Net-Pen Aquaculture in the Great Lakes

Michigan 4-H Youth Conservation Council

Kaitlyn Baljeu, Cheyenne Hewlett, Dan Christensen, Allison Melcher, Jerry Dunham, Megan Rylko, Emily Spranger, Peter Kurburski, Rachel LeFever, Ethan Rylko, and Kaitlynn Hammons.

Introduction

The mission of the 2016 Michigan 4-H Youth Conservation Council is to raise awareness of the effects net-pen aquaculture has on the environment and to educate the public on opposing views. The council recommends not implementing net-pen aquaculture, but includes suggested recommendations if legislation supporting the topic is introduced. These recommendations would serve to protect the environment, the people of Michigan, and the welfare of commercial industries.

Cheyenne Hewlett
Barry County
12 March 2016

Introduction to Aquaculture

Aquaculture, also known as fish farming, is the process of raising aquatic animals for the process of consumption. Many animals harvested through aquaculture include clams, shrimp and other shellfish, salmon, trout, yellow tail, cod, and many other fish species. There are multiple different types of aquaculture, such as net-pens, recirculating systems, hatcheries, and surface lines, just to name a few.

Net-pens are nets that are secured to the lake bed, generally close to shore. These nets can contain a large number of fish. Usually docks are built between the nets to allow workers to feed and test the fish. These nets only allow fish to swim in a small space. With these nets being secured, the waste and feces from the fish build up beneath the net. The moving tide of the water washes the waste away. Successful net-pen aquaculture critically depends on location. Pens near the shore are usually located in moderately shallow water with protection and access to shore. Most near-shore net-pens are square and anchored to the bottom. Because these areas are protected, difficulties with large waves and ice scour should occur less often than in offshore pens. If net-pens are used beyond a depth of 30 meters, circular plastic-collared pens can be used. Aquaculture can be conducted throughout the year, although greater efforts are required with regard to ice management. Near shore net pens are more easily monitored than offshore ones for disease, loss of fish, feeding rates, and environmental impacts. Large submersible cages are commonly used in offshore aquaculture and have been successfully deployed in marine systems with large waves and vessel traffic, but not in locations with significant ice conditions. Management of offshore cages requires boats to provide feed, clean cages, and monitor conditions. Monitoring and managing offshore cages add significant costs to aquaculture operations. However, offshore aquaculture minimizes sedimentation impacts on the bottom because the material from cages would be dispersed or decompose before accumulating on the lake floor.

Both Aquaculture and Mariculture are related to cultivating aquatic products under controlled conditions. While aquaculture typically relates to freshwater, mariculture is identified with saltwater.

Aquaculture is farming of both saltwater and freshwater organisms like finned fish, crustaceans and aquatic plants. Mariculture, on the other hand is preformed in marine environments. It involves cultivation of marine organisms in the open ocean or in an enclosed section of the ocean or ponds, tanks filled with seawater. Some of the fish that are produced in aquaculture are bluegill, catfish, salmon, tilapia, trout, and oysters. Some of the mariculture products include grouper, sea bass, snapper. The environmental impact for both aquaculture and mariculture have almost the same adverse effects.

Aquaculture is an industry known around the world and has been proven in many different types of ecosystems. No two ecosystems are alike and finding what works best is critical for the healthy survival of the fish and habitat around the net-pen. Before starting an aquaculture system, you should have a background on knowledge of what aquaculture is and what type of system would work. Knowing the type of the area where you want to place an aquaculture system is ideal for producing a healthy product to harvest and sell.

Rachel LeFever
Arenac County
23 February 2016

Aquaculture and Its Politics

Currently the debate is whether or not aquaculture should be allowed in the Great Lakes, specifically net-pen aquaculture. Bills have been made, such as the Jones Bill and the 2016 House Bill 5255 on the topic. Some regulations do exist for the net-pens in the Great Lakes which can be found in all different kinds of acts.

In order to begin and run a net-pen, or any other form of aquaculture, you must have permits. There are five regulatory requirements that would address the activity of commercial net-pen aquaculture in the Great Lakes. Three are housed within the Michigan Department of Environmental Quality (MDEQ) for construction, bottomland conveyance, and water quality; on in the Michigan Department of Natural Resources (MDNR) for fish stocking; and one in the Michigan Department of Agriculture and Rural Development (MDARD) for registration ("QOL Commercial Aquaculture Team"). Basically, if one were to start aquaculture in the Great Lakes they must have possession of five permits. "Many areas of the United States are suitable for aquaculture, but are not subject to land-use or water-use management policies that do not adequately consider the potential for aquaculture and may inhibit the development of aquaculture" (National Aquaculture Act of 1980). Just because the areas are suitable does not mean we should use them for net-pens, but possibly for other forms of aquaculture.

There have been many bills presented to the Senate about this topic. Senator Rick Jones, for example presented the Jones Bill. According to his website, Senator Rick Jones thinks "…commercial fish farms in the Great Lakes are all risk and no reward. These are proven sources of pollution, invasive species, disease, and fugitive fish escaping to wreak havoc on our Great Lakes fisheries. Caged fish culture was developed to produce thousands of fish with the purpose to sell as food. These factory fish farms are floating nets placed in waterways and are huge threats to the existing ecosystem." Jones Bill was presented to ban aquaculture in our Great Lakes. Another bill presented to the Senate was the 2016 House Bill 5255. This bill was brought before the Senate by Rep. Jon

Bumstead on January 26, 2016, to ban the fish farms from the Great Lakes and all of its connecting waters ("2016 House Bill 5255")

Now, there are groups and people who support the net-pens in the Great Lakes such as the Michigan Sea Grant (MSG). "Michigan Sea Grant and NOAA support expansion of safe and sustainable aquaculture as a means to feed the world's growing population and help create a more diverse economy for coastal communities." In the final report, the MSG said that net-pen/cage systems would be one of the three best systems for the Great Lakes. "Economy of scale is expected to drive RAS and cage culture as preferred primary production systems." District 35 State Senator Darwin Booher supports the aquaculture in the Great Lakes by saying, "The U.S. currently imports 90 percent of the seafood Americans consume, given the interest consumers have in buying locally grown, fresh and healthy foods, there is a real opportunity for Michigan to responsibly use its land and water resources to produce seafood." Senator Booher is currently pro aquaculture. Senate Bills 681-683 would make reforms to the permitting and application processes of aquaculture and would allow for net-pen aquaculture operations in Michigan.

People are talking about having net-pen aquaculture in the Great Lakes. Whether is the bills passed in favor of or those opposed. Even some Senators, such as Rick Jones and Darwin Booher have put in their opinions. Aquaculture is a hot topic in the Mitten State with everyone.

Ophelia Huerta

Kent County

12 March 2016

Michigan Net-Pen Licensing, Landfills, Rules and Regulations, and Managing

There are strict permits and licensing that go into starting and opening a commercial or small fish farm. Around six different licenses are needed for starting or opening a fish farm in Michigan. The first are the state and federal licenses: the Construction Permit, Bottomland Conveyance, National Pollutant Discharge Elimination System (NPDES) Permit, Fish Stocking Permit, 2000 Consent Decree, and the Registration and Aquaculture Facility. For the Construction Permit, the Michigan Department of Environmental Quality (MDEQ) and United States Army Corps of Engineers (USACE) joint permit was used. The Bottomland Conveyance uses the MDEQ Permit. In the case of the NPDES permit, they use the MDEQ permit as well. The rest of the necessary state and federal licenses also continue into Fish Stocking Permit in which the MDNR permit is used. 2000 Consent Decree is the combination of the MDNR, United States Fish and Wildlife Service (USFWS), and 5 tribal nations was used. Last the Registration and Aquaculture Facility Michigan Department of Agriculture and Rural Development (MDARD) is used as the permit. For licensing, there is also the Binational Agreements which are the Great Lakes Water Quality Agreement, the Great Lakes Commission, and the Great Lakes Fishery Commission: Joint Strategic Plan for Fisheries Management.

Fish farms have multiple different wastes that are produced, and there are different ways to dispose of these wastes. Different forms of waste include, dissolved waste, pathogenic waste, metabolic waste, and chemical waste. NPDES permits are for the regulation and safety of the water as well as the disposal of nonconventional pollutants, conventional pollutants, and with a small percent of toxic pollutants. Effluent limitations guidelines need management practices and record keeping to control pollutants in the water from these net-pens. This rule is enforced in the NPDES permit. Waste can be removed through raceway and tank design, transformation, filtration, radiation / ozone, settling basins, recirculating systems, and more. All of these ways of disposal are tested and used on other farms. However, some farms use landfills to dispose of their waste.

When managing a fish farm, detailed records need to be kept. The extensiveness of the data depends on the size of the farm, the interest the farmer has in the farm, and the education of the farmer. T he farmer must take neat, precise notes in order to see the average fish production or the annual price income. The farmer needs to make sure the amount of pounds of fish produced is equivalent to the amount of feed used. Detailed records should be taken to lower the risks of anything affecting the animals and the people in the area. They need to evaluate a potential farm site to see if the environmental conditions are right for the species that will be raised there. Sites with good water exchange are not depositional environments.

Rules and regulations are needed to keep our society as it currently is. These guidelines have been made and implemented to prevent any harm from coming to the plant life and the water quality in any way. Some of the regulations of net-pens specifies that they cannot be within 1500 feet of a special animal habitat. Fisheries will be held responsible if anything is to happen to a special species. No feed that is non-pelleted can be used to feed in net-pens. There is a maximum fish production rate depending on the farm and the size of fish it can hold. The rules listed can not interfere with the rules from the document section 134.020.

Kaitlyn Baljeu
Van Buren County
12 March 2016

Net-Pen Operations

In order to maintain a healthy net pen, there are a lot of precautions that are needed to be taken. A healthy pen makes for healthy fish.

Net-pens require a sufficient amount of water flow through current in waves. The churning and constant movement of water will allow for waste materials and excess feed to be washed away and prevent accumulation directly underneath the pens. Without the riddance of by-product, water quality will degrade and the susceptibility for disease increases.

Each pen should be built with specific features to ensure safety of the livestock and wildlife fish species in the surrounding area. Farming in setups such as net pens only allow for the raising of larger scale breeds. Small fish would be able to escape through the holes in the netting. Therefore, smaller types would need to be grown in inland settings. Large scale escapes occur when extreme conditions cause catastrophic failures of the pens. Every pen must be built in order to withstand rare extreme events such as large waves with short wavelength, ice scouring, and collision with floating ice and other debris. The tops of pens should be covered in such a way to reduce the risk of predation. One specific type of bird that tends to feast on our tasty are the cormorants.

If a fish were to potentially escape, the genetic pool of the wildlife species around the pen could become altered if they were to start breeding. Fish net pens should be stocked with triploids or other infertile fish. However, this will only work with salmonids (ex. salmon and rainbow trout) and are not available for walleye, lake whitefish, or lake trout.

Having a high concentration of fish in a single pen along with keeping poor management can increase stress, thus increasing disease or parasites within the pen. The potential risk of spreading diseases or pathogens to outside populations is also amplified. Therefore, it is critical to closely monitor what is happening inside each pen. Culture observations include determination of appropriate feeding levels- based upon percentage of body weight to be increased per day- and assessment of

mortality rates. Overfeeding can be assessed visually, setting up sediment traps beneath the cages, and even underwater video cameras placed in the operations themselves.

Many diseases naturally occur in the Great Lakes and it is important to be educated and keep the fish vaccinated. Not all diseases create problems for the wild population and commercial fish alike. Infection with a pathogen is not always expressed as mortality, morbidity or other signs of the clinical disease. Fish can by carrying a pathogen, but show absolutely no signs of being ill. Early on, these pathogens begin to replicate within the host. Under certain conditions, a fish may not be affected at all by the disease, like if a fish is recovering from a natural infection or has been immunized. For example, the Koi Herpevirus will be shed from the fish's body if they become stressed out. Unless the mortality rate is noticeably high, it is often difficult to tell which disease or pathogen occurs in wild fish populations. Because fish are highly concentrated in an aquaculture facility, specifically net-pens, an outbreak of a disease can amplify quickly with frequent recognizable increases in mortality, morbidity, and reduced growth or production.

Appropriate biosecurity need to take place on any fish farm. Specific measures need to be taken to prevent disease introduction in the first place. There need to be specific plans on what to do in the case of a disease outbreak and how to maintain and control that problem. Vaccinations can help prevent, or at least minimize, any diseases or pathogens from being spread.

Emily Spranger
Saginaw County
4 April 2016

Aquaculture in the Great Lakes

Aquaculture is a growing industry in the Great Lakes, mainly because of Canada. Canada has used the Great Lakes as sites for their net-pens for many years. It is now considered one of their main contributors to the economy. It is essential to the economy because it provides many jobs for people to support their families.

If we allow net-pens in the Great Lakes, we could create many job openings for people. When we look at Canada, where they have been using net-pens in Lake Huron and Georgia Bay, they have supplied many jobs for their citizens. They have about 16,000 jobs and a majority of their employees are under 35 ("Economic Benefits"). There are many different types of jobs, including fish farm technician, instructor, habitat biologist, aquaculture diver, and many more. Education could be implemented at aquaculture facilities, where they teach the general public about aquaculture and how it works. Some colleges and universities may be able to teach courses, or develop research ("Economic Benefits"). Education of the people can create more interest and potentially more workers.

Aquaculture in Canada has been producing a lot fish and money since 1986 and every year it continues to grow. In 1986, they made $35 million and in 2006 it was estimated they made $912 million ("Economic Benefits"). There will be a higher demand within the next few decades for fish because it is a popular source of protein and many countries support it for food. Dan Vogler, who owns a fish farm in Michigan, stated in an article, " It is our best interest to start supplying the U.S. with fish, since we have the resources." On that same article the author states that we have about twenty percent of the world's freshwater ("Great Lakes").

However, although net-pens could create many jobs; many citizens of Michigan are concerned about the risks that come with net-pens. The main issue is that the fish may carry disease or an illness and may widely affect all of the native species in the Great Lakes. It may also spread from one lake to another to pose a major problem. Another factor that people are concerned about is that with so many fish in one place, together their feces may cause an outbreak and may not be transported throughout the area continuously like in small streams or rivers ("GLEAM"). The public needs to be educated to make sure they also know the values of aquaculture but also the consequences if anything goes wrong. There would need to be regulations to prevent potential problems. Net-pens will benefit the Great Lakes even if there are risks.

Trip Dunham
Leelanau County
11 March 2016

Canada's Aquaculture Laws

Canada is using freshwater water aquaculture in the Lake Huron. They have been doing this for more than twenty years. They have many laws and equations in place to protect the Great Lake and the environment. In 1985, Canada passed the Fisheries Act that paved the way for fishes in the Great Lakes and other places around Canada. They point in regulation to reduce the amount of harm aquacultures cause to the environment. The Department of Fisheries and Oceans Canada (DFO) was created to ensure healthy aquatic ecosystems and to conserve and protect wild fish and fish habitat. Canada has put in place many regulations to make sure the Great Lakes won't be negatively affected by aquaculture.

Canada defines aquaculture as "growing and cultivation of aquatic plants… or fish, for commercial purposes, in any water environment or in human made containers of water, and includes the growing and cultivation of shellfish on, in or under the foreshore or in water." Both the federal and provincial governments have the power to issue aquaculture licenses. In the Great Lakes, you must receive a federal license if it is offshore. The DFO either grants these licenses or not based on the potential impact they could have on wild fish, commercial and recreational fisheries, aboriginal fisheries, and fish habitat.

Canadian Environmental Assessment Act (CEAA) is the basis for the federal practice of environmental assessment. It lays out what must be considered during the screening of a project . It looks at the environmental effect which is defined as "any change that the project may cause in the environment, including any effect of any such change on health and socio-economic conditions, on physical and cultural heritage, on the current use of lands and resources for traditional purposes by aboriginal persons, or on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance; and any change to the project that may be caused by the environment, whether any such change occurs within or outside Canada". Environment Canada, Health Canada,

Canadian Heritage, Department of Indian Affairs and Northern Development may be assist DFO in the environmental assessment.

National Code on Introductions and Transfers of Aquatic Organisms(the “Code”) regulates the movement of fish in Canada. The “Code” looks at the induction and transferring of aquatic species in aquaculture. The “Code” looks at the risk of the aquatic environment and how it could affect the native species in that area. The “Code” also looks at the risk of diseases that could be spread to the native population. Fish Health Protection Regulations (FHPR) also regulate fish movement. The FHPR looks at the ways to minimize the spread of diseases to the wild population of fish. Aquaculture sites must have four inspections every eighteen months to retain their fish health certificate. If drugs are used in aquaculture they must meet Food and Drug Act requirements.

Canadian Food Inspection Agency under the Feed Act regulates the livestock feed produced and sold in Canada. They make sure that standards for safety and usefulness is meet for the feed. Fish Inspection Act makes sure all fish is traded is harvested, transported and processed under condition that meet international standards.

Peter Kurburski
Emmet County
27 February 2016

Other Countries with Net-Pens

There are many different net-pens that are operating around the world that show both the benefits and disadvantages. There are net-pens in Norway and Uganda that have been producing an economical income. They have also lowered the fish endangerment list by not commercial fishing. They have been able to create stable and efficient farming practices. They have learned how to create the least environmental impact while producing tons of fish every year. Rwanda also used to have net-pen operations but soon failed because of bad management.

Norway has produced 1.24 million metric tons of fish last year. They put regulations on the amount and kind of food the fish are given and the amount of escapes. They also research the damage of the chemicals that are used and limits are out on the type and amount that each company can use. Norway also looks at what kinds of fish is being stocked and the potential diseases that could infest the fish. Recent tests on the amount of waste produced have shown most operations have little impact on the environment. If there is a big problem, there are efficient ways to solve the issue quickly. Norway has been able to put in 1.2 tons of food to get out 1 ton of salmon (Bridson). With fish they are able to put less food in to get out a pound of fish better than they have been able to get a pound of beef. They have been able to grow large amount of fish food that feeds millions a year because they can hold tons of fish in these net-pens.

Net-pens have been used in Uganda for fourteen years. Recent studies show that their aquaculture has given jobs to more than 300,000 people (Lewis). They have given out over 750 permits to put net-pens in 164 minor and major lakes. They produce mostly African catfish because they tend to grow the biggest the fastest. In a period of eight months, they can grow from 500 grams to 1000 grams. In 2005, they had 10,000 tons of fish produced. Today Uganda produced around 95,000 tons of fish produced per year (Lewis).

In Rwanda, they have had some problems with aquaculture. Rwanda is covered by only 8% water. They have very rich water resources but they don't utilize the full potential of them because of the terrible management and organization of the sector (Lewis). Only 10% of their water resources are being utilized today to produce fish for income. They don’t have the right amount of education.

Kaitlynn Hammons
Eaton County
16 April 2016

Biological and Ecological Effects of Net-pen Aquaculture Operations in the Great Lakes

The Great Lakes are an incredible resource, housing one fifth of the world's freshwater as well as a multitude of diverse ecosystems and species. A resource such as this must be used, but it is essential that it is used wisely, maintaining such a treasure for future generations and the world.

Net-pen operations seek to use this resource, posing substantial threats to the ecosystems of the Great Lakes. One of the most well-known of these issues is the large amounts of effluent that these operations release. According to measurements by Swedish scientists in 1983 at several land-based farms (as the effluent for net-pens is not contained, it is extremely difficult to measure), the yearly oxygen demand and nutrient release per ton of rainbow trout produced at a Danish pond farm was reported to be 300 kg (Biochemical Oxygen Demand)5/t/y, and 10 kg Total-Phosphorus/t/y and 81 kg Total-Nitrogen/t/y (Barg, 1995). True, with copious fish in the Great Lakes, there are substantial quantities of effluent antecedently; however, a sizable quantity of fish in an enclosed area can create a substantial aggregation of effluent. The speed of this accumulation, however, is affected by many variables (lake bed type, currents, weather, etc.), and therefore is extremely difficult to estimate for a given area. Although the level and range of effect may be difficult to project, some effects are foreseeable. Benthic fauna, various plants found living in or on the lakebed, are often used as an indicator in studies on the effects of aquaculture, as they are relatively stable(Barg, 1995)(Nash, 2001). Organic enrichment of the soil could result in a lowered biodiversity, decrease in species size, genetic drift among species, and even the disappearance of macrofauna in the affected area. Such changes would drastically alter the surrounding ecosystems.

As a whole, net-pen operations pose a much bigger threat in the Great Lakes than they do on the oceanic coast, due to the lack of tides to disperse effluent and simply because freshwater is a more hospitable environment, both to eukaryotes and pathogens. In 1987, a Taiwan prawn aquaculture company produced 80,000 mt of Penaeus monodon. A year later, the industry collapsed to 20,000 mt because of an onslaught of virulent diseases. Research has found that this was likely caused by

ecosystem mismanagement resulting from poor farming management and the Monodon baculovirus, a viral disease that was partially responsible for the shrimp farming collapse. Polluted water was also released in the area, further damaging the aquaculture, but the movement of the disease spread quickly, dispersing from one farm to the next, the high concentrations of shrimp a breeding ground for the virus.

Another highly discussed issue surrounding net-pen operations is the risk of escaped fish. As net-pens are an open water method of aquaculture, there will be some escapees. However, with proper precautions, this issue is not as detrimental as other issues. On average, the amount of unexplained fish escapes from individual net pens range ±2-5% (Nash, 2001), which, although these numbers can add up, the effects of these escapees on natives are minimal. In a study over Atlantic salmon on the Atlantic coast, results showed that wild salmon were twice as likely to survive as the non-native, farmed salmon, and that although the farmed female salmon laid more pockets (nine versus an average of two) they laid fewer eggs (459 compared with an average 707) (Nash, 2001).

Despite the numerous variables that are in effect on the biological and ecological effects of large scale net pen aquaculture, there are several things that can be done to improve these issues; such as careful site selection to reduce effluent accumulation based on variables like lake bed composition and topography, current ecosystems, depth and exposure to weather. However, that effluent, although distributed, nonetheless accumulates, and will lead to long-term issues if not managed and restricted properly. Even with extensive management, the environmental effects of large scale net-pen operations would be clear, due to genetic drift, lowered biodiversity, and a decrease in size of benthic fauna; the effects then spreading throughout the ecosystem. Damage due to escaped farmed fish is relatively small, as farmed fish have a lowered fitness, but the effects could be all but eliminated by restricting net-pens in the Great Lakes to infertile or triploid stock. Comprehensively, the negative biological and ecological effects of net-pen operations in the Great Lakes are substantial, and although a mark of a strong entrepreneur is the willingness to make risks, no matter how well net pen operations are regulated, there will be mistakes. In this case, the mistakes can decimate whole ecosystems, risking the destruction of that which Michigan is known for: The Great Lakes State.

Dan Christensen

Kalamazoo County

12 March 2016

Water Quality

In the discussion of net-pens in the Great Lakes, one of the biggest issues is water quality. With Michigan's great desire to keep the waters of the Great Lakes healthy and clean for all individuals, a conflict in allowing net-pens arises. Cleanliness is threatened because of the large number of fish, food, and waste in a small area. In addition to the threat of how clean the water is, the health of natural habitat for fish and other aquatic life must be protected. Most concerning is the possibility of causing a toxic algal bloom due to an increase in phosphorus levels.

Toxic algal blooms cause dissolved oxygen levels in water to drop. Once the level of dissolved oxygen drops far enough, fish begin to suffocate. The Great Lakes fishery currently brings in approximately seven billion dollars annually. (Bittel 2013) The Great Lakes are also an important source of drinking water for many people and cities. The impact of toxic algae has been recently seen when it shut down the water supply of the city of Toledo. While this was not caused by net-pens, it demonstrates what could possibly happen if excess phosphorus is introduced to the Great Lakes. This introduction of phosphorus would come from fish waste and excess food that the fish do not eat. Algae blooms also make water unsafe to swim in for the young or elderly. Even with all of these potential problems, there are already some net-pen operations already operating in the Great Lakes.

In Georgian Bay in Lake Huron there are several net pens in use today. In a study conducted in 1999 it was found that "In 1998, there was an estimated production of 3,000 tons of rainbow trout in Georgian Bay (Lake Huron) which would have contributed an estimated 15 tons of phosphorus to Lake Huron that year". (Water 1999) With this information, it would seem that for every two hundred tons of fish grown, one ton of phosphorus is created. With this much fish produced compared to so little phosphorus, it would seem that a few net-pens would not hurt anything. However, one must look closer at the active net-pens to see why they are having such success. This amount of phosphorus is acceptable in Georgian Bay because of natural water flow that carries out excess food and flushes

away the fish waste. This same flushing action is achieved in marine aquaculture by underwater tides going in and out.

Underwater tides play a pivotal role in marine aquaculture as they take away and spread fish waste and extra food over a wide area, thus preventing a large amount of phosphorus to accumulate in a small area. While the Great Lakes have a tide, it is so small that without fine-tuned equipment, it would be unnoticeable. And, without tides to spread potentially dangerous fish waste, a lot of phosphorus can accumulate very quickly. In absence of a significant tide in the Great Lakes, the best place for a net-pen is near the mouth of a river so a flushing effect can be achieved. Yet, accomplishing this would put natural fish at a higher risk to pick up diseases and parasites. Because there is nothing to take the fish waste away in the Great Lakes, the quality of water in and around net-pens would deteriorate and the potential for a toxic algal bloom would increase exponentially.

Another issue in Great Lakes aquaculture is accessibility in the winter. When winter rolls around in Michigan a layer of snow and ice is to be expected. This causes a problem for net pens as ice can damage can damage the pens and rip holes that fish can escape through. Along with the danger of damaging the net-pens, the ice and snow also make it more difficult to access the net-pens especially if they are in deep water. When this happens in some cases fish that have died in the pens are left because it is not possible to get them out. If a fish has died of disease and is left in a large captive population, the disease will likely be able spread quickly from fish to fish. This also makes it more likely for disease to spread to the wild population and the dead fish add to the levels of phosphorus in the lake.

Aquaculture is a wonderful resource when used properly in proper places. While it has the potential to bring great economic benefit to the state, it also has the potential to destroy the delicate ecosystem that is present in the Great Lakes. If aquaculture is to be allowed in the Great Lakes, then there needs to be stringent rules in place so that the next generation can still have the same wonderful time at that lakes that we have been privileged to have for so many years.

Ethan Rylko
Oakland County
30 Mar. 2016

Aquaculture – Economics – Commercial Uses and Imports

Aquaculture is an opportunity to grow the economy through the production of seafood. It could be more beneficial to raise our own fish rather than importing from foreign countries, as it is a steady food source. However, there are more uses for aquaculture than to create food. This paper will explore the economic positives of the possible commercial uses, and the negatives of relying on imports.

There are many commercial uses for aquaculture. One use is the farming of fish to restore populations. In a net-pen, endangered fish can be bred and released into the wild to increase the population of the species. Fish like the Great Lakes Sturgeon and other endangered species could repopulate in net-pens and be released into the Great Lakes. The benefits of this process include the re-balancing of the ecosystem and enhancing sport fishing areas.

Another commercial use for the net-pens is to create opportunities for community-based management and education. These opportunities will allow people to become involved with aquaculture and learn about its benefits. This will allow the general public to understand fish better. A better understanding of aquaculture can also increase business and food supply.

Finally, some people support aquaculture in the Great Lakes because it is an economical benefit. In 2011, 16 billion dollars of farmed fish was imported to the United States. On the other hand, less than 6 billion dollars worth of farmed fish was produced in the United States. Allowing more aquaculture operations would be a huge boost to the economy. The United States may be able to produce enough fish to equal or even surpass the amount lost to importing fish from other countries. However, the effects these net-pens have on the environment would not be good.

In conclusion, it is possible to allow aquaculture in the Great Lakes for more reasons than food production. To allow net-pen aquaculture would provide lots of opportunities for community-based management and education as well as an efficient way to restore populations of endangered species. However, it is best to remember that, despite the economic benefits, the ecosystem will be hurt.

Megan Rylko
Oakland County
26 February 2016

Economical Benefits of Net-Pen Aquaculture

Net-pen aquaculture could help to significantly boost Michigan's economy if implemented correctly; however, it is important for one to be informed about the finances of the industry as a whole before creating legislation. Net-pen aquaculture costs less and is more economically efficient than the Recirculating Aquaculture System (RAS).

To begin, the cost to start a net-pen is less than the cost of starting a Recirculating Aquaculture System. In one Norwegian study, an RAS and a net-pen were built for comparison. About 32 million US dollars were spent on the RAS and about 12.3 million US dollars were spent on the net-pen. (Rosten) Additionally, the RAS operated in only one site while the net-pen operated in two. (Rosten) A Canadian study also found net-pens cost significantly less to build than other systems. The cost to build a net-pen was $5,000,716 while the flow-through systems ranged from 23 to 29 million dollars, the land-based systems ranged from 18 to 72 million dollars, and the RAS was $22,622,885. (Feasibility) In both the Canadian and Norwegian studies, building a net-pen has been shown to cost less than building a recirculating, flow-through, or land-based system.

Next, the profit of a net-pen operation is greater than a Recirculating Aquaculture System operation. In the Norwegian study, the RAS made 18.68 million US dollars while the net-pen made 18.67 million US dollars (Rosten). This is rather impressive considering the net-pen cost $19.7 million dollars less to build than the RAS. The operation costs of the net-pen and RAS were $13.99 million and $13.13 million respectively, so their final profits were $4.68 million and $5.55 million (Rosten). Overall, both farms made roughly the same amount of money, but the net-pen did so for a much smaller initial investment. The Ontario study shows results in favor of the net-pen as well. The researchers took data from the different aquaculture systems' incomes from their third year of operation, and the results are startling. Only the RAS and the net-pen made a profit, while the other systems ranged from about 250 thousand to 17.4 million dollars in debt ("Feasibility Study of Closed-Containment Options for the British Columbia Aquaculture Industry"). Both the net-pen and RAS sold

enough fish to make $10,478,750; however, after the operation costs the net-pen earned $2,641,147 while the RAS gained only $381,467 ("Feasibility Study of Closed-Containment Options for the British Columbia Aquaculture Industry"). Overall, net-pen aquaculture yields a greater profit than other forms of aquaculture.

In Michigan, net-pen aquaculture is an economically beneficial alternative to the RAS. In two separate studies, net-pens have cost less than the RAS and other forms of aquaculture. In addition, the net-pens yielded an equal or higher profit than a RAS. Net-pen aquaculture has a solid economic backing and could lead to a bright future for Michigan; however, the decision to implement this type of legislation should not be decided on economics alone. It is important to see both sides of the argument and how net-pen aquaculture can affect the environment before coming to a final verdict.

Allison Melcher

Washtenaw County

11 March 2016

Negative Economic Impacts of Net-Pen Aquaculture

Although net-pen aquaculture may at first seem good for the economy due to its low start up costs, the true cost of net-pen aquaculture has the potential to be disastrous for the economy. Tourism, property values, commercial fisheries, recreational fishing, boating, beaches, and even drinking water supplies could sustain substantial damage and economic costs due to net-pen aquaculture.

Drinking water supply is the economic issue that matters most because it is a public health issue. Clean drinking water is essential to everyday life. Net-pen aquaculture pollutes the water supply both directly and indirectly. Net-pens can directly pollute the water supply with the metals and chemicals used to treat fish disease and maintain equipment. (Anderson 2015) They can also indirectly pollute the water supply by causing toxic algal blooms. The phosphorous and nitrogen present in fish food can lead to dangerous toxic algae blooms. In 1978, amendments to the Great Lakes Water Quality Agreement set target loads for the amount of phosphorous allowed in the Great Lakes. (Anderson 2015) These loads are generally regulated by controlling point-source pollution. That approach worked until the late 1990's when dreissenid mussels invaded. These mussels complicate the issue by feeding on desirable phytoplankton and rejecting undesirable bacteria that contribute to harmful algal blooms. (Anderson 2015) Containing or removing the waste from the lake floor beneath and around the net-pens is very costly and nearly impossible, so it is usually not done. Treating water that has been contaminated with toxic algae, metal, or fish medicine, is also very costly in both terms of money and potentially human lives.

In 2014, tourists spent over $20 billion dollars and created an economic impact of about $37 billion dollars. (Lupi 2015) It is safe to say that tourism is a large and important industry in Michigan. Many of these tourists come here to enjoy our natural resources. Tourists come to fish, boat, bird watch, and relax on the beaches, all of which could be damaged by net-pen aquaculture, leading to reduction in profit from tourism. The Great Lakes contain many sensitive habitats such as bird

sanctuaries and fish spawning grounds. The nutrients being deposited by the net-pens and the increase in boat and vehicle traffic due to net-pen operations could affect these sensitive habitats leading to less fish available for recreational fishing and loss of birds for bird watching. Disease outbreak from the net-pen fish is also a major threat to native fish and recreational fishing. Net-pen aquaculture is also unsightly, and depending on its location, could disrupt scenic views. While some of the issues affecting tourism could be solved with correct placement of net-pen aquaculture, there is still the distinct possibility of reduction of tourism revenue.

Existing commercial fisheries could see a loss of profits due to competition from net-pen aquaculture, and due to pollution and disease outbreak. The Great Lakes support commercial fisheries for tribal fishermen and state-licensed commercial fishermen. According to the DNR, state-licensed and tribal commercial fisheries in Michigan's great lakes harvested about 8.8 million pounds of fish, with value of just over $14 million, in 2013 (Lupi 2015). Commercial fishing is a vital part of Michigan's economy. It is hard to predict the extent of damage net-pen aquaculture could cause, but pollution and disease outbreak could damage the native fish population and reduce profits of commercial fisheries.

Home owners may see a reduction in property values caused by net-pens. One way net-pens could affect property values is through contamination of water supply as I discussed in my first paragraph and through disruption of scenic views as I mentioned in my second paragraph. Property values could also decrease due to noise and smell from net-pen operations. Waterfront property is generally expensive, and homeowners (voters) would not be happy to see their property value go down.

I would recommend that net-pen aquaculture not be allowed in the Great Lakes. If it is to be allowed, I recommend that net-pen operations are located in areas that minimize impacts on sensitive environments and species, follow a rigorous biosecurity program, only use native fish species, and have regular and thorough inspections to ensure compliance.

Conclusion

To conclude, the 2016 Michigan 4-H Youth Conservation Council recommends using triploid fish, regulating antibiotics, using native or naturalized fish species, restricting possible locations to protect wildlife, using food pellets, and adopting policies from Canada if legislation supporting net-pen aquaculture is passed. These restrictions and regulations would protect the population of Michigan, the environment, and commercial industries.

Works Cited

Anderson, Eric J., John M. Dettmers, James S. Diana, Keith McCormack, James A. Morris, A. David Scarf, Craig Stow, and Roy A. Stein. "Great Lakes Net-Pen Commercial Aquaculture: A Short Summary of the Science." (2015). *Michigan.gov*. Web. 8 Mar. 2016.

Lupi, Frank. "Overview of Natural Resource Values Potentially at Risk from Consequences of Net - Pen Aquaculture." *Overview of Natural Resource Values Potentially at Risk from Consequences of Net-Pen Aquaculture* (2015): n. pag. 16 Oct. 2015. Web. 8 Mar. 2016.

Bittel, Jason. "Great Lakes and $7 Billion Fish Industry Threatened by Invasive Species." *Alternet.* On Earth Magazine, 06 Nov. 2013. Web. 12 Mar. 2016.

"Water Quality Concerns from Large-Scale Aquaculture." *Water Quality Concerns from Large-Scale Aquaculture.* Aug. 1999. Web. 12 Mar. 2016.

"Feasibility Study of Closed-Containment Options for the British Columbia Aquaculture Industry." *Government of Canada, Fisheries and Oceans Canada, Communications Branch*. N.p., n.d. Web. 26 Feb. 2016.

Rosten, Trond W., Kristian Henriksen, Erik Skontorp Hognes, Brian Vinci, and Steven Summerfelt. "Land Based RAS and Open Pen Salmon Aquaculture: Comparative Economic and Environmental Assessment." *Land Based RAS and Open Pen Salmon Aquaculture: Comparative Economic and Environmental Assessment* (n.d.): n. pag. Web. 26 Feb. 2016.

"FAO Fisheries & Aquaculture Canada." FAO Fisheries & Aquaculture Canada. N.p., n.d. Web.

11 Mar. 2016.

"Fisheries Act (R.S.C., 1985, C. F-14)." Legislative Services Branch. N.p., n.d. Web. 11 Mar 2016.

"Could Great Lakes Fisheries Be Revived Through Fish Farms?" NPR. NPR. Web. 04 Feb. 2016. <http://www.npr.org/sections/thesalt/2014/09/08/346874331/could-great-lakes-fisheries-be-revived-through-fish-farms>.

"Economic Benefits: Aquaculture in Canada: Canadian Aquaculture Industry Alliance." Economic Benefits: Aquaculture in Canada: Canadian Aquaculture Industry Alliance. Web. 25 Jan. 2016. <http://www.aquaculture.ca/files/economic-benefits.php>.

"GLEAM." Aquaculture. Web. 24 Jan. 2016. <http://www.greatlakesmapping.org/great_lake_stressors/3/

"Aquaculture." umich.edu. N.p., n.d. Web. 9 Apr. 2016.

Michigan State Republicans. "Jones Introduces Bill Banning Fish Farming in the Great Lakes." www.senatorrickjones.com. Michigan Senate Republicans, 29 Sept. 2015. Web. 9 Apr. 2016.

QOL Commercial Aquaculture Team. *A Regulatory Analysis of PROPOSED COMMERCIAL NET PEN AQUACULTURE in the Great Lakes.* N.p.: QOL Commercial Aquaculture Team, Oct. 2015. PDF.

"2016 House Bill 5255: Ban Great Lakes Aquaculture." -Michigan Votes. Mackinac Center for Public Policy. Web. 09 Apr. 2016. <https://www.michiganvotes.org/2016-HB-5255>.

Fishsta, Source: Fao. "World Production of Aquaculture." *World Production of Aquaculture World Consumption of Seafood* (n.d.): n. pag. National Oceanic and Atmospheric Administration. Web. 25 Feb. 2016.

Leber, Ken. *Alternative Uses of Aquaculture: Replenishing Depleted Fisheries* (n.d.): n. pag. Science Consortium For Ocean Replenishment. Web. 25 Feb. 2016.

Bridson, Peter. "Seafood Watch." (n.d.): n. pag. 31 Mar. 2014. Web.

Lewis, A.g., and Anna Metaxas. "Non Sustainable Aqua Culture." Aquaculture 99.3-4 (1991) 269-76. Web.

Barg, U. C. Guidelines for the Promotion of Environmental Management of Coastal Aquaculture Development. Tech. no. 328. Rome: Fisheries and Aquaculture Department, 1992. FAO Corporate Document Repository. Web. 12 Apr. 2016.

Nash, C.E. (editor). 2001. The net-pen salmon farming Industry in the Pacific Northwest. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-49, 125 p.

"Difference Between Aquaculture and Mariculture." *Difference Between*. N.p., 27 Oct. 2009. Web. 23 Feb. 2016.

"Economic Benefits: Aquaculture in Canada: Canadian Aquaculture Industry Alliance." *Economic Benefits: Aquaculture in Canada: Canadian Aquaculture Industry Alliance*. N.p., n.d. Web. 21 Jan. 2016.

"Types of Aquaculture." *Types of Aquaculture*. N.p., n.d. Web. 22 Feb. 2016.

"What Is Aquaculture?" *:: Office of Aquaculture*. N.p., n.d. Web. 22 Feb. 2016.

Miller, Dan, and Ken Semmens. "Waste Management in Aquaculture." *Aquaculture Information Series*. West Virginia University, Jan. 2002. Web.

"Final Report: Recommended Interim Guidelines for the Management of Salmon Net-Pen Culture in Puget Sound." Science Applications International Corporation, 30 Dec. 1986. Web.

"National Pollutant Discharge Elimination System (NPDES)." *EPA United States Environmental Protection Agency*. N.p., 11 Apr. 2016. Web.

QOL Commercial Aquaculture Team. "A Regulatory Analysis of Proposed Commercial Net Pen Aquaculture in the Great Lakes." (n.d.): n. pag. *Michigan.gov*. Michigan Department of Environmental Quality, Michigan Department of Agriculture and Rural Development, and Michigan Department of Natural Resources. Web.

"Start Here: Aquaculture in Michigan, An Overview." *Michigan Department of Agriculture and Rural Development*. N.p., 2016. Web.

"Legislation Introduced to Reform Michigan Aquaculture | Senator Darwin Booher." *Senator Darwin Booher*. N.p., 16 Dec. 2015. Web.

"Agriculture Code: Production, Processing, and Sale of Animal Products- Bees and Nonlivestock Animal Industry- Regulation of Aquaculture- General Provisions." N.p., 1 Sept. 1999. Web.