mintel, p.1). A rough estimate of the total size of the market that is one day's drive is 4.8 billion pounds of seafood consumed by approximately 99 million consumers.

However, there are also some severe weaknesses that need to be overcome, and if they are not the small aquaculture sector in Michigan could decline to total irrelevance. Opportunities in the sector are broad and pervasive and comparatively speaking there are relatively few threats and some of those that

exist such as high feed prices affect all aquacultural producers throughout the world. These weaknesses, opportunities and threats are outlined below.

Overall, Michigan is well suited to expand the aquaculture industry but success is by no means assured. While market trends point to a growing demand and interest in fresh seafood, without increased production and new investment in the state, this increased demand will be met somewhere other than Michigan. Aquaculture is a global industry and some opportunities such as commodity salmon production have likely already been lost. Time is of the essence if the industry is going to expand.

It is important to note that a SWOT analysis is primarily designed to provide information and provide a framework for understanding the sector. Conclusions, if they exist at all, should be considered very preliminary and subject to change.

Strengths

Mintel's analysis of the seafood market identified the following trends in marketing: personalization (get to know the fisherman), convenience, health, kid-friendliness, versatility, quality, education and environmental awareness (Mintel, p.57). Michigan is well suited to appeal to personalization, health, quality and environmental awareness.

Access to water is a key strength of the sector. The Great Lakes account for 90 of the U.S. fresh water supply and 20 percent of the world's fresh water supply. Michigan borders all the great lakes with the exception of Lake Ontario. The state also is home to many inland lakes and rivers. This provides a natural habitat for fish that are well suited to Michigan's climate.

Water treatment facilities with excess capacity are a potential asset that could be used to expand the industry. Cities such as Detroit and Muskegon appear to have excess capacity in their water treatment plants. Aquaculture facilities can use this excess capacity to grow fish and handle effluent without going through some regulatory hurdles such as obtaining a wastewater discharge permit. Also, shuttered industrial facilities in urban areas might be retrofitted for aquacultural production. Warm water species such as shrimp and tilapia appear to be well suited for these types of operations based in former industrial sites.

One of the strengths of the Michigan aquaculture sector is its relatively central location to some major population centers. Table 1 shows the distance between Muskegon and some major population centers and table 2 shows the distance between Detroit and the same areas. Muskegon and Detroit represent the Western and Eastern part of the state respectively and both cities have excess water processing facilities that could be used by aquacultural operations.

While the general regulatory environment is not conducive to the development of an aquaculture industry aquaculture is covered under Michigan's Right to Farm Act. This act gives farmers an affirmative defense in lawsuits provided the farmer follows Generally Accepted Agriculture Management Practices (GAAMPS). Michigan also has an Aquaculture Development Act which encourages the development of the industry.

Michigan has a geographic strength in that is it close to major population centers. This is shown in tables 1 and 2.

Table 1: Distance from Muskegon to Selected Cities	
City	Distance (Miles)
Chicago	184
Cleveland	340
Columbus	363
Indianapolis	301
Louisville	481
Memphis	684
Milwaukee	277
Minneapolis/St. Paul	593
New York	785
Pittsburgh	456
St. Louis	454
Toronto	402
Washington, D.C.	696

Table 2: Distance from Detroit to Selected Cities	
City	Distance (Miles)
Chicago	283
Cleveland	169
Columbus	204
Indianapolis	281
Louisville	361
Memphis	744
Milwaukee	370
Minneapolis/St. Paul	690
New York	614
Pittsburgh	286
St. Louis	523
Toronto	245
Washington, D.C.	525

Tables 1 and 2 show that both Detroit and Muskegon and within a one day's drive to some major population areas. There are approximately 99 million people within 700 miles of Michigan. However, it should be noted that both New York and Washington D.C. are unlikely to get their seafood from Michigan. The interior of the U.S. lags behind the coasts in the consumption of seafood, and truly fresh seafood is a relatively rare item. Fresh seafood from Michigan could find a market of tens of millions of people who live reasonably close to the state.

Nationwide, per capita consumption of seafood is 15.8 pounds per year, far below the *USDA Dietary Guidelines for Americans* recommendation of 26 pounds per year (Weeks). People in the Midwest are the least likely to consume fish. This is particularly true for fresh fish and shellfish. Consumption in the Midwest of frozen and canned fish is not fundamentally different than other regions of the country (Mintel, p.77). Compared to other parts of the country, Midwesterners have less access to truly fresh fish. There could be pent up demand for fresh seafood products, and markets such as Chicago and the

Twin Cities have particular potential. It should be noted that there is less potential in the plains and Western Corn Belt where there is less of a culture of eating seafood.

While overall the U.S. is a major importer of seafood it is major producer of trout; the U.S. ranks 6th globally in the production in trout from aquacultural facilities. However, most of the trout in the U.S. is produced in Idaho (ReThink and CAS, p.1).

Table 3 summarizes the strengths of the Michigan aquaculture sector.

Table 3: Summary of Michigan's Aquaculture Strengths	
Access to freshwater	
Ability to take advantage of consumer trends	
	Personalization
	Health
	Quality
	Environmental awareness
Excess capacity in some water treatment facilities	
Within driving distance of 100 million consumers	
Potential to expand the Midwest market	

Weaknesses

A major weakness facing the sector is its size. There aren't many producers in Michigan, and those that do exist are relatively small. The North Central Region of the U.S. only accounted for 3.1 percent of aquaculture production in 1998 (Weeks). The equipment and facilities of some of these operations are old and no longer state of the art. Most of these facilities are 20 to 50 years old (Originz, p.32). Aquaculture farmers are aging and there is some concern that that there are few or no young people interested in entering the industry. Older producers and aging equipment appear to have a negative impact on access to credit. It appears that lenders are not particularly interested in extending credit to aquaculture farmers. Due to the lack of some markets, the lack of government support prices and other factors aquaculture is considered by some to be more risky than other agricultural activities. Without additional financial capital whether in the form of internal capital injection, venture capital, grants or loans the industry is not likely to grow.

Production practices may be another weakness. A feasibility study of trout production in New Brunswick showed that a small facility that raised fingerlings to market size fish is not profitable (ReThink and CAS, p.65). To be profitable a facility show either focus on raising hatchings to fingerlings or fingerlings to market fish. There is precedence for this; the hog sector is evolving along similar lines.

Processing capacity is also a potential concern. While processors are interested in expanding the industry and currently have sufficient capacity to handle all the production in Michigan it may not have the capacity to handle a dramatic increase in farm level production, although it appears that scaling up production is not an issue, and producers could expand processing themselves. The processing sector must grow in step with the increase in farm production in order for the sector to truly grow.

Other actors in the supply chain are completely missing. The state lacks fishmeal-processing capacity, and the ability to produce specialty fish feed for therapeutic use. This is particularly important for therapeutic feeds that occasionally need to be fed to seafood species to address disease issues.

While there appears to be a broad market opportunity in the production of shrimp and tilapia, high energy prices may preclude producers from ever taking advantage of this opportunity. Shrimp and tilapia need water temperatures in excess of 80 degrees to prosper; given Michigan's climate that means that the water must be heated for several months of the year. At current energy prices it may not be profitable to produce these species.

The regulatory environment is considered by some to be the biggest impediment to industry expansion and a root cause of investment risk. Firms have to interact with several agencies and generally need to obtain several permits to operate. Furthermore, some permits take several months to obtain. Depending on the activity an aquacultural producer could need permits from the Department of Agriculture and Rural Development, the DNR, the DEQ and federal agencies (Originz, p.23). One area needed for regulatory flexibility is provisions that would allow aquaculture producers to occasionally dredge their raceways and ponds (Originz, p.48), this is particularly important for trout production. This is very important for producers of species that are dependent on clear water. Another area for regulatory flexibility is reducing the regulatory burden of re-obtaining permits after the expiration of the previously issued permits. These regulatory barriers exist despite the fact that the state has a right to farm statute and an Aquaculture Development Act.

Another regulatory shortcoming is the difficulty of obtaining permission for cage culture production. Trout presents a good example. The smallest cage culture farm in Ontario is larger than the largest land based trout facility (ReThink and CAS, p.12). It appears that trout produced in cage culture facility exhibit economies of scale or are better converters of feed.

One possible way to overcome some of these regulatory problems is for a fish farm to partner with a municipality that has excess wastewater treatment capacity. These municipalities often already have the necessary permits that an aquacultural operation may face difficulty in obtaining and maintaining. In order to support the industry while maintaining health and environmental standards an easier, more streamlined regulatory process needs to be developed. One way to do this is by using a single permit and reporting process (Originz, p.25). A streamlined process does not necessarily mean lower standards. If Michigan seafood products are to be marketed as safe and environmentally sustainable, and superior to imported products strong yet reasonable regulations need to be in place.

There is some concern that public sector investment in the industry is declining. Of particular concern the transfer of resources from Michigan State University to Iowa and the reduced state government support for extension and research activities. The facilities at MSU are rather old and no longer considered state of the art. Extension and research support would be helpful for the industry to grow. There is particular need for research and development for genetic improvements in seafood species and the development of new feeds. Research in developing fish that produce easy to cook fillets would also increase the demand for seafood. However, given current budget difficulties additional state support may be difficult to obtain. Non-traditional sources of funding may be necessary.

Table 4 summarizes the weaknesses facing the aquaculture sector.

Table 4: Summary of Michigan's Aquaculture Weaknesses	
Small (both producers and processors)	
Facilities are small and no longer state of the art	
Difficulty of obtaining credit	
Difficult regulatory environment	
Decline in public sector investment, lack of R&D	
High level of risk	
Lack of other infrastructure (fishmeal facility)	

Opportunities

A major opportunity is the increasing demand for seafood products. Global demand for seafood is increasing. This is due to both an increase in the population as well as increases in per capita consumption. Per capita demand is also increasing in the U.S., although it is quite low. For example per capita consumption of trout is only 0.09 pounds (ReThink and CAS, p.14). The nature of global demand is also changing. As incomes have increased particularly in Asia, the demand for higher valued species has increased (Rana, Siriwardena, and Hasan, p.17). This increase in demand for higher valued species is less evident in the U.S. which is a more mature market.

One barrier to increased seafood consumption that can be turned into an opportunity is the fact that less than half of the consumers surveyed trust seafood labels (Mintel, p.11). One survey indicates that only 46 percent of those surveyed are confident that the fish purchased is what is says on the label and women, who still do most of the shopping are slightly less confident than men (Mintel, p.86). Concerns about mercury and chemical contamination remain a concern in the minds of some consumers (Mintel, p. 22). If the Michigan industry can generate trust it can increase market share and sales. If produced and marketed in the right way the Michigan industry can assuage consumer fears and concerns about food safety, freshness, and environmental sustainability. Concerns about labeling and knowing exactly what you are buying do create an opportunity for a branded product. One of the reasons Legends of the Lake, a cooperative that sells branded whitefish products in retail markets has been successful is that it has earned a reputation as a superior product compared it generic imported whitefish.

The U.S. market is particularly well suited for increases in demand. Fish is widely considered as a healthy food, which should appeal to health conscious consumers. Many types of seafood are naturally low in calories and sodium (National Aquaculture Association). The American Heart Association recommends that Americans eat two servings of fatty fish per week and the U.S. Department of Agriculture has recommended consumers eat two seafood meals per week, far above what most individuals, especially those in the Midwest, eat. The primary growth in the industry is in fresh seafood products (Mintel, p.7). It has been estimated that only 2 percent of imported seafood is inspected, only 0.1 percent is tested for drug resides, and some popular species of fish may be mislabeled up to 70 percent of the time despite the fact that 84 percent of the seafood consumed in the U.S. is imported (Mintel, p.15, 25). The presents a particular opportunity for the aquacultural sector in Michigan because consumers in the Midwest have limited access to truly fresh seafood; this access could be met with Michigan products. The increased interest in locally produced foods also works to the advantage of the Michigan aquaculture sector.

As mentioned in the introduction, restaurants are the primary outlet for seafood. Table 3 shows the prevalence of seafood by species from 2007 to 2011.

Table 3: Top Seafood Types on Menus 2007 -2011

	Number of Items			
Species	**2007**	**2011**	**Percent Change**	
Shrimp	908	1,040	14.9	
Salmon	334	398	19.2	
Crab	340	354	4.1	
Calamari	183	235	28.4	
Fish	259	213	-17.8	
Scallop	183	207	13.1	
Tuna	132	186	40.9	
Lobster	116	138	19.0	
Tilapia	60	135	125.0	

Source: Mintel

This table shows several interesting trends. There is less interest in the generic category "fish" consumers are increasingly interested in specific types of seafood. Shrimp is the dominant type of seafood sold in restaurants and has a consistent rate of growth. Shrimp is one value added market Michigan aquaculturalists should consider. Tilapia offerings have more than doubled from 2007 to 2011 and appear to be favored my many chefs and restaurants. Tilapia is another species the Michigan industry should consider. Fresh products are important for consumers and affluent consumers are particularly interested in fresh products (Mintel, p.88).

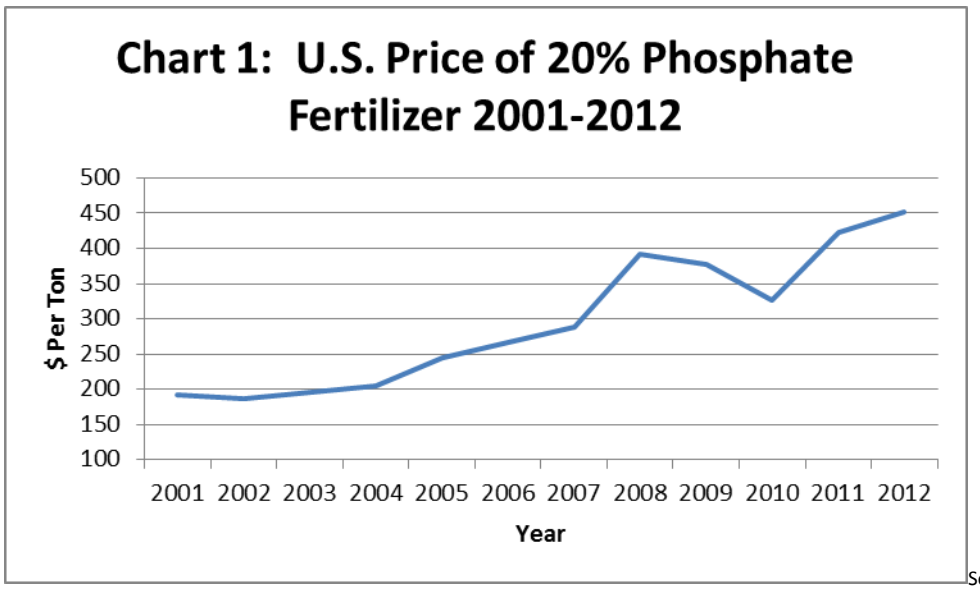
These menu items are somewhat limited. Species native to Michigan or which can be easily be grown in Michigan such as trout, perch, walleye and conceivably arctic char could add variety to menus; walleye and perch are already commonly found on menus in Northern Michigan and other state such as Minnesota. It should be noted that Michigan does not allow arctic char to be produced in its waters.

Changing demographics present another opportunity. There appears to be a strong relationship between Hispanics and seafood consumption (Mintel, p.18). Hispanics are now the largest minority group in the U.S. and their numbers are growing. While most Hispanics live in the Southwest, there is a fast growing Hispanic population in the Midwest both in urban and rural areas.

Feed prices are increasing which puts downward pressure on profits as feed is the major cost component of aquacultural production. However, fish are more efficient converters of feed than hogs, cattle and poultry. This is especially true for herbivore species such as tilapia. Over time, this should improve the competitive position of seafood relative to other sources of animal protein. More discussion of increasing feed prices is covered in the threats section.

Another opportunity worth mentioning is the co-products that can be produced by aquacultural production. One co-product is fish meal that could be produced by the offal generated by processing the filets. Producing fishmeal directly from species currently living in the region is also a possibility. There is some concern about the global decline in the supply of fishmeal (Rana, Siriwardena, and Hasan,

p. 32). Another co-product is fertilizer generated by manure generated by the fish. There has been a dramatic increase in the price of phosphorous fertilizers and it is conceivable that fish manure could be processed into fertilizer. Chart 1 shows the growth in 20 percent phosphate fertilizer prices from 2001 to 2012.



Source: ERS, USDA

During this time period the price of 20 percent phosphate fertilizer more than doubled from slightly less than $200 a ton in 2001 to just over $450 in 2012. There is a consensus that fertilizer prices are not likely to decline anytime soon.

Collecting the manure would also reduce environmental concerns about aquaculture. However, it should be noted that in order to take advantage of this opportunity, the industry will need to expand dramatically. Fish meal and fertilizer production both exhibit economies of scale and therefore the state will need a lot more fish if these co-product industries are going to establish themselves.

If regulatory and tribal concerns can be addressed cage production of trout present an opportunity. Michigan is well suited for trout production and there appears that demand outstrips supply at current prices. Processors and wholesalers have indicated an interest in handling more trout as have retailers. However, the industry will need additional support in order to expand.

Table 5 outlines the opportunities for aquaculture production in Michigan. These opportunities are quite broad

Table 5: Summary of Michigan's Aquaculture Opportunities

Increasing demand for seafood products
Consumers distrust of seafood - especially imported
Consumers are interested in health and consume less than the USDA recommended amount
Midwest market is underserved
Growing Hispanic population

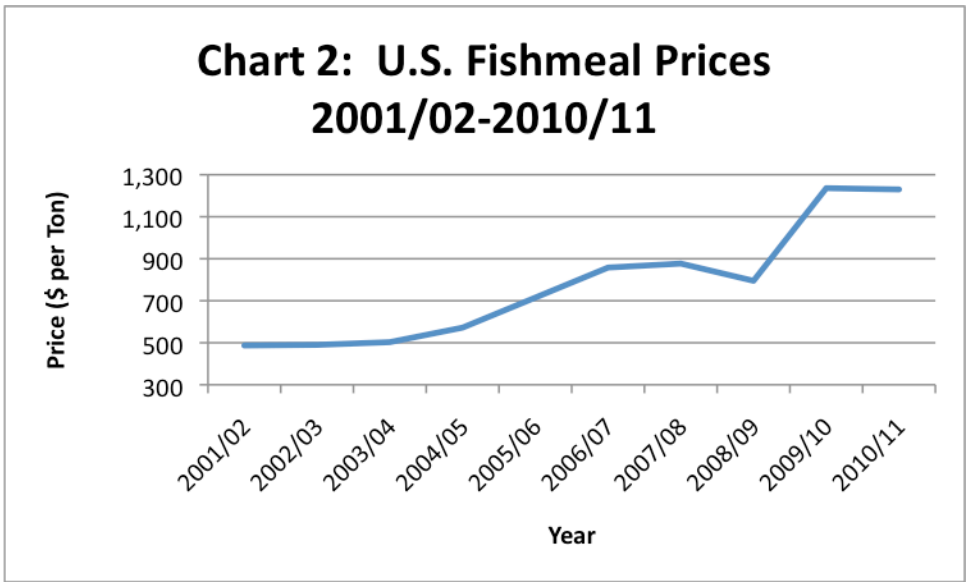
Threats

A major threat to the development of the industry is environmental concerns. Some will look on the introduction of non-native fish species with suspicion. The use of cage systems will almost certainly face opposition from environmental groups worried about diseases, manure and wild subspecies mating with captive fish. It should be noted that there is ongoing research into capturing nitrogen and phosphorous to reduce the impact of manure on ecosystems (Weeks).

Another environmental issue is the widespread concern about the long-term sustainability of raising carnivorous species such as trout which are dependent on fishmeal. There is a great deal of interest in developing plant based feed that carnivorous species can consume; soybean based feeds appear to show the most promise. This would address one of the major criticisms of aquaculture.

It should be noted that without a healthy aquaculture industry, wild fish populations would be under even more pressure than they currently are. If people are going to eat seafood and wild populations are to be protected, the aquaculture sector must grow in size. Careful research and management practices will be necessary to minimize environmental concerns of most people, but some individuals and organizations will never be fully satisfied.

One threat facing the entire aquaculture sector is higher feed prices. This is particularly true for producers of carnivorous fish such as trout. Historically feed costs account for about 50 to 70 percent of production costs (Rana, Siriwardena and Hasan, p. 12) and given current feed prices it might be more than 70 percent. Chart 2 shows the increase in fishmeal prices over the last ten years.



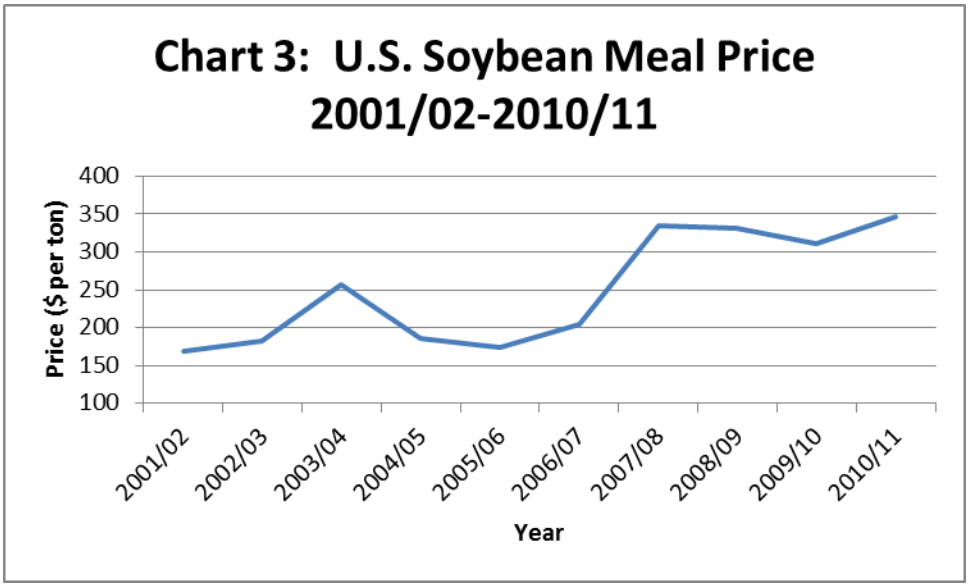
Source: ERS, USDA

From 2001/02 to 2010/11 the price of fish meal increased from $487 per ton in 2001/02 to $1,230 in 2010/11. Prices rose slowly but steadily from 2001/02 through 2004/05 and accelerated in 2005/06 and 2006/07. There was a dramatic increase in 2009/10 and prices have remained high since then. Fishmeal is purchased in bulk and there is a great deal of risk faced by aquaculture producers because only is the price going up from year to year there is also a great deal of price fluctuation during the year. Further

complicating the issue is the fact there is no futures or options market for fishmeal. Cross hedging using corn and soybeans could be used as an imperfect substitute (Parcell et al, p.1), but this requires a fair degree of sophistication.

The lack of wild catch fish such as anchovies coupled with the global increase in all feed prices have impacted the aquaculture sector. It should be noted that there is ongoing research on replacing fishmeal with high protein plant based feeds. However, there appears to be technical and biological barriers to the adoption of plant based feeds as a substitute for fishmeal.

The increase in another major feed price is shown in chart 3 which shows the increase in soybean meal prices over time.



Source: ERS, USDA

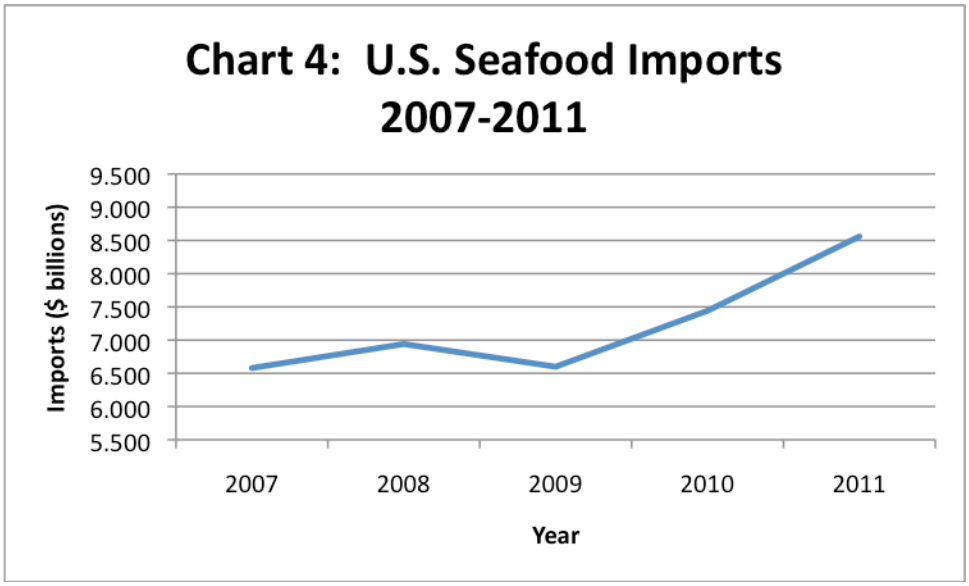
From 2001/02 through 2010/11 the price of soybean meal increased from $168 a ton to $346 a ton. There has been a precipitous increase from 2006/2007 through the present with current soybean meal prices well in excess of $500 a ton and soybean meal prices will be very high through at least the summer of 2013.

Higher feed prices limit the profit opportunities for aquacultural producers. The only good news is that fish tend to be better converters of feed compared to terrestrial animals which gives them a competitive advantage compared to hogs, cattle and chicken. The advantage is more pronounced for herbivore species such as tilapia than it is for carnivorous species such as trout.

Another threat is foreign competition. Asia dominates global aquaculture production accounting for 90 percent of production (Rana, Siriwardena and Hasan, p.x). The value of Asian production accounts for 80 percent of the total global value (Rana Siriwardena and Hasan, p. 1) which indicates that the species produced by Asian farmers are lower value than the species grown in other parts of the world; carp is a good example. Asian producers often do not directly feed their fish. More intensive aquacultural practices could enhance the efficiency of Asian aquaculture and could improve their competitive

position compared to American producers. The province of New Brunswick as also identified the U.S. as a potential marked for their aquacultural products.

Chart 4 shows the level of imports of seafood to the U.S. from 2007 through 2011.



Source: ERS, USDA

During this time the level of imports increased from $6.58 billion in 2007 to $8.56 billion in 2011. There was a slight decline from 2008 to 2009, but imports increased dramatically in 2010 and 2011. Among the species and varieties that showed the most increase include fresh Atlantic salmon, frozen Pacific Salmon, Tilapia, and both fresh and frozen shrimp.

In some respects aquaculture in the U.S. lags behind other countries. Nations such as Canada, Norway and Chile have well established Salmon industries and it is unlikely that Michigan could ever compete with these nations in the production of that species on a commodity basis. Given the popularity of salmon there may be some opportunities for Michigan producers of a fresh product for high quality restaurants. If the state does not take advantage of its strengths and opportunities it could lose out to other countries with respect to other species such as trout, shrimp and tilapia. Nations such as Bangladesh and Myanmar are increasing their production of crustaceans such as shrimp (Rana, Siriwardena, and Hasan, p. 11). The existence of this competition means that it is unlikely that Michigan producers will be able to compete on the basis of price. Michigan producers will likely have to compete on the basis of freshness, quality environmental sustainability and other non-price factors.

The economic slowdown is having a negative impact on seafood consumption. Most seafood is consumed in restaurants and is consumed by people with incomes in excess of $75,000 a year. Economic uncertainty, stagnant incomes and high rates of unemployment restrict consumption as people cut back on things such as restaurant meals. Many people consider fish, especially fresh fish, to be expensive. The economic slowdown has also had an effect on credit conditions. This was discussed in more detail in the weaknesses section of this paper.

The lack of time and a decline in cooking skills on the part of consumers also restricts seafood sales. The fact that some types of seafood are expensive compared to chicken, pork and beef can keep consumers from risking cooking seafood at home. Some seafood dishes are time consuming to prepare, and fewer and fewer people know how to cook fish. Also, some people don't like a "fish" smell. For these reasons it probably makes the most sense for the Michigan industry to focus on restaurant sales with the potential to expand to supermarkets as production increases. It should be noted that both Meijer's and Kroger have expressed an interest in buying trout.

Table 6 summarizes the threats facing the Michigan aquaculture sector.

Table 6: Summary of Michigan's Aquaculture Threats

Environmental concerns
High feed prices
Foreign competition
Global economic slowdown
Decline in cooking skills

Summary

This report outlined the strengths, weaknesses, opportunities and threats facing the Michigan aquacultural industry. The sector has two major strengths. It is located in the middle of the Great Lakes with a great deal of access to fresh, clean water, which can be used to produce aquacultural species. The second major strength is the fact that Michigan is also located within a day's drive of some major population centers, many without access to truly fresh seafood.

However, Michigan aquaculture also has some weaknesses, which hold the industry back and could keep it from ever developing. Many facilities are small and dated. This precludes farmers from taking advantage of opportunities such as producing co-products due to the lack of economies of scale. The lack of access to credit and other types of financial capital also holds the industry back and restricts new investment. Streamlining the regulatory process could also help the industry, but the regulation is still required to maintain the environment and protect public health as well as assure consumers that the Michigan seafood products are not only safe to eat but are good for them. Another concern is the relatively small size of the processing sector, although it is believed that this capacity can be increased. Currently, it is of sufficient size to handle the aquacultural products currently produced but on farm production the processing industry will also have to increase in size; coordinated growth along the supply chain is important. High energy prices, particularly heating costs are a barrier to the production of shrimp and tilapia which need warm water to grow efficiently.

There are broad opportunities that the industry could take advantage of. Growing populations and growing incomes around the world have increased the demand for seafood. Consumers in the Midwest consume less seafood than consumers in other parts of the country and have less access to fresh seafood. Michigan aquaculture could provide this access. By offering safe products the Michigan aquaculture industry can address consumer concerns about food safety and freshness.

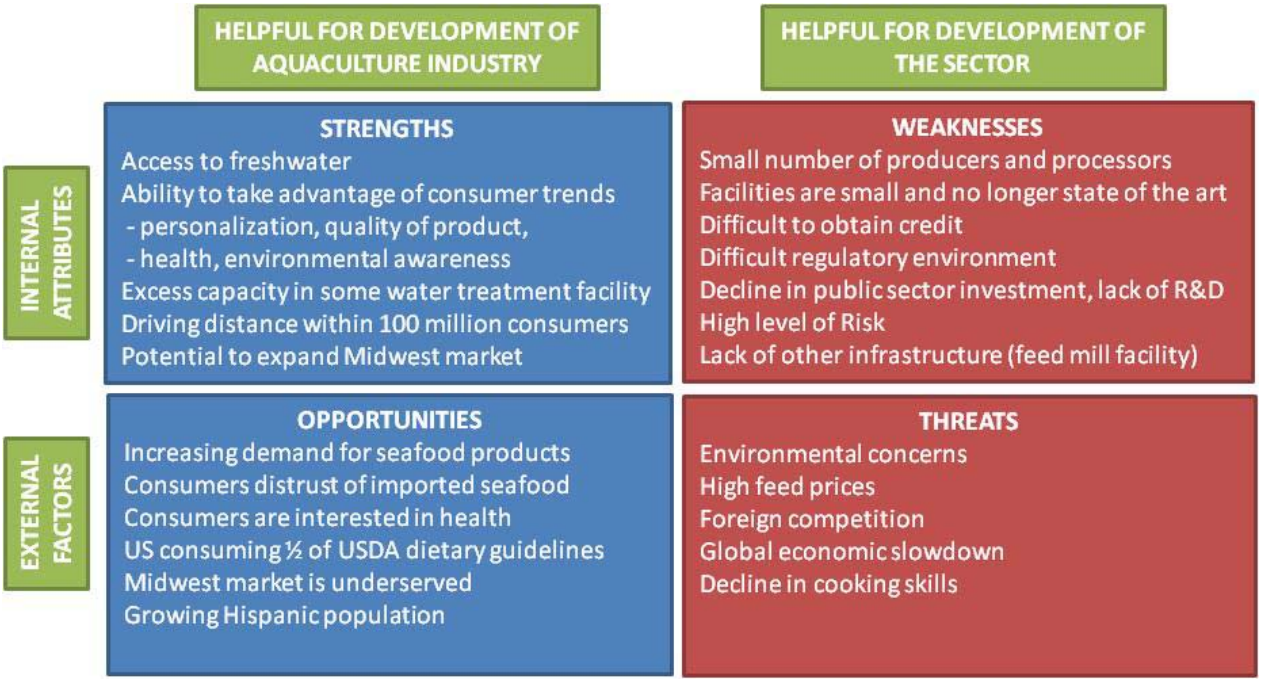
Restaurants are the primary outlet for seafood and are likely to be for the foreseeable future. Michigan could produce warm water species like shrimp and tilapia for this market. The market for tilapia is growing particularly rapidly. Traditional species such as trout could also find a market. Perch and

walleye production could also increase to meet regional demand. Arctic char could also find a market especially at those restaurants interested in expanding their menu options. Another opportunity is through the production of co-products such as fishmeal and fertilizer. However, to take full advantage of these opportunities that exhibit economies of scale output needs to increase. The lack of time and the overall decline in cooking skills somewhat limits the potential for expanding sales through retail outlets such as supermarkets.

While opportunities are stronger than threats there are some threats, which need to be considered. No matter what the industry does there will be some people and organizations concerned about the environmental impact of expanded aquacultural production. High feed prices are putting a squeeze on profits, and feeders of carnivorous fish such as trout may face particular difficulties. Herbivorous species such as tilapia may be in better shape because such fish have better feed conversion ratios than hogs, cattle and poultry.

Another threat is foreign competition. Asia dominates the global aquaculture industry but uncertainty with respect to their production practices does create an opportunity. However, this opportunity may not exist in the future if Michigan does not act fairly quickly. For example odds are the Michigan has lost any chance it had in entering the salmon market.

In conclusion Michigan is well suited to expand aquacultural production. The market is expanding and there are many opportunities available to the industry. However, if the industry does not move relatively quickly, others may capture these opportunities.



Graphic Overview of Michigan Aquaculture SWOT, 2012

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Appendix 9: Enterprise Budgets

The MSU Product Center (Bill Knudson) developed a set of four enterprise budgets for species and systems most suited to the near-term development of the aquaculture sector in Michigan. Those combinations are:

- Trout in Open Water Cage Culture
- Shrimp in RAS
- Tilapia in RAS
- Trout in Flow-Through

This Appendix includes those enterprise budget write-ups and example spreadsheets.

There is also a set of live, MS Excel Spreadsheets to accompany these budgets.

Cage Trout Enterprise Budget

Introduction

The following analysis is a five year enterprise budget for a trout farm using a cage production system. Included are balance sheets, income statements and monthly cash flow statements for each of the five years. The primary sources for this analysis are Leung and Engle and Edwards for the construction and initial investment figures and the financial statements of an existing trout farm. The size under consideration was increased to analyze a relatively large commercial sized farm.

It should be noted that these figures are estimates of what a typical trout facility might expect. In reality there is no such thing as a "typical" facility particularly when analyzing a nascent industry such as cage trout production. Actual performance will be different that than shown in the figures and in some cases could be dramatically different. This analysis is designed to provide general guidance and give potential producers, lenders and policymakers a general idea of what to expect from a trout farm located in Michigan. Additionally the focus of this analysis is on a commercial sized facility that generates close to $1.4 million a year in sales once the operation is operating at full capacity. It does not consider a small scale or hobby farm.

The farm is profitable after the second year of operation. The debt to asset ratios are reasonable. The primary issue is cash flow. The farm has substantial negative cash flows in the two years which carries over to a negative cash balance in the third year. In order for the farm to be successful, the farm needs substantial operating cash well in range of $1 million. Without this cash from a lender, a venture capitalist or other entity, the project will be unable to move forward.

Assumptions

The farm buys eggs and raises them in a nursery. A building is used for the nursery, fingerlings and an office and lab. The total size of the facility is 3 acres not including the cages. It is assumed that the farm has property rights to the water that allow it to operate the cages without paying rent or any other fee. Fifty percent of the assets are owned by the farmer with the remaining 50 percent borrowed at an interest rate of 10 percent. The life of the buildings and equipment is assumed to be 10 years with a 10 percent salvage value. Straight line depreciation was used to determine depreciation costs. It is assumed that it takes 18 months for an egg to be raised to market weight. As a result the farm does not generate any income in its first year of existence.

Total pounds sold are 250,000 pounds in the second year and 500,000 pounds in each successive year. The sale price is $2.75 a pound. The feed conversion ratio is 1.2:1 which requires state of the art equipment and excellent management. The farmer is assumed to be the owner of the farm. Profits and losses are before the owner pays himself or herself. The firm does have a hired farm manager.

Results

Table 1 shows the initial investment for the farm. The total amount of investment is about $900,000 mi of which about $426,000 is land based, and about $474,000 is not land based. The important thing to

consider is that the investments in land based facilities is fixed and cannot be easily transferred or moved and is somewhat limited in alternative uses; this particularly true for the nursery equipment which have little if any use in alterative activities other than aquaculture production.

Table 1: Initial Investment for a Cage Trout Facility	
Item	**Amount**
Land Based Investment	
Land	$ 9,000
12 cages 24 nets and moorings	81,000
Well and Electric Motor	54,000
Wastewater Treatment	32,000
Office/lab/shop/hatchery	250,000
Subtotal	**$ 426,000**
Other Equipment and Machinery	
Boat and related equipment	$ 35,000
Oxygen Meter and Probe	3,000
Feed Storage and Distribution	3,000
Heating System	150,000
Filtration System and Plumbing	10,000
Water Treatment System with ultra violet filter	12,000
Monitoring Equipment System Automatic Alarm	20,000
Pipes and Valves	5,000
Solenoid Valves and Timers, Backflush	8,000
Electrical Distribution	60,000
Biosecurity System	56,000
Harvest Equipment	7,000
Office/lab/shop equipment	50,000
Standby Generator	46,000
Perimeter Fence	4,100
Oxygen Injector Systems	5,000
Subtotal	**$ 474,100**
Grand Total	**$ 900,100**

Table 2 shows the income statements for the first 5 years of operation.

Table 2: Five Year Income Statement: Caged Trout					
	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	$ -	$ 687,500	$ 1,375,000	$ 1,375,000	$ 1,375,000
Variable Cost					
Labor	100,000	102,000	104,040	106,120	108,243
Feed	150,000	300,000	300,000	300,000	300,000
Eggs	21,333	21,333	21,333	21,333	21,333
Repairs, Maintenance and office	45,000	45,900	46,818	47,754	48,710
Heating ($7 per Thous. Cu. Ft.)	7,560	7,711	7,865	8,022	8,183
Electricity (7.5 cents per Kwh)	20,000	20,400	20,808	21,224	21,648
Harvesting and Hauling	0	68,400	136,800	139,536	142,326
Total Variable Costs	343,893	565,744	637,664	643,989	650,443
Income above Variable Costs	$ (343,893)	$ 121,756	$ 737,336	$ 731,011	$ 724,557
Fixed Costs					
Interest	45,005	40,504	35,554	30,108	24,109
Depreciation	89,110	89,110	89,110	89,110	89,110
Property Taxes and Insurance	24,000	24,591	25,083	25,585	26,096
Farm Manager Salary and Benefits	133,000	135,000	138,732	141,140	143,963
Total Fixed Costs	291,115	289,205	288,479	285,943	283,278
Total Costs	$ 635,008	$ 854,949	$ 926,143	$ 929,932	$ 933,721
Net Profit	**$ (635,008)**	**$ (167,449)**	**$ 448,857**	**$ 445,068**	**$ 441,279**

Given these assumptions the farm loses more than $800,000 in its first two years of operation and is solidly profitable in the third year on. No trout are sold in the first year and 250,000 pounds are sold in the second year. Full production of 500,000 pounds occurs after the second year. After the second year the firm is very profitable with profits in excess of $400,000 in years 3 through 5. Some expense items increase over time. This includes repairs and maintenance, labor, heating, electricity, etc. It is assumed that these items increase by two percent per year. Feed costs are the dominant cost, accounting for about one third of all costs and about half of variable costs after the first year of operation. It should also be noted that the farm manager is very well paid. Profitability could be increased if a farm manager could be found who is willing to accept a lower salary and benefits. However, finding a farm manager with experience may be difficult.

Table 3 shows the profit or loss per pound in years 2 through 5.

Table 3: Net Income per Pound Years 2 through 5: Cage Trout				
Year	**2**	**3**	**4**	**5**
Income Per Pound above Variable Costs	$0.49	1.47	1.46	1.45
Income Per Pound above Total Costs	($0.67)	0.90	0.89	0.88

The firm easily covers the variable costs in year two but still losses about 67 cents a pound. Profits are stable in years three through five being in the range of $1.46 per pound above variable costs and $0.89 per pound above all costs. The breakeven price for trout in years three through five is approximately $1.86 per pound.

Table 4 shows the firms balance sheet. The figures are quite good with one glaring exception. The debt to asset ratio is .43 in the first year and declines dramatically in the succeeding years. However, the cash position of the firm in the first three years is a major concern. In fact the cash shortfall in the first three years is so high it may be an insurmountable barrier to entry into the industry. In order to be successful the farm will need additional credit or additional owner capital.

Table 4: Five Year Balance Sheet: Trout

	Year 1	Year 2	Year 3	Year 4	Year 5
Assets					
Cash	$ (545,908)	$ (624,247)	$ (175,390)	$ 358,788	$ 889,177
Land Based Assets	426,000	426,000	426,000	426,000	426,000
Other Equipment and Machinery	474,100	474,100	474,100	474,100	474,100
Less Accumulated Depreciation	(89,100)	(178,200)	(267,300)	(356,400)	(445,500)
Trout	687,500	1,375,000	1,375,000	1,375,000	1,375,000
Total Assets	$ 952,592	$ 1,472,653	$ 1,832,410	$ 2,277,488	$ 2,718,777
Liabilities					
Bank Loan	$ 450,050	$ 450,050	$ 450,050	$ 450,050	$ 450,050
Less Principal repaid	(45,005)	(94,511)	(148,967)	(208,869)	(274,770)
Total Liabilities	$ 405,045	$ 355,539	$ 301,083	$ 241,181	$ 175,280
Owner's Equity	$ 547,547	$ 1,117,114	$ 1,531,327	$ 2,036,307	$ 2,543,497

The firm generates negative cash flow in the first 18 months of operation and generates positive cash flow through the end of the five year time period. There some variation in cash flow throughout the year. This is due primarily to when eggs are purchased. It is assumed that the farm is able to maintain a steady output throughout the year once it is operating at full capacity.

It should be noted that the heating cost is averaged out over the year, actual expenses will be higher in the winter months and lower in the rest of the year. It is assumed the farm has access to natural gas. Interest expense is also averaged out over the year.

Summary

This analysis shows the potential of a commercial sized trout operation in Michigan that produces 500,000 pounds of trout and generates $1.375 million in sales once production is maximized. Actual performance will be different and in some cases could be dramatically different. The financial performance is fairly good after the first two years.

Cash flow analysis helps explain the lack of investment in trout production despite the potential for success. Cash flow is negative every month during the first 18 months of operation, and the firm loses money in the first two years. The results of the negative cash flow are reflected in negative cash balances in the balance sheets in the first three years of operation.

The large negative cash flow shows the need for additional investment or additional credit. Without additional operating funds, such a project is not likely to be undertaken despite its potential for success.

Sources

Edwards, D.J. *Salmon and Trout Farming in Norway*. Farnham: Fishing News Books Limited, 1978.

Leung, P.S. and C. Engle. *Shrimp Culture Economics, Market and Trade*. Ames: Blackwell Publishing, 2006.

Shrimp Enterprise Budget

Introduction

The following analysis is a 5 year enterprise budget for a shrimp farm using a recirculating system (RAS). Included are balance sheets and income statements for each of the first five years of operation. The primary sources for this analysis are Posada and Hanson as well as Moss and Leung.

It should be noted that these figures are estimates of what a typical shrimp facility in a northern climate might expect. In reality there is no such thing as a "typical" facility particularly when analyzing a nascent industry such as shrimp production using a recirculating system. Actual performance will be different that than shown in the figures and in some cases could be dramatically different. This analysis is designed to provide general guidance and give potential producers, lenders and policymakers a general idea of what to expect from a shrimp farm located in Michigan. Additionally the focus of this analysis is on a commercial sized facility that generates close to $11 million a year in sales. It does not consider a small scale or hobby farm.

The figures show that a commercial operation is very profitable provided that there is sufficient owner capital initially invested in the firm. However, cash flow is a serious problem, particularly in the first year. This might explain why there are so few aquaculture firms in Michigan. The need for operating capital during the first year to 18 months of operation is critical for success.

Assumptions

The farm produces broodstock, has a nursery and a grow out facility. The grow out area consists of 10 heated greenhouses each with 8 raceways that are a total of 47,840 square yards for the total grow out facility. The total size of the facility is 13 acres. Fifty percent of the assets are owned by the farmer with the remaining 50 percent borrowed at an interest rate of 10 percent. The life of the buildings and equipment is assumed to be 10 years with a 10 percent salvage value; straight line depreciation is used. In the first year one crop of shrimp are produced as the farm completes construction and ramps up production. Four crops of shrimp are produced in each succeeding year. The price received by the farmer is assumed to be $4.00 per pound.

The grow out facility produces 543 shrimp per square yard; with a survival rate of 70 percent. Total output is 18.14 million shrimp in the first year and 72.58 million shrimp after the first year. Total pounds sold are 680,000 pounds in the first year and 2.72 million pounds in each successive year.

The farmer is assumed to be the owner of the farm. Profits and losses are before the owner pays himself or herself. The firm does have a hired farm manager.

Results

Table 1 shows the initial investment for the farm. The total amount of investment is $8.4 million of which about $6.5 million is land based, and about $2.0 million is not land based. The important things to consider is that the investment in land based facilities is fixed and cannot be easily transferred or moved and are somewhat limited in alternative uses. This particularly true for the raceways and rearing tanks which have little if any use in alterative activities.

Table 1: Initial Investment for a Shrimp Facility	
Item	**Amount**
Land Based Investment	
Land	$ 39,000
Greenhouses	3,734,000
Raceways/Rearing Tanks	1,876,000
Artificial Substrates	223,000
Service Area	281,000
Well and Electric Motor	54,000
Wastewater Treatment	32,000
Office/lab/shop	241,000
Subtotal	**$ 6,480,000**
Other Equipment and Machinery	
Truck	$ 35,000
Oxygen Meter and Probe	3,000
Refractometer	800
pH Meter	1,200
Ammonia and Nitrite Test Kits	3,000
Feed Storage and Distribution	9,000
Heating System	311,000
Filtration System and Plumbing	350,000
Recirculating Pump	26,000
Water Treatment System with ultra violet filter	44,000
Raw Water Pump with ultra violet filter	2,000
Monitoring Equipment System Automatic Alarm	20,000
Pipes and Valves	20,000
Solenoid Valves and Timers, Backflush	8,000
Electrical Distribution	60,000
Biosecurity System	56,000
Harvest Equipment	20,000
Ice Machine	40,000
Office/lab/shop equipment	335,000
Standby Generate	46,000
Perimeter Fence	18,000
All Terrain vehicles	10,000
Oxygen Injector Systems	523,000
Subtotal	**$ 1,941,000**
Grand Total	**$ 8,421,000**

Table 2 shows the income statements for the first 5 years of operation.

Table 2: Five Year Income Statement: Shrimp					
	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	$ 2,720,000	$ 10,880,000	$ 10,880,000	$ 10,880,000	$ 10,880,000
Variable Cost					
Labor	549,375	560,362	571,570	583,001	594,661
Feed	665,762	2,663,051	2,663,051	2,663,051	2,663,051
Post larvae	84,632	338,529	338,529	338,529	338,529
Repairs and Maintenance	351,946	358,985	366,165	373,488	380,958
Heating	126,325	505,300	515,406	525,714	536,229
Electricity	9,600	19,200	19,584	19,976	20,375
Harvesting and Hauling	29,459	117,839	120,195	122,599	125,051
Total Variable Costs	1,817,099	4,563,266	4,594,500	4,626,358	4,658,854
Income above Variable Costs	$ 902,901	$ 6,316,734	$ 6,285,500	$ 6,253,642	$ 6,221,146
Fixed Costs					
Interest	421,050	378,945	341,051	306,945	276,250
Depreciation	754,380	754,380	754,380	754,380	754,380
Property Taxes and Insurance	94,119	96,001	97,921	99,880	101,877
Farm Manager Salary and Benefits	133,000	135,660	138,373	141,140	143,963
Total Fixed Costs	1,402,549	1,364,986	1,331,725	1,302,345	1,276,470
Total Costs	$ 3,219,648	$ 5,928,252	$ 5,926,225	$ 5,928,703	$ 5,935,324
Net Profit	**$ (499,648)**	**$ 4,951,748**	**$ 4,953,775**	**$ 4,951,297**	**$ 4,944,676**

The project is solidly profitable after the first year of operation. The firm loses about $500,000 in the first year; this is primarily due to the fact that only one crop of shrimp is produced. The net profit is close to $5 million in each succeeding year. Some expense items increase over time. This includes repairs and maintenance, labor, heating, electricity, etc. It is assumed that these items increase by two percent per year. Feed costs are the dominant cost, which accounting for about 50 percent of all costs after the first year of operation. It should be noted that finding a farm manager with relevant experience will be critical for the success of the enterprise.

Table 3 shows the profit per pound in years two through 5.

Table 3: Net Income per Pound Years 2 through 5: Shrimp				
Year	**2**	**3**	**4**	**5**
Income Per Pound above Variable Costs	$2.32	2.31	2.30	2.29
Income Per Pound above Total Costs	$1.82	1.82	1.82	1.82

The firm is solidly profitable after the first year. Profit per pound above variable costs range in the $2.30 range and profit per pound above total costs is steady at $1.82. The break-even price for the shrimp is about $2.18 a pound.

Table 3 shows the firms balance sheet. Again, after the first year of operation the firm's balance sheet is very strong.

Table 4: Five Year Balance Sheet: Shrimp					
	Year 1	Year 2	Year 3	Year 4	Year 5
Assets					
Cash	$ (499,648)	$ 4,452,100	$ 9,405,875	$ 14,357,172	$ 19,301,848
Land Based Assets	6,480,000	6,480,000	6,480,000	6,480,000	6,480,000
Other Equipment and Machinery	1,941,000	1,941,000	1,941,000	1,941,000	1,941,000
Less Accumulated Depreciation	(754,380)	(1,508,760)	(2,263,140)	(3,017,520)	(3,771,900)
Shrimp	2,720,000	2,720,000	2,720,000	2,720,000	2,720,000
Total Assets	$ 9,886,972	$ 14,084,340	$ 18,283,735	$ 22,480,652	$ 26,670,948
Liabilities					
Bank Loan	$ 4,210,500	$ 4,210,500	$ 4,210,500	$ 4,210,500	$ 4,210,500
Less Principal repaid	(421,044)	(884,184)	(1,385,220)	(1,920,360)	(2,286,196)
Total Liabilities	$ 3,789,456	$ 3,326,316	$ 2,825,280	$ 2,290,140	$ 1,924,304
Owner's Equity	$ 6,097,516	$ 10,758,024	$ 15,458,455	$ 20,190,512	$ 24,746,644

Other than the negative cash balance after the first year of operation, the figures are quite good. The debt to asset ratio is below .40 after the first year and is less than .08 after the fifth year of operation. The cash position improves dramatically after the first year and the owner could withdraw large sums of money without doing damage to the firm's financial position.

The cash flow analysis shows the primary barrier to success of the venture is cash flow. Cash flow in the first year is the major issue facing a shrimp operation. The cash flow is negative in the first year of operation, and more than $2.4 million in needed for operation before the first crop of shrimp is harvested. Additional cash is needed in the first part of the second year of operation. From the middle of the second year on, the cash position of the shrimp farm is quite strong.

It should be noted that the heating cost is averaged out over the year, actual expenses will be higher in the winter months and lower in the rest of the year. Interest expense is also averaged out over the year

It is the lack of cash flow in the first 18 months of operation that is the major barrier to a shrimp farm. This analysis assumes that the owner supplies the cash himself or herself. If the owner cannot supply the cash then a line of credit or an operating loan is needed. A line of credit or operating loan would reduce the level of owner equity in the operation and have an adverse effect on the balance sheet. Such credit is unlikely to be made available for an untested project like a shrimp farm. The primary reason it

appears that there has been little investment in shrimp farms in Michigan is due to the issue of cash flow in the first 18 months of operation.

Summary

This analysis shows the potential of a commercial sized shrimp operation in Michigan. Actual performance will be different and in some cases could be dramatically different. The financial performance is quite good. The farm is profitable from the second year on. The balance sheet is also strong provided the owner has enough cash to cover the cash shortfall the first 18 months of operating.

The cash flow statement helps explain the lack of investment in shrimp production despite the potential for success. Cash flow is negative during the first year of production, and during the first 11 months of production the farm uses about $2.4 million with no revenue being generated. This is likely to make potential lenders and investors uncomfortable, particularly given the lack of experience many potential entrepreneurs have in growing and marketing shrimp.

Sources

Posadas, B.C. and T. R. Hanson. "Economics of Integrating Nursery Systems into Indoor Biosecure Recirculating Saltwater Shirmp Grow-out Systems", in P.S. Leung and C. Engle eds. *Shrimp Culture: Economics, Market and Trade*. Oxford: Blackwell Publishing Company, 2006.

Moss. S.M. and P.S. Leung. "Comparative Cost of Shrimp Production: Earthen Ponds Versus Recirculating Aquaculture Systems", in P.S. Leung and C. Engle eds. *Shrimp Culture: Economics, Market and Trade*. Oxford: Blackwell Publishing Company, 2006.

Tilapia Enterprise Budget

Introduction

The following analysis is a five year enterprise budget for a tilapia farm using a recirculating system (RAS). Included are balance sheets and income statements for each of the first five years of operation. The primary source for this analysis is Dunning and DeLong who analyzed a small facility in North Carolina. The size under consideration was increased to analyze a commercial sized farm.

It should be noted that these figures are estimates of what a typical tilapia facility in a northern climate might expect. In reality there is no such thing as a "typical" facility particularly when analyzing a nascent industry such as tilapia production using a recirculating system. Actual performance will be different that than shown in the figures and in some cases could be dramatically different. This analysis is designed to provide general guidance and give potential producers, lenders and policymakers a general idea of what to expect from a tilapia farm located in Michigan. Additionally the focus of this analysis is on a commercial sized facility that generates $1.25 million a year in sales. It does not consider a small scale or hobby farm.

The figures show that while a commercial operation can be profitable at the assumed prices and costs cash flow issues could preclude such a firm outlined in this analysis from ever operating. However, if it could obtain a higher price for tilapia or perhaps was substantially larger it could be successful.

Assumptions

The farm buys fingerlings (32,000 a month at 10 cents each). There are 24 total tanks including tanks for the fingerlings. The building is 16,640 square feet. The total size of the facility is eight acres including the settling pond for wastewater. Fifty percent of the assets are owned by the farmer with the remaining 50 percent borrowed at an interest rate of 10 percent. The life of the buildings and equipment is assumed to be 10 years with a 10 percent salvage value. Straight line depreciation was used to generate the deprecation estimate. Sales of the fish begin in July of the first year. The price received by the farmer is assumed to be $2.50 per pound. The feed conversion rate is 1.4 pounds of feed per one pound of fish. This may be somewhat conservative.

Survival rate is assumed to be 91 percent. Total pounds sold are 250,000 pounds in the first year and 500,000 pounds in each successive year. The farmer is assumed to be the owner of the farm. Profits and losses are before the owner pays himself or herself. The firm does have a hired farm manager.

Results

Table 1 shows the initial investment for the farm. The total amount of investment is about $1.6 million of which about $600,000 is land based, and about $1.0 million is not land based. This might be slightly underestimating the actual cost because the labor cost of installing the equipment may not be fully captured in these figures. Another important consideration is that the investment in land based facilities is fixed and cannot be easily transferred or moved and is somewhat limited in alternative uses; this particularly true for the rearing tanks which have little if any use in alterative activities.

Table 1: Initial Investment for a Tilapia Facility					
Item	**Amount**				
Land Based Investment			**Q1 Tank Equipment**		
Land	$	24,000	**Item**	**Amount**	
Settling Pond		10,500	Tanks	$	6,300
Aerator		4,700	Pumps		3,600
Composter		11,900	Particle Traps		10,300
Building		387,000	Oxygen Saturators		2,100
Electrical		23,500	Foam Farctionaors		4,300
Plumbing		45,700	Bio Sumps		2,500
Office/lab/shop		50,000	Bio Sumps Media		1,500
HVAC		33,000	Media Blowers		1,300
Subtotal	**$**	**590,300**	Regenerative Blowers		2,200
			Biosump Level Controls		1,200
Other Equipment and Machinery			Drum Screen Filters		37,000
Feed Bins	$	39,000	Drum Filter Rinse Pumps		3,100
Feeders		11,500			
Feeder Controller		800	**Subtotal**	**$**	**75,400**
Gas Generators		26,000			
Truck		35,000	**Q2 Tank Equipment**		
Oxygen Monitor		8,300	Tanks	$	25,400
Hoist, Trolley and Track		6,300	Pumps		7,100
Crowder for Harvest		1,900	Particle Traps		17,300
Miscellaneous Harvest Equipment		1,500	Oxygen Saturators		9,600
Water Heat Pumps		25,000	Foam Fractionators		4,300
Telephone Dialer		550	Bio Sumps		4,400
Lab Equipment		12,700	Bio Sump Media		2,200
Miscellaneous Equipment		6,300	Media Blower		1,300
Grow Out Tanks		127,000	Regenerative Blower		2,600
Pumps		28,700	Biosump Level Control		1,200
Particle Traps		93,500	Drum Screen Filters		35,000
Oxygen Saturators		40,000	Drum Filter Rinse Pumps		3,100
Foam Farctionators		17,000			
Bio Sumps		50,800	**Subtotal**	**$**	**113,500**
Bio Sumps Media		48,800			
Standby Generator		46,000			
Perimeter Fence		11,000			
Media Blower		5,400			
Regnerative Blowers		7,100			
Drum Screen Filters		140,000			
Drum Filter Rinse Pumps		6,300			
Biosump Level Controls		5,000			
Subtotal	**$**	**801,450**	**Grand Total**	**$**	**1,580,650**

Table 2 shows the income statements for the first 5 years of operation.

Table 1: Five Year Income Statement: Tilapia					
	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	$ 625,000	$ 1,250,000	$ 1,250,000	$ 1,250,000	$ 1,250,000
Variable Cost					
Fingerlings	38,400	38,400	38,400	38,400	38,400
Labor	63,175	64,438	65,727	67,041	68,382
Feed	199,470	265,960	265,960	265,960	265,960
Bicarbonate	84,276	112,368	114,615	116,907	119,245
Rock Salt	2,412	3,672	3,745	3,820	3,896
Repairs and Maintenance	16,500	16,830	17,166	17,509	17,860
Heating	18,090	27,000	27,540	28,090	28,652
Electricity	69,345	103,500	105,570	107,681	109,835
Office Overhead	1,850	1,887	1,924	1,963	2,002
Total Variable Costs	493,518	634,055	640,647	647,371	654,232
Income above Variable Costs	$ 131,482	$ 615,945	$ 609,353	$ 602,629	$ 595,768
Fixed Costs					
Interest	79,032	71,129	62,436	52,873	42,354
Depreciation	121,185	121,185	121,185	121,185	121,185
Property Taxes and Insurance	40,000	40,800	41,616	42,448	43,297
Farm Manager Salary and Benefits	133,000	135,660	138,373	141,140	143,963
Total Fixed Costs	373,217	368,774	363,610	357,646	350,799
Total Costs	$ 866,735	$ 1,002,829	$ 1,004,257	$ 1,005,017	$ 1,005,031
Net Profit	**$ (241,735)**	**$ 247,171**	**$ 245,743**	**$ 244,983**	**$ 244,969**

After the first year of operation the firm is profitable. Table three shows the return per pound over variable costs and fixed costs for years 2 through 5.

Table 3: Returns Per Pound Tilapia				
Year	**2**	**3**	**4**	**5**
Returns Over Variable Costs	$1.23	1.22	1.21	1.19
Returns Over Total Costs	$0.49	0.49	0.49	0.49

These figures are instructive; returns over total costs consistent at 49 cents per pound. The breakeven price of tilapia is about $2.00 per pound. While the firm is profitable, returns per pound are relatively low and may not be high enough to justify investment in a farm of this size particularly given the loss in the first year of operation. A larger operation would likely be more profitable.

There is some potential to enhance its profitability. The project does cover variable costs even in the first year. If interest costs could be reduced potential profitability would increase. Another way to reduce losses is to increase output and take advantage of economies of scale. The price of tilapia is assumed to be $2.50 a pound, which while somewhat optimistic does not represent a truly premium price. The firm could enhance its profitability by selling tilapia for more than $2.50 a pound. However, if more firms enter the industry the ability to maintain high prices will be reduced.

Table 4 shows the firms balance sheet. Except for the poor cash position of the firm the figures are quite good. After the first year of operation the debt to asset ratio is about .50 but it does decline over time to about .16 after the fifth year. One issue is that during this time the assets grow at a fairly low rate although liabilities decline dramatically from more than $700,000 in the first year to about $300,000 in year five.

Table 4: Five Year Balance Sheet: Tilapia					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Assets					
Cash	$ (241,735)	$ 5,436	$ 251,179	$ 496,162	$ 741,131
Land Based Assets	590,300	590,300	590,300	590,300	590,300
Other Equipment and Machinery	990,350	990,350	990,350	990,350	990,350
Less Accumulated Depreciation	(121,185)	(242,370)	(363,555)	(484,740)	(605,925)
Fingerlings	12,000	12,000	12,000	12,000	12,000
Tilapia	191,000	191,000	191,000	191,000	191,000
Total Assets	$ 1,420,730	$ 1,546,716	$ 1,671,274	$ 1,795,072	$ 1,918,856
Liabilities					
Bank Loan	$ 790,325	$ 790,325	$ 790,325	$ 790,325	$ 790,325
Less Principal repaid	(79,032)	(165,967)	(261,595)	(366,786)	(482,496)
Total Liabilities	$ 711,293	$ 624,358	$ 528,730	$ 423,539	$ 307,829
Owner's Equity	$ 709,437	$ 922,358	$ 1,142,544	$ 1,371,533	$ 1,611,027

One major problem facing the firm is that it has a negative cash balance throughout its first year of operation, and the cash position is weak after the second year of operation.

The cash flow analysis shows the firm generates large negative cash flows in the first few months of operation, and begins to generate positive cash flows after that. However, in the succeeding months, the positive cash flow does not offset the negative cash flow generated in the first six months for more than a year. In order to be successful, the firm needs to obtain additional capital and either get a higher price for its product or operate at a larger scale or reduce costs.

It should be noted that the heating cost is averaged out over the year, actual expenses will be higher in the winter months and lower in the rest of the year.

Summary

This analysis shows the potential of a commercial sized tilapia operation in Michigan. Actual performance will be different and in some cases could be dramatically different. At the scale of operation outlined in this analysis the financial performance may not be strong enough to justify the investment. While the farm generates profits once it is fully operational, it probably does not generate enough cash flow to be successful without additional investment or operating capital.

The cash flow analysis helps explain the lack of investment in tilapia production despite the potential for success. The results of the negative cash flow are reflected in the mediocre income statements in the first year of operation.

While the data shows that investment in tilapia production is risky the operation could be successful if the price it received for tilapia is above $2.50 a pound. Profitability could also be increased if the firm was larger and took advantage of economies of scale, or was able to reduce costs such as interest costs.

Sources

Dunning, R. and D. DeLong. *Aquaculture in North Carolina: Tilapia Inputs, Outputs and Economics*. North Carolina Department of Agriculture and Consumer Services, 2002.

Trout Enterprise Budget

Introduction

The following analysis is a five year enterprise budget for a trout farm using an outdoor raceway system. Included are balance sheets, income statements and monthly cash flow statements for each of the five years. The primary sources for this analysis are Leung and Engle for the construction and initial investment figures and the financial statements of an existing trout farm. The size under consideration was increased to analyze a relatively small commercial sized farm.

It should be noted that these figures are estimates of what a typical trout facility might expect. In reality there is no such thing as a "typical" facility particularly when analyzing a nascent industry such as trout production. Actual performance will be different that than shown in the figures and in some cases could be dramatically different. This analysis is designed to provide general guidance and give potential producers, lenders and policymakers a general idea of what to expect from a trout farm located in Michigan. Additionally the focus of this analysis is on a commercial sized facility that generates close to $1.4 million a year in sales once the operation is operating at full capacity. It does not consider a small scale or hobby farm.

The farm is profitable after the second year of operation. The debt to asset ratios are reasonable. The primary issue is cash flow. The farm has substantial negative cash flows in the two years which carries over into a negative cash position through the first four years. In order for the farm to be successful, the farm needs substantial operating cash well in excess of $1.0 million. Without this cash from a lender, a venture capitalist or other entity, the project will be unable to move forward.

Assumptions

The farm buys eggs and raises them in a nursery. A building is used for the nursery, fingerlings and an office and lab. The total size of the facility is 5 acres including the outdoor grow out raceways. Fifty percent of the assets are owned by the farmer with the remaining 50 percent borrowed at an interest rate of 10 percent. The life of the buildings and equipment is assumed to be 10 years with a 10 percent salvage value. Straight line depreciation was used to determine depreciation costs. It is assumed that it takes 18 months for an egg to be raised to market weight. As a result the farm does not generate any income in its first year of existence.

Total pounds sold are 250,000 pounds in the second year and 500,000 pounds in each successive year. The sale price is $2.75 a pound. The feed conversion ratio is 1.33:1 which requires state of the art equipment and excellent management. The farmer is assumed to be the owner of the farm. Profits and losses are before the owner pays himself or herself. The firm does have a hired farm manager.

Results

Table 1 shows the initial investment for the farm. The total amount of investment is $1.55 million of which about $900,000 is land based, and about $640,000 is not land based. The important thing to consider is that the investments in land based facilities is fixed and cannot be easily transferred or moved and is somewhat limited in alternative uses; this particularly true for the raceways which have little if any use in alterative activities other than aquaculture production.

Table 1: Initial Investment for a Trout Facility	
Item	**Amount**
Land Based Investment	
Land	$ 15,000
Raceways/Rearing Tanks	530,000
Service Area	79,000
Well and Electric Motor	54,000
Wastewater Treatment	32,000
Office/lab/shop/hatchery	200,000
Subtotal	**$ 910,000**
Other Equipment and Machinery	
Truck	$ 35,000
Oxygen Meter and Probe	3,000
Feed Storage and Distribution	9,000
Heating System	87,000
Filtration System and Plumbing	98,000
Recirculating Pump	26,000
Water Treatment System with ultra violet filter	44,000
Raw Water Pump with ultra violet filter	2,000
Monitoring Equipment System Automatic Alarm	20,000
Pipes and Valves	5,600
Solenoid Valves and Timers, Backflush	8,000
Electrical Distribution	17,000
Biosecurity System	16,000
Harvest Equipment	20,000
Office/lab/shop equipment	50,000
Standby Generator	46,000
Perimeter Fence	6,000
Oxygen Injector Systems	150,000
Subtotal	**$ 642,600**
Grand Total	**$ 1,552,600**

Table 2 shows the income statements for the first 5 years of operation.

Table 2: Five Year Income Statement: Trout					
	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	$ -	$ 687,500	$ 1,375,000	$ 1,375,000	$ 1,375,000
Variable Cost					
Labor	100,000	102,000	104,040	106,120	108,243
Feed	165,000	333,000	333,000	333,000	333,000
Eggs	21,333	21,333	21,333	21,333	21,333
Repairs, Maintenance and office	77,630	79,183	80,766	82,382	84,029
Heating ($7 per Thous. Cu. Ft.)	7,560	7,711	7,865	8,022	8,183
Electricity (7.5 cents per Kwh)	30,000	30,600	31,212	31,836	32,472
Harvesting and Hauling	0	34,200	68,400	69,768	71,163
Total Variable Costs	401,523	608,027	646,616	652,461	658,423
Income above Variable Costs	$ (401,523)	$ 79,473	$ 728,384	$ 722,539	$ 716,577
Fixed Costs					
Interest	77,630	69,867	61,328	51,934	41,602
Depreciation	138,384	138,384	138,384	138,384	138,384
Property Taxes and Insurance	10,000	10,200	10,404	10,612	10,824
Farm Manager Salary and Benefits	133,000	135,660	138,373	141,140	143,063
Total Fixed Costs	359,014	354,111	348,489	342,070	333,873
Total Costs	$ 760,537	$ 962,138	$ 995,105	$ 994,531	$ 992,296
Net Profit	**$ (760,537)**	**$ (274,638)**	**$ 379,895**	**$ 380,469**	**$ 382,704**

Given these assumptions the farm loses about $750,000 in its first year of operation and an additional $275,000 in the second year. No trout are sold in the first year and 250,000 pounds are sold in the second year. Full production of 500,000 pounds occurs after the second year. After the second year the firm is profitable with a net income in the range of $350,000. Some expense items increase over time. This includes repairs and maintenance, labor, heating, electricity, etc. It is assumed that these items increase by two percent per year. Feed costs are the biggest cost, accounting for about 30 percent of all costs after the first year of operation. It should also be noted that the farm manager is very well paid. Despite the high salary and benefits it still might be difficult to find a manager with relevant experience.

Table 3 shows the profit per pound in years 2 through 5.

Table 3: Net Income per Pound Years 2 through 5: Trout				
Year	**2**	**3**	**4**	**5**
Income Per Pound above Variable Costs	$0.32	1.46	1.45	1.43
Income Per Pound above Total Costs	($0.55)	0.76	0.76	1.05

The firm covers the variable costs in the second year but still incurs a loss in excess of $1.00 a pound when all costs are considered. Profits are stable in years three through five being in the range of $1.65 per pound above variable costs and 71 cents per pound above all costs. The breakeven price for trout in years three through five is approximately $2.00 per pound.

Table 4 shows the firms balance sheet. The figures are fair with one glaring exception that of the cash position of the firm. The debt to asset ratio is .47 in the first year but declines dramatically in the succeeding years to only .10 by the end of the fifth year. However, the cash position of the firm in the first three years is a major concern. In fact the cash shortfall in the first two years is so high it may be an insurmountable barrier to entry into the industry. In order to be successful the farm will need additional credit or additional owner capital. Alternatively it could reduce costs by reducing the amount it borrows or by finding a farm manger willing to accept a lower salary.

Table 4: Five Year Balance Sheet: Trout					
	Year 1	Year 2	Year 3	Year 4	Year 5
Assets					
Cash	$ (622,153)	$ (758,407)	$ (240,128)	$ 278,725	$ 799,813
Land Based Assets	910,000	910,000	910,000	910,000	910,000
Other Equipment and Machinery	642,600	642,600	642,600	642,600	642,600
Less Accumulated Depreciation	(138,384)	(276,768)	(415,152)	(553,536)	(691,920)
Trout	687,500	1,375,000	1,375,000	1,375,000	1,375,000
Total Assets	$ 1,479,563	$ 1,892,425	$ 2,272,320	$ 2,652,789	$ 3,035,493
Liabilities					
Bank Loan	$ 776,300	$ 776,300	$ 776,300	$ 776,300	$ 776,300
Less Principal repaid	(77,630)	(163,023)	(256,955)	(360,281)	(473,939)
Total Liabilities	$ 698,670	$ 613,277	$ 519,345	$ 416,019	$ 302,361
Owner's Equity	$ 780,893	$ 1,279,148	$ 1,752,975	$ 2,236,770	$ 2,733,132

The firm generates negative cash flow in first year and a half of operation and generates positive cash flow through the end of the five year time period as a result of positive cash flow in years three, four and five. There some variations in cash flow throughout the year with revenues being low in January and February. This is due primarily to when eggs are purchased as well as variations in production. Production is highest in late spring through early autumn and is lowest in the winter. This is based on the actual experience of a trout farm in the state.

It should be noted that the heating cost is averaged out over the year, actual expenses will be higher in the winter months and lower in the rest of the year. It is assumed the farm has access to natural gas.

Summary

This analysis shows the potential of a commercial sized trout operation in Michigan that produces 500,000 pounds of trout and generates $1.375 million in sales once production is maximized. Actual performance will be different and in some cases could be dramatically different. The financial performance is fairly good after the first two years.

The cash flow statement helps explain the lack of investment in trout production despite the potential for success. Cash flow is negative every month during the first year and a half of operation. The results of the negative cash flow are reflected in negative cash balances in the balance sheets in the first three years.

The large negative cash flow shows the need for additional investment or additional credit. Without additional operating funds, such a project is not likely to be undertaken despite its potential for success.

Sources

Leung, P.S. and C. Engle. *Shrimp Culture Economics, Market and Trade*. Ames: Blackwell Publishing, 2006.

Appendix 10: PERMIT APPLICATION PROCESS FOR NET PEN OPERATIONS IN MICHIGAN

1. Gauge Local Support of the proposed project

An operator can "test the waters" of their project by talking to local leaders, economic development officials and tribal leaders. This step does not have to be an official agreement with the above organizations, but more of an indication of how the community will receive the project. Organizations that will have an interest in net pen operations are listed under Attachment A.

2. Create a Plan

This will be the details of the proposed project. The document should address the size, scope, species, site, and management plan of the project. Many of these questions are addressed in the operator's business plan. If not, the Small Business Development Center could assist the operator with this plan at no charge. Some of the questions that should be addressed are listed in Attachment B of this document.

3. Meet with the Michigan Quality of Life group and Federal agencies to discuss the plan.

As with all aquaculture projects, the Michigan Quality of Life (QOL) Aquaculture Group (representatives from the Departments of Environmental Quality, Natural Resources, and Agriculture & Rural Development) have an agreement to meet with operators that are proposing an aquaculture project in the state. The meeting is designed to help the QOL Aquaculture Group better understand the proposed project and let the operator know what regulations that the project will need to abide by. Since net pen systems in the Great Lakes would also include federal agencies, we would ask those agencies to also attend.

4. Regulatory Requirements

We have broken this down into two areas: State and Federal.

State Requirements:
A. PART 325 GREAT LAKES SUBMERGED LANDS, OF THE NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION ACT, 1994 PA 451, AS AMENDED (NREPA) - CONSTRUCTION PERMIT APPLICATION AND BOTTOMLANDS CONVEYANCE APPLICATION

Administered by the Michigan Department of Environmental Quality.

Once a completed MDEQ/USACE Joint Permit Application is received, it takes up to 150 days for the permit to be acted on.

More details of the requirement are found in **Attachment C.**

B. THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PROGRAM

Administered by the Michigan Department of Environmental Quality.

Once a completed application is received, the DEQ must act on it within 180 days.

More details of the requirement are found in **Attachment B.**

C. SPECIES AND DISEASE MANAGEMENT PLAN

Administered by the Michigan Department of Agriculture and Rural Development and Michigan Department of Natural Resources.

MDARD regulates fish health through the Animal Industry Act, P.A. 466 of 1988 and the Michigan Aquaculture Development Act , P.A. 199 of 1996

Fish imported into Michigan destined for an aquaculture facility are required to have a certificate of veterinary inspection or a fish health certificate, signed by an accredited veterinarian. Disease testing for importation may also be required by MDARD.

In addition, certain diseases of aquaculture species are reportable to MDARD.

Because of the potential long-term impact of escaped fish on Great Lakes fish populations, the full Great Lakes Model Fish Health Program will need to be strictly followed.
(http://www.glfc.org/pubs/SpecialPubs/Sp93_1.pdf The 2014 updated version has not been published. Please check www.glfc.org for the updated version)

All fish transferred into Great Lakes cage operations will need to be certified by an approved fish health testing lab as free of the following pathogens :
Aeromonas salmonicida, Yersinia ruckeri, Renibacterium salmoninarum, Viral Hemorrhagic Septicemia virus (VHSv), Infectious Hematopoietic Necrosis virus (IHNv), Infectious Pancreatic Necrosis virus (IPNv), *Onchorhynchus masou* virus, and *Myxobolus cerebralis* (Whirling Disease).

D. AQUACULTURE FACILITY LICENSING

Administered by the Michigan Department of Agriculture and Rural Development.

Application link:
http://www.michigan.gov/documents/MDA_Aquaculture_Registration_Application_38588_7.pdf

Application submitted 60 days before the facility is operational.

Federal Requirements:

A. NOTIFICATION TO THE U.S. ARMY CORPS OF ENGINEERS

Depending the site location, the contact will be one of the following two individuals:
Wally Gauthier
U.S. Army Corps of Engineers, Lake Huron and Erie
313-226-6827
Walter.A.Gauthier@usace.army.mil

Charlie Simon
U.S Army Corps of Engineers, Lake Michigan
313-226-6828
Charles.M.Simon@usace.army.mil

The Corps will need a copy of the Part325, MDEQ/USACE Joint Permit Application. It is the same application that was submitted to the Michigan Department of Environmental Quality.
The Corps will then notify the following agencies about the project for their official notification:
• Tribal Organizations for their official approval
• U. S. Fish and Wildlife Service
• U. S. Coast Guard (9th District Office in Cleveland, OH)
• Environmental Protection Agency

Unlike the state agency requirements, the federal requirements do not have a statutory completion deadline, however, the Corps usually completes their review within the same time frame utilized by the DEQ (i.e., 150 days).

ATTACHMENT A - ORGANIZATIONS THAT HAVE AN INTEREST IN NET PENS

ORGANIZATION	LOCATION	CONTACT	TITLE	WEB SITE
Great Lakes Commission	Ann Arbor	Tim Eder	Executive Director	http://glc.org/
Great Lakes Fisheries Commission	Ann Arbor	Robert Lambe	Executive Secretary	http://www.glfc.org/
Healing our Waters Coalition		Andy Buchsbaum	Co-chair	http://healthylakes.org
Local Watershed Council	Site specific			
Michigan Sea Grant	Ann Arbor, University of Michigan	Jim Diana	Director and Professor	http://www.miseagrant.umich.edu/
National Wildlife Federation – Great Lakes Office		Andy Buchsbaum	Regional Executive Director	http://www.nwf.org/great-lakes.aspx
Northern Initiatives	Marquette	Dennis West	President	http://www.northerninitiatives.com
Lake Superior Citizens Fishery Advisory Committee		Mylan Koski	Chair	http://www.michigan.gov/dnr/0,4570,7-153-65134_65139_65169---,00.html
Lake Michigan Citizens Fishery Advisory Committee		Denny Grinold	Chair	http://www.michigan.gov/dnr/0,4570,7-153-65134_65139_65168---,00.html
Lake Huronn Citizens Fishery Advisory Committee		Frank Krist	Chair	http://www.michigan.gov/dnr/0,4570,7-153-65134_65139_65166---,00.html
Lake Erie Citizens Fishery Advisory Committee		Bob Neelyh	Chair	http://www.michigan.gov/dnr/0,4570,7-153-65134_65139_65165---,00.html

ATTACHMENT B

In the operational/business plan, some items that should be address are below. Answers to these questions will help the applicant fill out the above mentioned permit applications.

1. Facility Details a. Size of the cages including depth
    b. Type of cages
    c. Mesh size
    d. Anchoring system
    e. Will it be free standing, anchored to the lake bottom or attached to shore?
    f. What measures will be taken to prevent escapement?

        i. It is likely all fish in enclosures will go against our state stocking allocations (This leaves the reader hanging a bit. Are there options for dealing with this issue? What are consequences if fish get out?)

    g. What measures will be taken to collect wastes? (Do we need to define wastes? Excess food wastes and feces in the water or sediment? Dead fish in pens? Fish renderings on land?)
    h. How will the facility be fished (i.e., how will the fish be harvested)? i. Seasonally or year-round?
    i. How will the facility deal with severe weather including gale force winds and winter conditions?
    j. What legal instrument will be put into place to retire and reclaim the area if the facility is no longer in existence or goes into bankruptcy?
        i. Surety bond? NOTE – a financial instrument (surety bond, letter of credit, etc.) will be required to be in place for the term of a bottomlands conveyance (use agreement) in order to remove a structures if the facility is no longer in existence or goes into bankruptcy.

2. Siting
    a. Exact location
    b. Is it on or near key Great Lakes fisheries habitat?
    c. Is it on or near key recreational fishing or boating areas?
    d. Will it have the needed temperatures to grow fish as required?

3. Species to be reared
    a. What species and strain will be reared?
        i. Will the fish be compatible with existing fish stocks and fisheries management objectives?
        ii. Where will the fish come from to be placed in the cages?
        iii. Will all reared fish be marked?

    b. What sizes will be reared? i. Is the cage mesh size consistent with size of the fish to be reared?

c. What are the target and maximum densities and loadings for the cages?

4. Effluents
   a. How will effluents be managed and collected?
   b. Will low phosphorus feeds be used?
   c. How will bottomlands be kept free of effluents from the facility?
   d. How will the facility deal with excessive algal growth from nutrients provided by the facility if it occurs?
   e. How will the facility conduct water quality and sediment monitoring to meet any permit requirements?

5. Fish Health
   a. Prior to being transferred to the cages, **all** fish will need to be certified free of all of the same diseases tested for by the MDNR
      i. The Great Lakes Fishery Commission – Great Lakes Fish Health Committee - Great Lakes Model Fish Health Program will need to be strictly followed
      ii. *Aeromonas salmonicida, Yersinia ruckeri, Renibacterium salmoninarum*, Viral Hemorrhagic Septicemia (VHS), Infectious Hematopoietic Necrosis (IHN), Infectious Pancreatic Necrosis (IPN), *Onchorhynchus masou* virus, and Whirling Disease will need to be tested
      iii. Periodic independent checks will likely be needed

   b. Who will do the sampling and testing?
   c. What will be the proposed fish health testing regime?
   d. Are there plans for regular therapeutic treatments (e.g. salt baths)?
   e. How will disease outbreaks be handled and reported?
      i. How will the facility deal with any damages from fish diseases to wild stocks?
      ii. How will chemical treatments (antibiotics, Chloramine-T and associated neutralizer, etc.) be administered?

ATTACHMENT C
ENVIRONMENTAL REGULATIONS AFFECTING GREAT LAKES NET PEN OPERATIONS

I. PART 325 GREAT LAKES SUBMERGED LANDS, OF THE NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION ACT, 1994 PA 451, AS AMENDED (NREPA).

Placement and operation of aquaculture net pens for fish production in the Great Lakes is regulated pursuant to Part 325 Great Lakes Submerged Lands, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) administered by the Michigan Department of Environmental Quality (DEQ). Part 325 requires permits for the placement of the net pens, mooring buoys, bottom anchors and other materials in the Great Lakes. In addition, Part 325 also requires a conveyance (private use agreement) for the exclusive use and occupation of the State of Michigan's public trust bottomlands and waters.

Links to Part 325 and associated administrative rules can be found here:
http://www.michigan.gov/deq/0,4561,7-135-3313_3677_3702---,00.html
Permits are also required from the U.S. Army Corps of Engineers (Corps) for the placement of the net pens, mooring buoys, bottom anchors and other materials in the Great Lakes.

A. PERMIT APPLICATION PROCESS

Both the DEQ and the Corps accept the same permit application for construction activities in the Great Lakes, rivers, streams and wetlands. The joint permit application (JPA) can be found here:
http://www.michigan.gov/deq/0,1607,7-135-3307_29692_24403---,00.html
The JPA can be submitted to either the DEQ which will send a copy to the Corps or directly to both agencies simultaneously.

The application will be placed on public notice for 20 days for review and comment by various federal, state and local agencies, the general public and other interested parties. The Corps will also place the application on a separate public notice in accordance with their regulations. The DEQ may also hold a public hearing if the agency believes additional information would be best gathered through a hearing.

The Part 325 processing timeframes to make a decision on a permit application once the application is deemed complete can be either 90 days or 150 days if a public hearing is held.

A permit is required from both the DEQ and the Corps to place the net pens and associated anchors, etc. If one agency issues a permit and the other agency denies the application, then the proposed activity cannot be constructed.

See more information on processing here: http://www.michigan.gov/deq/0,4561,7-135-3307_29692_24403-67375--,00.html

B. SITING CONSIDERATIONS

The following information should be included in a permit application for placement of net pens in the Great Lakes to evaluate the impacts on the public trust, environment and riparian interests of adjacent owners as required by Part 325 and associated administrative rules:

- Baseline physical characterization surveys, or plans for such surveys, such as geological and geophysical surveys to identify bottom type (such as mud, sand, silt, bedrock, or rock outcroppings), water depths or other relevant physical characteristics in the proposed area.

- Baseline biological surveys, or plans for such surveys, such as fish and wildlife monitoring studies, using side-scan sonar, sub-bottom profiler or other means as required by the department to characterize biological resources, including, but not limited to threatened and endangered species and associated habitat, benthic communities, and vegetation at the proposed area.

• Baseline archaeological surveys, or plans for such surveys, using side-scan sonar, sub-bottom profiler, magnetometer, ground penetrating radar or other means as required by the department to identify submerged cultural, historical, and archaeological sites, including abandoned property (shipwrecks) at the proposed area.

• Competing use surveys that identify the current uses in the vicinity of the proposed area and the location of the uses; such uses may include, but are not limited to, commercial, treaty and recreational fishing activity, water intakes or outfalls, utility lines, military uses, shipping lanes, ferry routes, recreational boating courses, designated refuges, bottomland preserves, and special management areas in the vicinity of the proposed area.

• Proposed area identified by GPS coordinates at the corners of the site.

Other information such as distance offshore, total area proposed for occupation, anchor types, lighting, etc. proposed for the project.

C. BOTTOMLANDS CONVEYANCE APPLICATION

A proposed net pen occupation of Great Lakes public trust bottomlands and waters would require a conveyance in the form of a private use agreement from the DEQ pursuant to Part 325. Additional information can be found here: http://www.michigan.gov/deq/0,4561,7-135-3313_3677_3702-10865--,00.html

An application can be found here: http://www.michigan.gov/documents/deq/wrd-bottomlands-eqp2713-fillable_448843_7.pdf

The conveyance application will also be placed on public notice for 20 days normally during the same time as the permit application. A conveyance would be approved if the permit application was approved and denied if the permit application is denied.
An annual lease fee will be required if the conveyance approved. The conveyance could be issued for up to 50 years with two terms of 25 years each or for shorter periods of time as applicable. The conveyance will include specific conditions to regulate the use and operation of the activity.

D. POINT OF CONTACT

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517 284-5561
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Charlie Simon

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313-226-6828
Charles.M.Simon@usace.army.mil

II. THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PROGRAM

The NPDES Program protects the surface waters of the state by assuring that discharges of domestic and industrial wastewater comply with state and federal regulations. NPDES permits are required under Section 402 of the Federal Clean Water Act and under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). The state rules pertaining to NPDES permitting are found in Part 21, Wastewater Discharge Permits. Authority to administer the program is delegated to the Michigan Department of Environmental Quality.

A. PERMIT APPLICATION PROCESS

Applicability

If a facility produces 20,000 pounds or more of cold-water species fish in a calendar year, it is required to obtain an NPDES permit. This permit is required before the 20,000 pound threshold is reached.
Application

Go to www.mi.gov/deqnpdes and then click on "How to Apply for an NPDES Permit." Select "Permit Application for Surface Water Discharge" for the application and a set in instructions located at "Permit Application Appendix."

Antidegradation Demonstration
An Antidegradation Demonstration is required for all new or increased loadings of pollutants to surface waters of the state. Go to www.mi.gov/deqnpdes , click on "How to Apply for an NPDES Permit," and then "Procedure 14 – Antidegradation.. The WRD is always willing to assist applicants in completing the Antidegradation Demonstration.

Processing Time

The DEQ must act on the permit within 180 days of receiving a complete application. The application will be placed on public notice for 30 days during which time the public can submit written comments. During the public comment period, interested parties can file a petition with the DEQ for a public hearing.

NPDES Application Steps

1. Receive application from permittee
2. Review application for completeness and accuracy
3. Request additional information as necessary
4. Develop technology-based effluent limits in accordance with federal requirements using application data and other sources
5. Develop water quality-based effluent limits using application data and other sources
6. Compare water quality-based effluent limits with technology-based effluent limits and choose the more stringent of the two as the effluent limits for the permit

7. Develop monitoring requirements for each pollutant and condition
8. Develop special conditions
9. Consider variances and other applicable regulations
10. Prepare the fact sheet, summarizing the principal facts and the significant factual legal, methodological and policy questions considered in preparing the draft permit including public notice of the draft permit, and other supporting documentation
11. Public notice announces the permit and interested parties may submit comments regarding the draft permit
12. Complete the review and issue the final permit , taking the public comments into consideration
13. Ensure permit requirements are implemented

An Issued Net Pen NPDES Permit

Attachment D is a NPDES permit issued by the State of Washington, Department of Ecology, to Icicle Acquisition Subsidiary, LCC for a net pen operation in Puget Sound. Attachment E is a document containing responses to comments on a draft NPDES permit for marine salmon net pens. Attachment F is a letter dated October 16, 2012 renewing this permit. An NPDES permit application for net pens in the Great Lakes may contain some similar permit conditions and comments from the public. Water quality-based effluent limits may be based on protections for sediment quality, as with the State of Washington Permit.

B. FEDERAL REQUIREMENTS

Net pen operations that produce at least 100,000 pounds of fish per year will be subject to the Concentrated Aquatic Animal Production (CAAP) Effluent Limit Guidelines (ELG). The best management practices contained within the guidelines will be incorporated into the NPDES permit as conditions.

For more information about the CAAP ELG, go to:
http://water.epa.gov/scitech/wastetech/guide/aquaculture/

C. POINT OF CONTACT
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END